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(1) your paper should contain a new result;
(2) your paper should be written in understandable English;
(3) your paper size shouldn't exceed five pages.

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Plenary Talks

Seismo Electromagnetics: History and latest results

Hayakawa, M. (Research Station on Seismo Electromagnetics and Department of Electronic Engineering, The University of Electro-Communications, Chofu Tokyo, Japan)

A review of recent activity on seismo-electromagnetic research in Japan is presented. The following 4 topics of our research are outlined and their most important findings are introduced.

1. Seismogenic ULF emissions (Lithospheric effect)

The observation of seismogenic ULF emissions has been continued for the last several years at the network of stations in the Tokyo area. The spacing between the stations is of the order of 70–80 km to respond to any big earthquakes in the Tokyo area. The highlight from this Tokyo ULF network was the event of Izu islands earthquake swarm in July, 2007. We have found a significant ULF signature of this earthquake swarm by using different kinds of signal processing: principal component analysis, direction finding, fractal analysis. The results obtained are expected to be included in the improvement of the generation mechanism previously proposed by Molchanov and Hayakawa (1995).

2. Seismo-atmospheric effect (Observation of over-horizon VHF signals)

Here we consider two phenomena: Atmospheric perturbation, and Atmospheric radiation. We established a VHF network in Japan, covering from Sendai (Tohoku region) down to Kagoshima, and we are ready to look for any earthquakes near the coast of Pacific Ocean (Nankai, Tohnankai, Takai earthquakes) (Hayakawa et al., 2005). It is found that the reception of over-horizon VHF signals (FM transmitters) is due to the atmospheric perturbation caused by the earthquake (definitely not ionospheric perturbations). We have proposed a generation mechanism of such atmospheric perturbations based on the changes in geochemical quantities associated with earthquakes. The observation of lithospheric VHF electromagnetic noise (radiation) was carried out in the Sendai area. The VHF radio noise data observed at several stations have been analyzed on the basis of SOC

(Self-organized criticality) concept by using different kinds of fractal analysis (spectrum slope, Detrended fluctuation analysis, Wavelet based analysis etc.) for a particular large earthquake in August, 2005 (Miyagi-ken oki earthquake)

3. Seismo-ionospheric perturbations

In the framework of this topic the Anomalous Schumann resonance phenomena and the VLF subionospheric observation of seismo-ionospheric perturbations are considered. We have found the anomalous Schumann resonance phenomena observed in Japan, which are thought to be associated with the earthquakes in Taiwan. Hayakawa et al. (2005) have found the 1st event for the Chi-chi earthquake in Taiwan (M = 7.6) on September 21, 1999. The anomaly in Schumann resonance in Japan, was characterized by (1) an enhancement in the fourth harmonic and (2) the frequency of this 4th harmonic is significantly shifted from the conventional value by about $\sim$1.0 Hz. This anomaly is interpreted as interference between the direct signal from South America and the wave scattered from the ionosphere over Taiwan associated with this earthquake. The routine observation of VLF/LF transmitter signals has been continued in Japan by means of our VLF/LF network. The observing stations are (1) Moshiri (Hokkaido), (2) Chofu, (3) Chiba, Tateyama, (4)Shimizu, (5) Kasugai (Nagoya), (6) Maizuru (Kyoto), Kochi. At each station, we observe simultaneously several VLF/LF transmitters; (1) JJY (Fukushima, 40 Hz), (2) JJI (Kyushu, Ebino), (3) NWC (Australia), (4) NPM (Hawai), and (5) NLK (USA). The data have been accumulated in Chofu nearly for about ten years. The statistical correlation between the ionospheric perturbations and earthquakes has been analysed. This study has yielded a significant correlation between the LF characteristics (amplitude and fluctuation) and earthquakes with magnitude greater the 6.0. The case studies on seismo-ionospheric perturbations have been done for the Niigata earthquake, and for the Indonesia, Sumatra earthquake. Here we show the summary of our study on ionospheric perturbations associated with the Sumatra earthquake on 26 December, 2004. By using the cross-correlation and superimposed epoch analyses, we came to the following findings. (1) The fluctuation spectrum in the period range from 20-30 minutes to 100 minutes (the frequency of atmospheric gravity waves) is enhanced before the earthquakes. (2) The time delay at Chiba is about 2 hours with respect to Kochi, and so the propagation velocity is $\sim$20 m/s.

4. Lithosphere-atmosphere-ionosphere coupling

We have already proposed a few possible mechanisms; (1) chemical channel, (2) acoustic channel and (3) electromagnetic channel. We have found that the channel (3) seems improbable due to the emission intensity from the lithosphere, which is too weak to induce any ionospheric effects. So, both channels (2) and (3) are likely to be in operation. Our previous section has indicated an example of atmospheric gravity waves playing a key role in the lithosphere-atmosphere-ionosphere coupling. However, the channel (1) is also worth examing extensively (Molchanov and Hayakawa, 2007).

Global simulations: What do they tell about the large-scale magnetospheric dynamics?

Pulkkinen, T.I. (Finnish Meteorological Institute, Helsinki, Finland)

Global magnetohydrodynamic simulations have been developed to provide a comprehensive numerical representation of the large-scale processes that govern the solar wind – magnetosphere coupling. We have developed quantitative methods to evaluate the energy transport across the shock to the magnetosheath and into the magnetosphere. Furthermore, series of simulation runs have been conducted to examine the effects of individual parameters to identify the most important factors controlling the energy transport from the solar wind into the magnetosphere and ionosphere. Analysis of these results have brought new aspects that complement the earlier observational results: (1) The energy input through the magnetopause is delayed with respect to changes in the IMF orientation, which is seen as a delayed response in both tail dynamics and ionospheric energy dissipation. (2) The solar wind clock angle modulates the energy input, but the solar wind speed has a larger effect than that suggested by the empirical epsilon-parameter. (3) The solar wind density has a minor role in ionospheric parameters, but does affect the magnetotail dynamics and transport properties. We review several simulation results and compare them with recent observational analyses.

Modeling the geomagnetosphere using spacecraft data: challenges of space and time

Tsyganenko, N.A. (Institute of Physics, University of St.Petersburg, Russia); Sitnov, M.I. (Applied Physics Laboratory, Johns Hopkins University, Laurel, MD, USA)

In this talk, a review will be made of most recent advancements in the modeling of the Earth's distant magnetic field, based on large sets of spacecraft data taken over the vast range of distances and supported by concurrent upstream observations in the incoming solar wind. Two greatest challenges in this area are the complexity of the spatial structure of the magnetic field sources and their essentially dynamical nature, as a result of the highly variable solar wind driving, combined with largely different timescales of the response of major magnetospheric current systems to the external input.

Large sets of in situ data that became available in the last decade provided new opportunities to meet the above challenges. A new approach was developed recently, making it possible to greatly increase the spatial resolution of the modeling the field of both equatorial and field-aligned currents, and allowing one to further improve that resolution, as new data become available in the future. First results of fitting those models to the observed magnetic field not only demonstrated the feasibility of the approach, but also revealed new interesting features in the large-scale distribution of the storm-time magnetospheric field.

Another crucial aspect of the empirical modeling concerns its ability to faithfully reproduce and forecast the dynamics of the magnetosphere in the course of space disturbances. Two major approaches developed within the last few years will be discussed in this talk. The first one assumed a simple model of the magnetospheric driving, in which the response/decay timescales of individual current systems to the external input were treated as free parameters to be found from data. The second approach is based on the so-called "nearest-neighbor" method of selecting data subsets, representing different states of the magnetosphere in the course of a disturbance.

The obtained results demonstrate a large and previously untapped potential of the data-based approach to develop a truly dynamical model of the magnetosphere, capable to forecast geomagnetic disturbances as they unfold in space and time.

Section C. Conductivity of the Earth

Possibilites of the AMT method for localization of kimberlite bearing fields and clusters of kimberlite pipes

Antaschuk, K.M., Denisov, R.V., Nikiforov, A.B., Pyzhjanova, T.M., Romanova, N.E., Saraev, A.K., Shlykov, A.A. (St.Petersburg State University, St.Petersburg, Russia)

The problem of localization and contouring of kimberlite bearing fields and clusters of kimberlite pipes is one of the principals in diamond exploration. Solution of this task will allow carrying out purposeful detailed diamond exploration works using geological and geophysical methods including drilling. In spite of big volume of small-scale surveys in which the seismic method plays the leading role this task is not solved confidently. That is why development of the existing complex of methods for receiving new data and for increasing of reliability of exploration works is very important. Last years works by the MT method allowing study the basement in the depth range of 3 – 40 km were carried out in big volume in diamond bearing regions by ALROSA. Results of works by the AMT method allowing study the sedimentary cover in the depth range from 50–100 m to 2–3 km are presented in this article. According to data of previous geological and geophysical works it is known that kimberlite hosting and kimberlite controlling faults, cupola-shaped structures, flexure bends and subsidence structures are seen in sedimentary cover. Besides that more deep structures of basement can be reflected in sedimentary cover. Borders of kimberlite fields have the isometric or elongate shape and its square is not more then first hundred square kilometers. Separate clusters of kimberlite pipes are localized within limits of kimberlite bearing fields and their square is not more than first tens square kilometers. The task of works by the AMT method was to determine a complex of typical features of kimberlite bearing field which exist in sedimentary cover. Works by the AMT method were carried-out using ACF-4M tensor equipment. The recorder has four synchronous channels and 24 bit ADC in each channel. The working frequency range is from 0,1 Hz to 800 Hz. The technology for measurements with ungrounded electrical lines in the frequency range of 7–800 Hz for realization of winter measurements on the surface of snow and ice has been developed. Measurements were carried out along regional profile of 74 km length across Alakit–Marchinskoe diamond bearing field (Yakutia) with point separation of 100–200 m for estimation of possibilities of the AMT method for localization of kimberlite bearing field and clusters of kimberlite pipes. This kimberlite bearing field was studied by complex of geological and geophysical methods. Within its limits have been found of 58 kimberlite pipes including some industrial important ones. So AMT data were compared with known border of kimberlite bearing field. Borders of kimberlite bearing field could be contoured confidently on results of the AMT method. The main attention was paid to tracing of the reference horizon of conductive water saturated rocks in the interval of + 150 − 300 m (the second conductive layer of geoelectrical cross-section) under the bottom of frozen rocks. This horizon has regional distribution and it is contrastly allocated on results of 2D inversion of AMT data. Thickness of this layer is enlarged and it changes from 300 to 450 m within the limits of kimberlite bearing field. It decreases to 250 m out of the field. Increased variability of morphology of the water saturated layer is typical for kimberlite bearing fields and thickness of horizon is stable out their limits. The tectonic fragmentation of rocks which is higher within the limits of kimberlite bearing field is determined the features such as thickness, morphology and features of localization of reference horizon of high mineralized water. Cluster of kimberlite pipes which is crossing by regional profile is contrastly allocated on geoelectrical cross section using AMT data as vertical conductive zone of 5 km wide and in the depths range of 500 to 2000 m. Determination of features of the zone of kimberlite hosting faults Diagonalny was the principal task of works by the AMT method in Nakyn diamond bearing field (Yakutia). Four kimberlite bodies are allocated within limits of this zone. This zone is allocated confidently by results of works of AMT method on complex of features of audiomagnetoteluri field (localization along the border of the sharp change of impedance phase on low frequencies 10–20 Hz and availability of conductive sites which are slanting to direction of this zone and which could be connected with crocks of split). The obtained results show that the method can be successfully applied in diamond bearing regions for allocation of kimberlite bearing fields and clusters of kimberlite pipes.

Geothermal and geoelectrical models of litosphere of Belarus

Astapenko, V.N., Levashkevich, V.G. (Institute of Geochemistry and Geophysics, National Academy of Sciences of Belarus)

Large part of Belarus had been studied by different geophysical methods. The most representative is a profile EUROBRIDGE, along which seismic, geoelectrical and heat models of crust and upper mantle are compared. Complex interpretation allows to narrow a collection of alternative models and explain a nature of geophysical anomalies. Anomalous areas of conduction in the upper crust are in accordance with isotherms of 180–200°C. Anomalies in the lower crust are correlated with temperatures exceeding 450°C and connected with fluids which are separated from number of minerals. Within Orcha trough is expected presence of geoelectrical astenosphere on depths more than 80 km. Here installed anisotropy of shallow seismic waves. Low heat flow witnesses of absence of partial melting in this areas. Possible reason of anomaly may be a presence in mantles an amphibolite, as far as in this region is expected triple joint palaeoproterozoic segments of the crust: Fennoscandia, Sarmatia and Volga–Uralia.

New possibilities of GPR for the investigations of fresh water reservoirs

Bobrov, N.Yu., Kiselev, E.Yu, Krylov, S.S., Othman Mohammed Nasser (St.Petersburg State University, St.Petersburg, Petrodvoretz, 198504, Russia)

Ground penetrating radar (GPR) is nowadays widely used in various areas. One of the most efficient GPR applications is a sounding of fresh water reservoirs (lakes, rivers) from the surface of water. GPR allows to detect the depth of a reservoir (down to 20 meters), the thickness of bottom sediments, the local targets at the bottom, like industrial wastes or sunk ammunition. In all these cases the GPR works like a sonar.

GPR has demonstrated efficiency for solving some hydrological problems, for example, for detection of a boundary between fresh and saline water in the estuaries. Due to strong contrast in conductivity between fresh and saline water, their boundary proved to give a distinct mark at the records of reflected signal. GPR survey carried out with the use of small boat gives a possibility to follow the dynamics of fresh and saline water interaction in the river mouth in the real time scale.

Information about damping of reflected signal is not used in standard procedures of GPR data processing. Damping depends on the electrical conductivity of the medium, and therefore conductivity can be estimated if to take into account amplitude values of reflected signal. Determination of water conductivity in the course of GPR survey from the surface of water reservoirs opens a possibility to evaluate mineralization of water in a fast and efficient way when solving various problems of ecological monitoring.

Deep structure of Baltic Shield

Cherevatova, M.V. (St.Petersburg State University, St. Petersburg, Petrodvorets, 198504, Russia)

The object of the present work is review and analysis of the main results of geophysical researches at the Baltic Shield in order to obtain the clearest conception of problems of this region during the last ten years. Because of absence of a sedimentary cover Baltic Shield represents natural ground for geophysical researches, especially for magnetotelluric researches with the purpose of revealing the deep structure of the Earth, which is at present very actual.

In the eastern part of the Baltic Shield geoelectrical methods everywhere show presence of two conductive layers: the crust layer, at the depth of 10-15km, and the under-crust one, at the depth of 40-160 km. Nowadays, the nature of the crust conducting layer is interpreted as an increased horizontal splitting zone, and the under-crust conducting layer is usually connected with the astenosphere.

Furthermore, the seismic researches have been considered too, with the view of construction an abyssal section of the Shield. The brief review of a geological structure of investigated area is carried out using works by N.V. Sharov (1982, 1993), A.A. Kovtun (1994, 1998, 2002), Yu.Yi. Sistra (1991), M.V. Mints (2002) and others.

Analysis of results of geoelectrical works carried out at the Baltic Shield allows to point regions which require additional investigation.

Experimental investigation of granular systems electrical conductivity systems

Iudin, D.I. (Institute of Applied Physics RAS, Nizhny Novgorod)

The presentation devoted to experimental investigation of dispersion medium electrical conductivity. The dispersion medium we use is maintained as electrolyte filled granular system subjected to uniaxial compression. We use fragmented polyurethane sheet. Our experiments show that conductivity of equigranular system vanishes at the finite percolation threshold predicted by continual percolation theory. This result is completely different from well-known Archie's law situation, when a slight amount of conductivity persists down to zero porosity, rather than having conductivity vanish at a finite percolation threshold. We also study mixtures of two equigranular systems with different granular sizes and obtain that conductivity of mixture vanishes at threshold that is noticeably less than the finite percolation threshold predicted by continual percolation theory. Our calculations are shown to reproduce qualitatively and quantitatively the trends found in our experiment.

Interpretation of the remote-sensed video-thermal imaging data of the Earth's thermodynamic field

Karimov, K.M., Mukhamedyarov, R.D., Onegov, V.L., Kokutin, S.N., Kolesnikova, E.R. (ZAO "Institute of Aerospace Instrument-Making", Kazan, Russia)

During the last decades there has been indicated considerable progress in collecting and processing data of remote sensing in order to solve geological, ecological and technogenic problems.

We represent the technology of multileveled remote sensing of the Earth's thermodynamic field interpretation based on the Mukhamedyarov's method of the video-thermal imaging generalization — MMVTIG. The basis of the method is the following: any object emits thermal energy, that contains information about process taking place within the object. The technology consists of three stages:

The first stage is collecting data acquired from remote sensing systems mounted at the satellites (Landsat, Terra, Aqua) and aircraft; creating redundancy of spatial and spectral resolution;

The second stage is processing thermal imaging data using generalization, i.e. exchange spatial or spectral resolution for the increase of temperature sensitivity. This results in layer-by-layer penetration into the depth of the Earth with temperature resolution to 10^{-5} K;

The third stage is decoding and interpretation of anomalous temperature zones.

The following part of this technology allows to process mosaic of original thermal images, acquired from aircraft. These output images of visible and thermal range are combined into an integrated digital data set. Layer-by-layer combining is practiced with simultaneous geocorrection of images. This results in constructing of geological environment models.

The represented technology makes possible to solve such geological problems as studying the depth structure by geotraverse, oil and gas finding, underground water finding; such technogenic problems as investigating sites for planned building, revealing possible causes of technogenic catastrophes, pipelines observing, monitoring of landslips, mudflows, karst cavities; inspecting the arterial and local pipelines illegal tie-ins; such ecological problems as monitoring of rivers and water areas including unapproved polluting water discharges detecting, inspecting the spots of underground pipelines (oil and gas) leakage, detecting unapproved concealed dumps, defining the spots of underground spontaneous ignition at peatbogs and dumps.

Research of electric parameters of the rock massifs

Khromov, A.A., Lementueva, R.A., Irisova, E.L. (Institute of Physics of the Earth RAS, Moscow)

The subject of the research are variations of electric apparent resistivity (ρ_K) and caused polarization (η_K) under pressure and demolition (destruction) of rock massifs blocks in a mine along with the tests of the rock samples in laboratory. The research was carried out at the Karanasurt mines (Kola peninsula). The rock consists of nepheline syenites incorporating layer of loparites. The change of the stressed-deformed state (SDS) of the tested blocks was reached by increasing of the pressure beyond the estimated strength limit by means of explosion of the neibour blocks. The research of the ρ_K and η_K variations of the blocks under pressure was carried out in two stages with a one-year interval. Typical changes of these parameters were discovered before the blocks were destructed. During pressure tests of the rock blocks up to complete destruction of the samples (both in laboratory tests and in the blocks in mines) significant abnormal variations of apparent polarization and electric resistance were registered. Comprehensive research has revealed that the process of cracks growing during pressure tests is accompanied by increase in electric conductivity and leads to relative decrease in both ρ_K and η_K. This effect is explained by re-distribution of electric current due to emerging of electric heterogeneity inside the tested blocks and rock samples. Further study of variations in the above-mentioned parameters (ρ_K and η_K) may prove perspective for research of stressed state of the rock blocks.

Using the quasi-2D approximation for the estimation of the mantle conductivity by data of deep MT and MV sounding on the Fennoscandian Shield

Kovtun, A.A., Vardaniants, I.L., Legen'kova, N.P., Sinkevich, O.A. (St. Petersburg University, St. Petersburg, Russia)

On the base of 2D modeling there was developed technique of interpretation of magnetotelluric (MT) and magnetovariational (MV) data, obtained on the Fennoscandian Shield territory with the purpose of defining parameters of the crust anomalies and deep mantle conductivity distribution. This technique suppose using the 1-D interpretation of "longitudinal" curves and phase curves of the maximal impedance because these curves are less sensible to the influence of the upper crust anomalies of the conductivity.

There were used experimental data of the international project BEAR and sounding data obtained by geophysicists of Oulu University (Finland), Uppsala University (Sweden) and Sanct-Petersburg State University (Russia). During the analysis of material we used the conductance map of Fennoscandian Shield crust made under T. Korja leadership. This map made it possible to distinguish the main parts with the increased conductivity of the crust, which must by taken into account during the deep MT investigations.

Using the numerical modeling there were defined the distances where the influence of stretched conductive zones located along the joint zone of the Karelian and Svecofennian blocks became insignificant. Within the region of the central conductive anomaly the deep distribution according to 1-D interpretation of model data become close to the real one at the distance more then 400 km from the anomaly axis. By the results of modeling we obtained formula for the estimation of the anomaly conductance by the analysis of the frequency characteristics of MT and MV parameters.

By the MT data within the extended period range ($10^3 - 10^4$ s) there were built two vertical sections: along the profile Vyborg–Suoyarvi within the region of the Ladoga anomaly and along the profile SVECA-2. Both profiles were built by the "longitudinal" curves which were chosen according to their closeness to the global MV curve at large periods ($T > 10^4$ s).

The analysis of model data of the profile SVECA-2 showed that the 1-D interpretation of the "longitudinal" curves and phase curves of the maximal impedance allow to obtain true information on the deep distribution of conductivity.

Variations of natural electric field in ore body and enclosing its rocks

Maibuk, Z.-Ju.Ya. (Institute of Physics of the Earth RAS, Moscow, Russia)

Experimental studies of behavior of variations of local quasi-uniform natural electric fields (NEF) in polymetallic ores of blende-halenit-chalkopyrite structure and containing rocks (limestones) were carried out at a transmission of seismic waves generated by natural and technogenic sources. Variations of NEF probably characterize the processes of microfractures and accumulation of defects in rocks against mechanoelectric and electrochemical transformations in ores at violation of quasi-constant and non-uniform sressed condition. Registration of NEF have been conducted within 40 days in a continuous mode on a surface ore in observation area and on barren area simultaneously with application of a technique of the four-electrodes scheme of indemnification of external fields from sources of natural and technogenic character (Seismicheskie prybory, N 39, 2003 (in Russian)). Such way possesses the raised accuracy at the expense of fall of displacement and zero drift. On perimeter of observation areas graphite electrodes (S = 200 cm^2, R = 600-800 Ohm) have been installed on a distance 45x45 m from each other and at a depth 170 m. Initial signals of NEF completely were compensated. Signals of NEF in a frequency range to 25 Hz were investigated. Elastic waves on observation areas were monitored by seismogages (-3 type) mounted on the rocky outcrops (a range of frequencies 0.3 - 14 Hz). On ore areas 23 abnormal variations of NEF by amplitude to 240-370 mV are registered at mean level of a background 30-60 mV. Durations of anomalies were from 0.5 till 14 hour. On barren area the variations of NEF by amplitude 20-40 mV without obviously expressed anomalies were observed. During studies 64 groups of seismic signals are registered. Probably the majority of them had technogenic character. To identify signals of distant earthquakes it was possible from three events. It is possible to allocate confidently only eight coincidence of seismic and electric anomalies including from one earthquake. Two most significant anomalies of NEF with maximum amplitudes were not accompanied by seismic events. Now the mechanism of occurrence of NEF in ores and a character of their interaction with other physical fields depending on those or other physical-geological conditions is poorly studied. In dynamic properties of NEF signals the signs of ore mineralization can be revealed.

Comparison of statistical characteristics of marine-measured electric transient fields

Malovichko, M.S. (St. Petersburg State University, St. Petersburg, 199034 Russia)

The most popular seabed exploration method using the controlled source is the frequency-domain geometrical sounding, called CSEM. Such exploration method is noise-immune, but doesn't let to measure lithosphere polarizability. In contrast, the time-domain measurements using the bottom stations let us to get it. The source is the towed transmitter antennas which generate bipolar square pulses. These measurements are not so noise-immune. The variable geometry doesn't allow stack the long-term signal. In case of deep water the electric field is measured with the help of the short receiver line of about 10 m length. In case of shallow water the long receiving line is put to the seafloor. Another transient measurement mode is the survey when both the transmitter and the receivers array are towed by the ship. This method allows the long-term signal stacking, but its noise level is pretty high.

This paper concerns statistical characteristics of measurements in the moving and bottom station measurements in case of deep water as well as in case of shallow water. It is shown that the data received with the help of bottom stations are of more quality. The spectral characteristics study shows that the deep measurements are free from the wave noise and the AFMAG range telluric noise. The deep measurements noise distribution is close to normal one. The noise abnormality of two other measurements modes is mainly related to the intensive low-frequency noises. The outliers influence is considerably less. It explains why the applying of robust preprocessing algorithms or the least square estimation gives practically the same results. It is shown that the signal robust estimates at the later transient stage are biased. The bias is determined by the wave-noise level. It is also shown that the existent preprocessing systems use the redundant number of simultaneously stacked curves.

Complex seismic and magnetotelluric monitoring

Moskovskaya, L.F. (SPbF IZMIRAN, St.-Petersburg, Russia)

The dynamic processes proceeding in an tectonically active zone, are reflected in seismic, magnetic, electric, thermal fields. In this paper the joint analysis of the information received by seismic and electromagnetic methods is executed. In our disposal there were data of the seven-year seismic monitoring covering the area more 350000 km2 at east coast of Japan. The seismic data contained all events registered in a zone of supervision, and their spatial coordinates. We also had magnetotelluric time series during seven months. A volcanic eruption began in final month of supervision.

Seismic monitoring has revealed the basic morphological features of a geological section. That well appropriate to present knowledge about a geological structure of a zone. Results magnetotelluric monitoring have revealed, that resistance variations occur in the certain range of depths of a geological section. The spatial scheme of morphology of researched area of the geological environment is a key to understanding of the reasons of variations of the electroresistance.

Correlation connections of bursts of weak seismicity with dynamics of change of resistance of a section are found experimentally. Different areas of space most strongly react to different phases of variations of pressure: on an initial stage or the period of pressure drop (reset of water from cracks of rocks).

The mechanism of the coordinated variations magnetotelluric and seismic geophysical fields in subduction zone

Moskovskaya, L.F. (SPbF IZMIRAN, St.-Petersburg, Russia)

As a result of the analysis of the data magnetotelluric and seismic monitoring, we have found out correlation between change of resistance and bursts of weak seismicity of a geological section in Japan. It is possible to offer two basic schemes of an explanation of the mechanism of the coordinated variations: thermodynamic and physicomechanical.

The first model explains process by periodic variation of physical parameters of a viscous layer between slabs. The increase of temperature may cause increase of melt of the connected water in a subduction lithosphere. Increase of pressure in a viscous layer forces water to fill in cracks and pores in the top horizons of a section. As result resistance falls. Because of morphological spatial connectivity of environment, strengthening of pressure from depth through structure of the main break transfers to a superficial part of an island wedge, and also is distributed on a viscous layer. It causes bursts of seismic activity.

In physicomechanical model a change of geometrical distances between blocks of geological structure is the reason of variations. change of geometrical distances is connected by oscillatory movements of an island wedge. Reduction of height of a viscous wedge forces water to rise upwards in cracks of rocks. Contact and friction of blocks of geological rocks causes weak earthquakes in zones of the greatest roughnesses.

The results of magnetotelluric monitoring in subduction zone

Moskovskaya, L.F., Kopytenko, Yu.A. (SPbF IZMIRAN, St.Petersburg, Russia)

In Japan on peninsulas Boso and Izu two groups magnetotelluric stations MVC-3DS developed in SPbF IZMIRAN are established. Stations continuously register three components magnetic and two horizontal components electric fields.

We processed the data of continuous monitoring for seven months: since February till August, 2000. We used measurements of two magnetotelluric stations (S) of peninsula Boso. Resistance was estimated by means impedance regression analysis.

Results monitoring have revealed, that resistance variations occur in the certain range of depths of a geological section. The resistance is stable on the periods more than 256 seconds. This level determines the top border of a subduction slab. Character of resistance change shows, that water on cracks is distributed from below upwards. Resistance in a transitive zone varies jump on the o decade. Environment reaches full saturation by a moisture during short enough interval of time. On high horizons of a section (T=64 s) saturation of cracks by water increases dispersiveness of rocks. In a zone of oceanic deposits of a subduction slab, on low horizons (for T256 s), environment is more homogeneous. Here the leaving of water from pore increases dispersiveness of environment.

At the end of July and in August there was an eruption of the underwater volcano, which is taking place near to structure of the main break of an island wedge. Emission of significant energy has resulted in increase of pressure, temperatures in the environment, probably, to penetration of water in cracks zones. Resistance has fallen in all range magnetotelluric sounding above a plunging plate (T128 s).

On sections of the module and a phase of vector Umov-Pointing the layer of discrete change of parameters is allocated clearly, as well as on a section of apparent resistance. The stream of energy of an electromagnetic field is distributed from the top downward (the phase is negative). In intervals of fall of resistance of environment the density of energy is increased and bigger uniformity of environment (the module of a phase is increased) is observed.

Magnetotelluric monitoring has shown, that in a geological section there are the regular changes of electroresistance connected to a fluid regime in a zone of tectonic breaks and cracks.

Preliminary results of the BEAR data processing with application of nonlocal response functions

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The unique synchronous data from the magnetotelluric and magnetovariation station array are received during the project BEAR execution by study of the conductivity spatial distribution beneath the Baltic Shield. Alongside with traditional methods, it enables to use nonlocal electromagnetic response functions at data processing. The data processing with the Tikhonov–Cagniard model becomes essentially complicated in a real situation, when a primary field of a natural source and medium properties change appreciably on lateral coordinates. For overcoming arising difficulties, the fact is used in this study that the electromagnetic field inside any volume is completely determined by the surface distribution of tangential components either electrical or magnetic fields (the uniqueness theorem). The solution of the inversion problem can be carried out by the correlation with each other of surface distributions of mentioned tangential components during search of the spatial conductivity distribution in the volume. We developed the appropriate algorithm of the data processing. Spatial approximation of discrete station data on surface is carried out. The electromagnetic field is represented by two modes which are connected with each other in 3D case. The approach of the medium smooth heterogeneity is used for the calculation reduction. The field of the electrical mode is found by the approximation method in this case. Distributions of the electromagnetic field components found by spatial approximation are recalculated in values of the entered potential functions and their vertical derivatives on the surface of investigated volume. These values also are coordinated further during search of spatial conductivity distribution in volume by optimization methods. Testing the developed algorithm is carried out on synthetic models of medium heterogeneity. The influence of the observation network density and errors on the restoration degree of the synthetic heterogeneity is investigated. It is established that the restoration degree is increased at averaging the required output data both on several observation intervals and on the next harmonic time periods. In conditions of the small number of observation stations, it is possible to achieve improvements by the registration repeated on networks with the varied station configuration and by subsequent averaging of required results. It is important that changes in time and poorly known parameters of a natural primary field source have not an effect. Some preliminary results of the BEAR data processing are received by the described method. Maps of the lateral distribution of the apparent conductivity are constructed on the time harmonic periods. For comparison, known maps are used for the crustal thickness and for the P-velocity anomalies determined by the seismic tomographic data, and also for the integrated conductance of the top layers in the specified region of the Baltic Shield. It is possible to notice some similarity of the specified maps. In particular, the increased conductivity values are traced along the tectonic suture between the Karelian and the Svecofennian blocks. Some correlations are observed in distributions of the conductivity minima and of crustal thickness maxima, and also with the zone of the increased P-velocity anomalies. The work is executed at RFBR financial support (grant N 07-05-00007).

Electromagnetic induction experiments with three different sets of geomagnetic observatory data

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Electromagnetic soundings have been carried out with hourly means of the three components of the Earth's magnetic field during

– the *International Geophysical Year*, July 1957 to December 1959;
– the *International Quiet Sun Year*, January 1964 to December 1965;
– from October 1982 to March 1983.

The purpose of this study is to test the compatibility of results with particular attention to the possibility of systematic errors.

In the intervening 25 years recording instruments and observers may have changed, some observatories have been closed and others have been newly established at different locations. Also the experimental conditions have changed with regard to the inducing source fields. The IGY has been a time of intense solar and geomagnetic activity, the IQSY a time of extreme geomagnetic quietness, the third epoch a time of variable geomagnetic activity. EM responses are determined for the time harmonics of daily variations and for their activity-related spectral background continuum. The sounding methods applied are *the potential method* for global responses and the horizontal gradient method for local responses in Europe, the latter also in combination with *geomagnetic depth sounding.*

The study has given confidence in the results of EM soundings with geomagnetic observatory data on a global and on a continental scale. Stochastic errors appear as correctly estimated and systematic errors seem to be absent. Their causes could be the twofold: Expansions into spherical harmonics (in the potential method) or into spatial polynomials (in the horizontal gradient method) have an unavoidable dependency on the number and location of observing sites. Their distribution has changed considerably, however, within the analysed data sets. A second possible cause is calibration errors of the recording variometer. When in the determination of expansion coefficients numerous observatories are involved, these errors may simply add to the random errors of the final estimates. But in horizontal gradient sounding any calibration error of the Z-variometer at the sounding site modifies the absolute values of estimates proportionally by the same factor for all frequencies.

We have not found any significant improvements in data quality between the IGY and the 1982/83 epoch 25 years later. But definite progress has been made in the documentation. From the 6.5 million hourly values, compiled for the IGY, about 15 000 were clearly erroneously and had to be corrected manually, while the 1982/83 data were nearly without obvious errors. Their problem lies else-where. Still the editing of the time series remains the most time-consuming part of the analysis. Disappointing is the undiminished large number of data gaps in all three epochs.

The solution of a inverse problem of frequency controlled source magneto-telluric – audio-magneto-telluric (CSMT-AMT) sounding with a horizontal electric dipole in view of properties of the waveguide a ground - ionosphere

Shevtsov, A.N. (Geological Institute of the Kola Sci. Center RAS, Apatity, Murmansk region, Russia)

Experiments on frequency sounding with a power lines executed earlier in northern Kareliya on removals up to 400 km [Zhamaletdinov et al. 2005] have confirmed the basic features of normal model of a geoelectrical section of a top of earth crust of the Baltic shield. At the same time, the obtained outcomes have shown essential distorting of curves of apparent resistivity for a component electrical and magnetic field on removals from a source more than 200 km bound with influencing of properties of the upper half-space. During experiment on frequency CSMT-AMT sounding with a power lines in 2007 the measurements in northern and central Kareliya in frequency band from 0.1 up to 200 Hz are conducted and the outcomes from two mutual - orthogonal sources on removals up to 700 km are obtained. By results of measurements, a component of a tensor of an impedance by a technique of an effective linearization (ELT) [Porokhova, Kharlamov, 1989] the model of a geoelectrical section for studied region is built. The components electrical and magnetic field subject to influencing of the waveguide was used for definition of electrical conductivity of the upper half-space. During inverse were determined an altitude of a conducting stratum (ionosphere), its integral conductance and factor of an anisotropy (ratio of longitudinal conductivity (in a horizontal direction) to a cross conductivity (in a vertical direction)). The obtained data allow drawing a conclusion about a capability of definition of parameters of the upper half-space under the data of frequency sounding on removals superior an altitude of the ionosphere, that can be used for monitoring an ionospheric conditions.

The research is done under support from Russian Fund of Basic Research grunts No 06-06-64429a and No 07-08-00181a and of the Project Department of the Earths Sciences of RAS - 6 “Geodynamics and gears of deforming of rock sphere”.

Technique of processing of frequency controlled source magneto-telluric – audio-magneto-telluric (CSMT-AMT) sounding with a power line (PL)

Shevtsov, A.N. (Geological Institute of the Kola Sci. Center RAS, Apatity, Murmansk region, Russia)

Experiments on frequency sounding with a power lines executed earlier in northern Kareliya on removals up to 400 km [Zhamaletdinov et al. 2005] have confirmed the basic features of normal model of a geoelectrical section of a top of earth crust of the Baltic shield. The given model essentially differs from models obtained by results of MTS [Hielt et al. 2006, Kovtun et al.1986]. During experiment on frequency sounding with PL in 2007 year the measurements in northern and central Kareliya are performed in the frequency band from 0.1 up to 200 Hz and the outcomes from two mutual - orthogonal sources on removals more than 500 km are obtained. For a comparison of information of frequency sounding and outcomes MTS the technique permitting to meter apparent resistance, both on components of an electromagnetic field, and on impedance relations is designed. The processing of time series for a component of a field and current in a source is carried out by definition of a spectral power density as frequency function. The records of component of a field in a point of observations and current in a source are clocked by means of GPS. It allows carving out a signal of a monitored source from fields of a natural genesis. The outcomes of processing have shown the quality consent of curves of apparent resistance and phase values a component of a tensor of impedance for CSMT-AMT sounding and MTS. At the same time the inaccuracy valued on standard deviation of measured values from their median estimations, for the data S appears much above, that results in much greater dispersion in definition of parameters of a geoelectrical section at interpretation.

The research is done under support from Russian Fund of Basic Research grants No 06-06-64429a and No 07-08-00181a and of the Project Department of the Earths Sciences of RAS - 6 “Geodynamics and gears of deforming of rock sphere”.

Opportunities of application of method MTS for studying anomalies of conductivity of crust and a normal profile of the mantle on the Baltic shield

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The main heterogeneity of crust of Fennoscandian shield is welding zone or a zone of joint Svecofennian and Karelian geoblocks. Existence of anomaly is noted in many works and its position is the fullest presented in work [Koria, 2007]. The purpose of work consists in estimating of influence of anomalies on behaviour MT curves and estimating an opportunity of their use for studying the most abnormal zone and normal distribution of conductivity on greater depths. For the decision of a task in view numerical modeling in the bidimentional approach [Vardanjants, 1976]. At first model of conductive insert was considered. Conductive insert located on depth of 10 km with width of 100 km and resistance 5 Ohm·m, which much less than normal resistance of a bark on these depths and is accepted equal 5000 Ohm·m has been offered. Modeling a component of field E_x, E_y, H_x, H_y, H_z, impedance Z and magnetovariational parameter w= H_z/H_x was spent in an interval of the periods $1 - 10^4$ s.

By results of modeling was estimated geoelectric parameters of a conductive body.

1. On spatial behaviour the component of a field and an impedance at H-polarization is precisely shown width of conductive anomaly.

2. By position of a maximum of the frequency characteristic $\alpha_E(x) = |(Z_E(x) - Z_N)/Z_N|$ the size of conductivity of cross-section $G = \sigma_a \Delta S$ were obtain, where σ_a is conductivity of abnormal conductive body, and ΔS - the area of cross-section. From empirical equation $G = 1,2 \cdot T_{max}^{\alpha_E} \cdot 10^6 = 1,2 \cdot 10^8 Sm \cdot m$ and it is correctly while top of a conductive insert is above 30 km. G estimated by MV data is $G = 3 \cdot T_{max}^{h} \cdot 10^5 = 0,9 \cdot 10^8$, and it remains a constant with growing of depth.

3. Depth of the conductive body and its longitudinal conductivity is well determined on a curve of sounding at E-polarization if the width of a zone is much more, than its depth. In work the analysis of restoration of a profiles within the range of model of horizontally layered environment by means of software package MEL [Porokhova and Kharlamov, 1990]. Restoration was spent according to e-, o-polarizations and on phases of the maximal impedance. Results of

influence of a non-uniform insert for two polarizations are presented. Quality estimation of restoration shows, that in case of the considered structure of environment it is more preferable to use the data received at e-polarized field. It is entered two criteria for a quantitative estimation of quality of restoration: an average square of divergences of the modeling and restored values of resistance in all available points and the average logarithm of divergences.

All conclusions in this work in the further will be considered at interpretation of real data on the Baltic board.

Special thanks to my science advisor professor Kovtun A.A.

A 3D magnetotelluric study of the basement structure in the Mygdonian Basin (Northern Greece)

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During the project "Euroseistest Volvi-Thessaloniki", a European Test site for Engineering Seismology was employed in the Mygdonian basin, situated between the two lakes Volvi and Lagada northeast of Thessaloniki in order to study velocity cross sections across the valley. In this context, the actual EM survey intends to map the top-of-basement to give input parameter for the seismic wave propagation models.

During 2006/2007 a total number of 92 MT/GDS sites have been installed in the Mygdonian basin. The sites were roughly arranged on an orthogonal grid (North-South and East-West) reflecting the predominant East-West orientation of many normal faults in this area. Based on this survey design we have obtained reliable estimates in the period range from 0.001s to 1 s for day recodings only and from 0.001s to a 1000 s for the sites where both day and night recordings were available. The time series have been processed with the robust remote reference code by Smirnov (2003).

The strike analysis of the MT data revealed two predominant strike directions: For short periods up to ca. T= 3 seconds, a local strike of about 0°/90° is found, whereas for longer periods a regional strike of about 135°/45° can be deduced from the data. The codes by Siriponvaraporn and Egbert (2000) including the modifications made by Pedersen and Engels (2005) to allow for inversion of the determinant of the impedance tensor were used to perform 2D inversion. Error floors equal to 2% for the impedance phase (corresponding to 1.20) and 10% for the apparent resistivity were adopted. The higher error floor for the resistivity is chosen to allow to the inversion procedure more freedom to compensate for the static shifts, since there was no other information in order to constrain the static shift and site spacing is relatively small.

Initial and apriori model for the inversion was taken to be a homogeneous halfspace of 100 Ωm. At all profiles we have fitted the data within the error bars (RMS 1) provided after data processing.

The same data set consisting of 76 preselected good quality sites were used for 3D inversion. The model grid was constructed to be 34x34x21 including 10 horizontal outer cells extending to 60 km from each side.

The second trial we have increased number of cells in between cites twice and made better vertical discretization at target depths, having as the result model grid 42x54x26 cells. For 3D inversion we have used complete impedance tensor providing 4 complex data values at each site and period. The real error bars estimates were provided as for the 2D inversion. The RMS fit archived after 4 successful iterations was about 9.

One- and two-dimensional inversion magnitotelluric data by the regularization SVD method

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In work algorithms and programs for one-dimensional and two-dimensional inversion of magnitotelluric data by the regularizated SVD method are presented. Questions of convergence and stability of the algorithms, and also such important geophysical questions, as resolution of data, information pithiness of data and optimal parametrization are considered. Work of algorithms is investigated using weight matrixes for modelling parameters and data. It is shown, that as initial approach it is better to take a normal pseudo-section, instead of uniform conductive semispace with a preset resistivity value. In order to reduce total time of calculation defining of Freshet-matrix can be made not on every iteration, and the less become the discrepancy the less often can be calculated Freshet-matrix. Research of work of algorithms on model and natural data is carried out. Comparison of work of algorithms with the previous algorithms of the author based on a method of controllable transformation, and also with works of other authors is carried out.

Conductivity of the Fennoscandian Shield mantle by the results of combined interpretation of deep MTS and global MVS data

Vardaniants, I.L., Kovtun, A.A. (St. Petersburg State University, St. Petersburg, Russia)

n order to investigate the depth conductivity distribution at the Baltic Shield territory there were used data of project Bear together with data of St. Petersburg university and data of Oulu (Finland) and Uppsala (Sweden) universities. In this work we have chosen only those “longitudinal” curves and corresponding to maximal impedance phases curves which gave the best agreement with the global MV curve and allowed to perform the combined interpretation with small discrepancy. The performed analysis confirmed our earlier conclusions that at the depths less than 100 km conductivity distributions defined by interpretation of “longitudinal” curves and of corresponding to maximal impedance phases curves differ noticeably. The reason of this difference is the strong non-homogeneity of the crust which causes the different behavior of MT curves depending on the field polarization. However beginning from the depth 100 km the curves of conductivity depth distributions defined by both kinds of MT curves don’t considerably differ and give practically the same section till 800-900 km. The average curve of the mantle conductivity built in logarithmic scale is close to the straight line and within the interval 400–700 km has no marked peculiarities which could confirm the presence of phase transitions in the olivine mantle. However comparison of the conductance of three mantle layers with the thickness 300 km shows the noticeable increasing of conductance with the depth: the conductance of the layer 100 - 400 km is 4500 S, for the layer 400 - 700 km it attains 24000 S, for the layer 700 - 1000 km – 60000 S. The change of the velocity of the conductance rise notes to the change of the conductance mechanism. Depths of these changes approximately correspond to the boundaries of the phase transitions within the olivine mantle defined by seismic data and laboratory studies. These depths are practically the same all over the Fennoscandian Shield. In order to obtain more reliable conductivity distribution in mantle till 700 km it is necessary to reduce the experimental errors within the range of Sq-variations.

The authors are thankful to all members of BEAR working group for the unique material which allow to carry out this analysis.

Studying of MTS data analysis errors distribution on the Baltic Shield

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In the work are presented theoretical estimations of the Magnetotelluric Sounding (MTS) data analysis errors, done with accounting of the Earth layers conductivity change. There can be observed deviations from the Tihonov-Cagniard model in non-conducting layers. These deviations can result in systematical impedance evaluation errors, depending from layer depth and consequently electromagnetic radiation frequency. In the presented work, results of BEAR international experiment data processing, carried on by Smirnov M.Yu. and Varentsov I.M., were used for analysis. Obtained estimations shows that 30 percents of data matches declared assumption. There were noticed and discussed other regularities in errors behavior.

The deep tensor CSMT sounding with industrial power lines at the Eastern part of the Fenno-scandian (Baltic) shield (FENICS experiment)

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The deep tensor controlled source magnetotelluric (CSMT) sounding with industrial power lines has been made at the Eastern part of the Fennoscandian (Baltic) shield at the summer 2007. The experiment have got the name FENICS (Fennoscandian Electrical conductivity from results of soundings with Natural and Controlled Sources). As radiating antennas two mutually orthogonal (EW and NS) industrial transmission lines were used. Power line of EW-direction has the length of 109 km and power line of NS-direction has the length of 120 km. Sounding were executed in a range of frequencies 0.1–200 Hz. Generator "Energy-1" of 100 kW power has been used as the source of alternating current. The current has the shape of the sine with stability on frequency up to 10–7 Hz. The power of current changed from 150–200 A at the lowest frequencies 0.1–1 Hz up to 20–40 A at the highest frequencies 200–100 Hz. The GPS synchronization of a current of the generator and measuring signals is supplied on the basis of GPS satellite system and Blue Tooth interface. Electromagnetic signals measurements were executed on the territory of the Kola-Karelian region, in Northern Finland and on Spits Bergen. According to data analysis the maximal distance of signals registration reached to 1500 km (observatory Barensburg). The uniform primary database of the FENICS experiment is in progress the same way as uniform system for results the data processing and interpretation. With this purpose the program of synchronous spectral analysis of current and measured signals is developed, the programs of the forward and inversion problems solution for the deep soundings with taking into account the influence from ionosphere and displacement currents are developed. The detailed processing and interpretation have been made in complex with MT soundings. The inversion problem for the tensor soundings has been solved on the basis of bimodal scheme with taking into account both (NS and EW) polarizations of the primary source. By results of tensor sounding the parameters of a “normal” geoelectrical section lithosphere are specified. The direct correlation of apparent resistivity curves is established at axial and equatorial installations at distances of up to 600–700 km. That points out on the high horizontal uniformity of substance at the low crust and upper mantle depth. The received data have allowed to specify parameters of a lithosphere electrical conductivity in a transition zone "crust–mantle". On the basis of the experiment “FENICS” data it is made the quantitative modeling of the tectonical and physical conditions in lithosphere of the Fennoscandian (Baltic) shield at the transition zone “crust–mantle” and constructed the scheme of location of the low boundary of the “cold” lithosphere. Connected to the data, the boundary between pseudo-brittle and ductile conditions of substance is studied.

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Section M. Solar-Terrestrial Physics

Mapping technique for the USTEC-derived field of velocity of TEC redistribution

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Study of ionosphere dynamics is one of the most important problems of geophysics. A quantity of papers has been devoted to study of the ionospheric response to strong geomagnetic storms. At equatorial and midlatitude regions one of the most outstanding modifications are alterations in ionospheric total electron content (TEC). Drastic changes in ionosphere vertical TEC can be produced by intense disturbance electric fields originating from the magnetosphere–ionosphere interaction. These electric fields, depending on their polarity and duration, could cause large uplifts or downdrafts of the ionosphere plasma leading to large-scale local time enhancements or decreases of the vertical TEC. TEC measurements from GPS networks provide information about perturbations in an ionization distribution. Using techniques mentioned extensively in the literature Global Ionosphere Maps (GIM) of vertical TEC can be calculated. However, the ionosphere maps can only describe spatial distribution of TEC but they cannot provide quantitative characteristics of TEC dynamics. We propose a method for calculation of regional maps of velocity of TEC isoline movement (TECIM) using USTEC maps (http://www.ngdc.noaa.gov/stp/IONO/USTEC/home.html) with a high temporal (15 min) and spatial (1 deg. of latitude and 1 deg. of longitude spatial grid) resolution. We tested our method by calculation of TECIM velocity at local sunrise (06:00 LT for 105°W) in geomagnetically quiet conditions, on January 9, 2005 (value of planetary index Kp = 1). Applying of our method allows us to obtain additional information about the ionosphere plasma redistribution. Thus, during the main phase of geomagnetic storm on 8 November 2004 (maximum level Kp = 9), when during local nighttime a large-scale ionization redistribution was observed, the velocity of TECIM reached 1000 m/s. On the contrary, during similar time interval on geomagnetically quiet day 15 November 2004 (maximum level Kp = 1), the velocity of TECIM did not exceed 100 m/s. The presented here examples illustrate significant distinctions of the dynamics of the ionization redistribution under geomagnetically quiet and disturbed conditions. During quiet time periods the velocity of the night ionization changes far off the terminator is much smaller than the velocity of the terminator. On the contrary, during geomagnetic storms fast changes of the spatial TEC distribution essentially exceed the terminator velocity value. Such changes are determined by the spatial configuration and the intensity of the electric field originating from the magnetosphere–ionosphere interaction. The field of TECIM velocity calculated by the proposed here method can be useful when analyzing the ionosphere dynamics during geomagnetic storms.

Ionospheric disturbances excited by solar terminator moving

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Recent investigations show that movement of the solar terminator (STE) causes generation of acoustic-gravity waves (AGW), turbulence and instabilities in the ionospheric plasma. These effects depend substantially on solar and geomagnetic activities, point of observation, season, etc. The great variety of STE-linked phenomena in the atmosphere and stratosphere gave rise to a number of studies on the analysis of ionosphere parameter variations obtained by different methods f ionosphere sounding. However, virtually all experimental data have been obtained using indirect methods for the analysis of spectrum of ionosphere parameter variations, which can result from a number of factors. This makes difficulties for the reliable identification of AGWs, induced by STE motion. In our study, the direct experimental evidence for the generation of AGW by moving STE has first been obtained. We developed a method for mapping absolute (dI) and relative amplitudes (dI/I) of the total electron content (TEC) variations, filtered within 20–60 min corresponding to medium-scale (50–500 km) traveling ionospheric disturbances (MS TIDs), as deduced from data of the global GPS-receiver network.

The relative amplitude dI/I is determined by the dI normalization to the background I0 value, where I0 is the absolute vertical TEC, obtained with two-hour time resolution from the global TEC maps in the IONEX format. The analysis results are presented of the dI and dI/I global distribution probability for 110 days with different levels of solar and geomagnetic activities. It has been established that, when the morning STE travels through Europe and North America, the mean value of the dI/I variation intensity in the middle latitudes is almost an order of magnitude more than the background level and runs to 2–3%. This can be compared with the increase of the TEC variation amplitude during a magnetic storm main phase and corresponds to changes in the local electron density up to 5–7%.

Kelvin-Helmholtz instability in finite Larmor radius MHD and consequences at Venus

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By solving the magnetohydrodynamic (MHD) equations for a compressible plasma the Kelvin-Helmholtz instability is studied. The effect of the gyration of the ions (finite Larmor Radius (FLR) effect) is incorporated in the equation of motion in the form of the so-called gyroviscosity tensor, and a finite transition layer between two plasmas, across which the plasma properties change, is assumed. The transverse case, i.e., the magnetic field is perpendicular to the flow velocity, is considered. The results show that due to the consideration of the FLR the growth rate depends upon the relative configuration of the magnetic field: The growth rate is either larger or smaller than in the ideal MHD case.

Around Venus there exists a boundary layer between the magnetosheath and ionospheric plasma. Due to a velocity shear between these two plasmas, this boundary layer should be subject to the Kelvin-Helmholtz unstable. The different sides of such a boundary layer correspond to different magnetic field-velocity configurations. This means that the FLR effect introduces an asymmetry of the development of the Kelvin-Helmholtz instability such that it should develop more easily on one side of the boundary than on the other.

On the influence of cosmic rays on the secondary aerosols formation in the atmosphere

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Secondary aerosols in the atmosphere (sulfates, nitrates, etc.) are formed from the gases (sulfur dioxide, nitrogen oxide and dioxide, etc.) as a result of chemical and photochemical transformations. The presence of ozone and water vapor in the atmosphere contributes to the formation of secondary aerosols. These aerosols have high optical activity, possess condensation properties, influence on the biosphere, etc. As a result secondary aerosols exert a substantial influence on the local and global climate changes, ecological state of environment. Studies of the last years showed that the ionizing emission of radionuclides and cosmic rays can have an effect on the formation of these aerosols.

In this work the preliminary results of investigating the influence of cosmic radiation, surface ozone and air relative humidity on the formation of secondary aerosols in the atmosphere under the conditions of industrial city are represented. The data about the atmospheric aerosol optical depth (Y - the indicator of secondary aerosols), surface ozone content (X1), air relative humidity (X2) and intensity of galactic cosmic rays (X3) in Tbilisi are used. The period of observation is 1985 - 1989. 42 cases with the situation, which is favorable to the formation of smog ozone (wind speed to 1 m/s, cloudless weather, ozone concentration not less than 50 mg/cub m) are examined. The detailed statistical analysis of the indicated data is carried out. In particular the following results are obtained.

The direct correlation of values Y with X1, X2 and X3 is revealed. The equation of the multiple linear regression of connection Y with X1, X2 and X3 is obtained. In the limits of variation range the values Y changes are caused by the surface ozone content approximately to 40%, by the air relative humidity to 42% and by cosmic rays to 31%. In the limits of the standard deviation the values Y changes are caused by the surface ozone content to 16%, by the air relative humidity to 19% and by cosmic rays to 18%.

Thus cosmic radiation is one of the important factors in the formation of secondary aerosols in the atmosphere.

Conjugate observation of sharp dynamical boundary in the inner magnetosphere by Cluster and DMSP spacecraft and ground network

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We investigate an unusual sharp boundary separating two plasma populations (inner magnetospheric plasma with high fluxes of energetic particles and plasma sheet) observed by the Cluster quartet near its perigee on 2003/12/16. Cluster was in a pearl-on-string configuration at 05 MLT and mapped along magnetic field lines to ~8-9 R_E in the equatorial plane. It was conjugate to the MIRACLE network and the DMSP F16 spacecraft passed close to Cluster footpoint. The properties of the sharp boundary, repeatedly crossed 7 times by five spacecraft during ~10 minutes, are: (1) upward FAC sheet at the boundary with ~30 nA/m^2 current density at Cluster and ~2000 nA/m^2 at DMSP; (2) the boundary had an embedded layered structure with different thickness scales, the electron population transition was at ~20 km scale at Cluster (<7 km at DMSP), proton population had a scale ~100 km, while the FAC sheet thickness was estimated to be ~500 km at Cluster (~100 km at DMSP); (3) the boundary propagated in the earthward-eastward direction at ~8 km/s in situ (equatorward-eastward ~0.8 km/s in ionosphere), and then decelerated and/or stopped. We discuss the boundary formation by the collision of two different plasmas which may include dynamical three-dimensional field-aligned current loops.

Baric systems dynamics during Forbush-decreases of galactic cosmic rays

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Short-time effects of galactic cosmic ray (GCR) variations on baric system evolution at middle latitude of the North Atlantic were investigated. Noticeable pressure growth after sharp GCR intensity decreases (Forbush-decreases) was found, the maximum being observed at the 4th day after the event beginning over Scandinavia and the northern region of the European part of Russia. It is shown, that the detected pressure growth is caused by more intensive anticyclone formation in the region of climatic arctic front location. The found effects seem to be due to the changes of the thermo baric field structure at middle-high latitudes associated with the phenomena under consideration.

Instability of the current sheet and structure regions of reconnection

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Our theoretical work shows the possibility for developing of tearing perturbation in the thin anisotropic current sheet. The combined tearing and kink/sausage modes in such plasma equilibrium are investigated. Tearing and kink/sausage modes are low frequency ones and they propagate along two mutually perpendicular directions of developing. Thus tearing mode is the perturbation wave in the direction of a magnetic field, contrary, kink/sausage modes propagate along current direction. In this work the perturbation in intermediate direction (between tearing and kink modes) is investigated. It is found that growth rate of oblique modes depends from the direction of a wave propagation, and corresponding growth rate value is positive for majority modes. Therefore the different modes of perturbation can develop simultaneously in thin current sheet. This investigation makes possible to present central region of current sheet (where tearing mode destroys the magnetic lines) as the plane with different types of plasma perturbations.

Trigger mechanism of solar-atmospheric relationship and the contribution of the anthropogenic impact

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A unified approach is suggested to the problem of impact of both space and anthropogenic sources on the weather and climate changes. This impact is conducted by microwave ionospheric radiation with is generated both solar flares and by corpuscular precipitations from magnetosphere. Precipitations of electrons and proton fluxes from radiation belts take place during geomagnetic storms and also as result rocket launches, technological activity and at work of powerful radio transmitters and stations. Essentially new are the following two positions: 1) Taking into account generation in the terrestrial ionosphere of the microwave radiation which intensity rises during solar flares and geomagnetic storms. As a source of the microwave radiation we propose to consider the process of excitation of Rydberg states in atoms and molecules of the upper atmosphere gases by energetic ionospheric electrons namely photoelectrons, secondary electrons and Auger electrons. It was shown that at time of strong geomagnetic storm microwave radiation of ionosphere in Rydberg transitions might reach 10^{-11} W cm^{-2} and 10^{-100} times less at time of solar flare. 2) Taking into account Rydberg states excitation at the preliminary stages of association and dissociation of clusters (as well as ionized clusters) of water vapour and carbon dioxide. The rates of association and dissociation processes depend strongly on the magnitude of the Rydberg state orbital quantum number. An increase in the orbital quantum number by one results in a decrease of cross-sections of the dissociation processes by an order of magnitude. According to the developed theory this increase in the quantum number is caused by stimulated absorption of the ionospheric microwave radiation quanta as well as solar radiobursts radiation quanta during the periods of increased solar and geomagnetic activity (or anthropogenic precipitation impact). Thus we suggest three-stage radio-optical trigger mechanism for the influence of solar flares and geomagnetic storms on the weather characteristics. The first stage is an increase in generation of the microwave radiation which penetrates from the ionosphere to the earth surface. The second stage is a change in the proportion of water vapour to water clusters caused by increased microwave radiation. The third stage is a change of the atmosphere transparence in the absorption bands of water vapour and clusters. The atmosphere transparence determines the fluxes of solar irradiance coming down as well as flux of the thermal radiation coming out from the underlying surface. These fluxes form the basis of the thermal balance and affect the weather and climate characteristics of the lower atmosphere. The maximum of 200 years cycle solar activity was observed in eighties last century. Since 1985 the total solar irradiance and EUV/X-ray ionizing fluxes have been decreasing but geomagnetic activity (aa - index) has been going up till 2003 (+0.3% / year). Only during the last few years (on October 2007) geomagnetic activity also started decreasing (-5.7% / year). This means that negative trends have come both for solar and geomagnetic activities. We suppose that according to our mechanism the natural global climate changes will go down to lower levels.

Magnetometric spectra of auroral currents compared with the Doppler radar measurements

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Doppler radar measurements have revealed the enigmatic frequencies of 1.3, 1.9, 2.6, 3.2 – 3.4 and probably 0.6 – 0.8 mHz associated with the auroral activity. The frequencies are nearly invariant, i.e. repetitively observed at various independent events. The undertaken study applies the spectral analysis to the 10-second magneto-difference data obtained by the IMAGE magnetometer network. The proposed technique analyzes seven 4-hour events of high to very low activities of the auroral electrojet observed at the southward and northward IMF. Each selected event, except that of the lowest activity, displayed a quasi-stationary auroral arc, with its latitudinal position being retained within a narrow interval of latitudes. The magneto-difference data used consist of the differences between the meridional components of the magnetic fields detected by neighboring magnetometers of the meridional chain of instruments. These data extract the signals of near ionospheric currents and fairly eliminate the contributions of distant sources. The spectrograms show nearly equidistant harmonics. The power peaks of these harmonics indicate different frequencies varying from case to case, but the frequency distances between adjacent peaks tend to coincide with or closely approach the invariant frequencies revealed by the Doppler radar measurements. An important new feature is that the lower frequencies dominate at southward IMF while higher at northward. This fact indicates that the ULF signals observed at the auroral activity cannot be explained by the MHD resonances solely. The proposed explanation interprets the low-frequency harmonics as the spectra of the auroral currents generated by some rotating sources associated with the magnetospheric convection. The spectrograms display different harmonic spectra for different latitudes, thus indicating that there is a fine spatial structure of the currents in the auroral oval. The spectrograms obtained for the very low activity demonstrate a pattern that can be attributed to the MHD spectrum alone. Identifying such patterns in other spectrograms draws a conclusion that the ULF spectra in general contain the low-frequency harmonics of the intramagnetospheric sources and the MHD response to both internal and external sources. The author is grateful to the institutes maintaining the IMAGE Magnetometer Array. This work was supported by the RFBR grant 07-05-00104.

Surge-like auroral structures and quasi-periodic precipitations of energetic particles in the morning sector: a case study

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Relationship between series of surge-like auroral structures and quasi-periodic precipitations of energetic particles registered in the morning sector during 1900–2200 UT on November 8, 2004 is studied. This event has been analyzed on the basis of data from the all-sky TV camera and magnetometer at Tixie (71.6 N, 128.9 E), riometer station chain along 190 MM and measurements of energetic particle fluxes aboard geostationary LANL satellites. Surge-like auroral structures expanding 4 degrees in latitude appeared in the field-of-view of TV camera with a periodicity of 12–20 min and were accompanied by the intense geomagnetic pulsations in the Pi3 range and quasi-periodic oscillations in the riometer absorption. A peak to peak value of geomagnetic pulsations in H and Z components was $\sim$600 nT and exceeded the amplitude in D-component by factor of 3. It is found that variations of discrete aurora intensity in latitude one-to-one cor-

respond to quasi-periodic oscillations in the riometer absorption observed at Tixie and are in an antiphase to the riometer pulsations at more southern station Dzhardzhan (69.0 N, 124.2 E). The analysis of experimental data has shown that both surge-like structures and quasi-periodic oscillations in the riometer absorption have begun to be registered, when high-energy electrons injected during a substorm with the onset at ∼1837 UT reached the meridian of the observation (190 MM). Possible reasons of the relationship between surge-like structures, energetic particle precipitations and pulsations are discussed.

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Theta-aurora: topological aspect

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A possible mechanism responsible for the theta-aurora generation for nonzero IMF By is presented. Magnetic topology of the magnetospheric field during northward IMF allows us to explain the formation of theta auroras. A key role is played by the electric field potential drop between two magnetic nulls in vicinity of the magnetospheric cusps, where three-dimensional reconnection occurs for northward IMF. The transpolar arcs as well as the magnetospheric convection are driven by the solar wind electric field, thus they are connected with each other.

Solar-terrestrial physical phenomena and functional state of biosystems

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In this report are summarized findings of experiments carried out to elicit a fact the relation between solar-terrestrial physical phenomena and functional state of biosystems. For this aim the indices,

characterizing the physical processes from solar activity (SA) to variations of geocosmical agents on the Earth's surface, were picked out. They were included: number of sunspots (R); X-rays 1-8A; velocity (V) of solar wind (SW); the density of particles (N) in SW and solar protons with energy 100 Mev; the sector structure signs and strength of interplanetary magnetic field (IMF); indices of planetary geomagnetic activity (Kp, Dst); the data on the fluxes of nuclear-active particles in the near Earth's space, which could generate the secondary cosmic radiation near the Earth's surface at the latitude of experiments (α–particles with energy range 630-850 MeV and 850 MeV, as well as proton data with energies 850, 640 - 850, 480 – 640); regional and local variations of uncorrected (uncor) and corrected on the atmospheric pressure of the neutron count rates, atmospheric pressure; indices of local variations of the H-component of the total geomagnetic field (GMF) and short-periodic oscillations (SPO) of the H-component. Detection of influence of geocosmical agents on biosystems were carried out on microflora, plants, cell cultures, peripheral blood and human organism. It was found that variations of GMF and secondary cosmic rays (CR) are principal agents on the Earth's surface for modulation of biosystem functional state.

In this connection, variations of secondary CR intensity actuate upon physic-chemical and cellular substances of biosystems, whereas variations of GMF — on separate organism systems, including functions of human brain. The significance of variations of CR for biosystems were found in experiments on cell cultures carried out during the great solar particle events coincided with an increase of solar high energetic particles in the near Earth's space and an increase of the neutron count rate near the Earth's surface in October 1989. The results of such experiments have demonstrated extraordinary phenomena, associated with destructions of genetic substancein the diverse cell cultures. Significance of CR for functional state of biosystems was found in the experiments on microflora growth and peripheral blood. It was revealed that growth of microbial population abruptly increase, when the intensity of CR has maximum value and GMF variations – minimum one. In the Solar cyclic activity such events are regularly observed in minimum of SA. Hence, that is the reason that influenza outbreaks and increase of diverse epidemics must be manifested in minimum of SA. The "geocosmical tropism" of the plant Maranta leuconeura "Fascinator" was revealed under study of leaf movements and variations of geocosmical agents. Dynamics of leaf movements had significant correlations with variations of GMF, neutron count rate near the Earth's surface and other agents, including the regular variations of the gravitational field under combined influence of the Sun and the Moon.

Under study of the relation of functional state of human brain with variation of geocosmical agents were revealed that the all examined psycoemotional reactions have depended on geocosmical agents. The increase of electric field intensity of solar wind (Esw) are correlated with increase of anxiety and psychopathic reactions, while the intensity of such state decrease under increase of Kp-index. The schizophrenic as well as psychopathic states increase under a raising of sunsport activity and increase of Bz-component of IMF. The all geoeffective agents, the parameters of which are associated with high level of geomagnetic activity on the earth's surface, have a positive manifestation in psychoemotional state and opposite when they associated with low level of geomagnetic activity. Direct significant correlations (p 0,05) were found between indices of geomagnetic activity and indices characterizing of hyper activation of immune system. Our findings have allowed suggest the following mechanisms for modulation of biosystem functional state: 1) alterative regulation by GMF variations and neutron intensity near the Earth's surface, when the one in a two component has maximum value and other — minimum value, 2) complementary (additional) regulation, when the values of the GMF variations and neutron intensity near the Earth's surface reciprocally supplement each other, 3) prevalent regulation by GMF variations or neutron intensity near the Earth's surface, when the one in a two component has predominant significance over other. By this means, the byosystem functional state is modulated by "dose" ratio of actuate agents, where the GMF variations and the secondary component of CR execute the principal role. The net result of exposure of these agents on biosystems is determined by the sensitiveness of different systems to predominant impact of electromagnetic or nucleon components near the Earth's surface. Relative contribution of each agents in common process of the biosystem functional state modulation are determined by "dose" ratio of GMA, intensity of nucleon component, biosystem functional activity. IMF, as global agent, modulates the GMF variations and intensity of secondary nucleon component of CR on the Earth's surface, and hence, it modulates the bioeffectiveness of the GMF variations and the secondary CR in the each span. SA and associated geocosmical agents (N, V, X-rays and etc.) are indicators of events, which will realized on the Earth's surface and which will directly impact on biosystems, by cooperative influence of GMF variations and CR. In such a manner the biosystem functional state are modulated by cooperative influence of the GMF variations and CR, and in its turn are modulated by global geocosmical agents associated with SA . The research was supported by Grant "Fundamental Sciences to Medicine", 2008.

New results of solar activity and magnetic field on the Sun (review)

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For the last decade the solar space missions (Yohkoh, Coronas, Ulysses, SOHO) make a progress in the investigations of the solar activity in Photosphere, Corona and Solar wind. The Hinode and Stereo space labs continue the progress of previous missions and extend our knowledge about the solar activity, an evolution of vector magnetic field, a structure of photosphere, chromosphere and corona. Upcoming Solar Dynamics Observatory will investigate the vector magnetic field, corona and solar irradiance with a purpose to understand the nature of the solar cycle on the base of the high-resolution images. In this presentation, I review the recent and most important results of the investigation of the solar activity from the interior to the corona and their relationship to the dynamo theory.

Variations of ionospheric critical frequency before substorms

Blagoveshchensky, D.V., Kalishin, A.S. (St. Petersburg university of aerospace instrumentation, St. Petersburg, 190000, Russia)

In this paper, the main attention will be given to the Earth's ionosphere processes preceding to the onset of the active phase of an isolated substorm (moment To), in particular, to positive enhancements of the critical frequency foF2 (deltafoF20) 6–8 hours before To which have been observed by ionosondes in Europe irrespective of the polarity of substorms (positive or negative). Results of such analysis can be useful and important for development of algorithms of substorm onset forecasting with 2–3 hours ahead To. It is very necessary for problems of wave propagation, space weather and so on. The following results can be formulated from the studies. It was shown that mechanisms of electron concentration variations in the ionospheric F-layer during all three phases of isolated substorms are different in middle and high latitudes. At high latitudes, these variations are rather connected with winds in the atmosphere and specific features of the polar ionosphere (auroral electrojets, particle precipitation and so on). At middle latitudes, electric fields of the magnetospheric origin have a dominant role. Mechanisms of ΔfoF2 variations for positive and negative substorms are different too, especially at high latitudes. These mechanisms are distinguished for the day-time and night conditions in the case of a substorm with the same polarity. Little-known mechanisms of formation of ΔfoF2 ionospheric positive peaks during 6–8 hours before To (onset of the expansion phase of an isolated substorm) are considered in details. They are connected with an impact of the high-speed particles in the foreshock region of solar wind on the Earth's magnetosphere. Here, the main feature is an entirely other channel of solar wind penetration in the ionosphere. This channel realizes the transmission of energy through the entry layer into the inner magnetosphere and through the day-time cusp into the ionosphere as distinct from the classical channel which describes all three substorm phases, namely, through the magnetospheric tail, plasma sheet and auroral ionosphere. The ionospheric effect due to cusp and magnetospheric entry layer manifests most likely at high latitudes (polar cap and auroral oval). Enhancement of ΔfoF2 values can be used for prediction of the ionospheric disturbance onset and accordingly of space weather problems, radio propagation and so on. Substorm effects in the ionosphere are observed along the lengthy intervals of geomagnetic latitudes and longitudes on all territory of Europe and Western Asia. It was shown from the morphology point of view, there is no principled difference in influence on ionosphere the geomagnetic storms or substorms. However, fulfilled estimations and discovered regularities in this paper are not final ones. It is necessary to carry out some additional investigations and comparisons of experimental data with theoretical models in the future.

Size and location of the auroral oval equatorial boundary

Bobrovnikov, S.Yu. (Moscow State University, Moscow, Russia)

The method of auroral oval equatorial boundary determination on the basis of Polar UVI data is presented. In corrected geomagnetic coordinates (CGM) this boundary was considered as a circle. To obtain the parameters of the circle mathematical formalism and programming code have been developed. Series of calculations have been carried out for the different level of geomagnetic activity and the capacity of the original data. Benefits and disadvantages of the method has been discussed.

Reconstrunction of the heliospheric current sheet

Budnik, A.I., Ponyavin D.I. (Institute of Physics, St. Petersburg State University, Russia)

A new model for reconstruction of the Heliospheric Current Sheet based on kinematical approach was developed. We use synoptic maps as boundary condition for our simulations. To verify the model and to perform some analysis of accuracy benchmarks based on mapping back technique using Ulysses and ACE data were performed. This revealed some problems which originate from quality of input data and model approximations. Some improvements have been done based on this analysis. Moreover we were able to understand what parameters like differential rotation, solar wind dynamics (acceleration of plasma) or synoptic charts artifacts influence more.

Diversity of severe space weather effects on middle latitude ionosphere

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Severe space weather effects on the Earth's environment are studied for their basic science value as well as for their crucial practical impact on human technological systems. Increased dissipation of solar wind energy in the near-Earth environment is a significant source of consequent perturbations in the upper atmosphere and ionosphere. Adverse stormy conditions can cause disruption of satellite operation, navigation, degradation of radio communications, leading to significant economic losses. Current understanding of the ionospheric response to severe space weather-induced magnetic storms has been

obtained through different observations, modelling and theoretical studies. As long as variations in the ionosphere are related in regular patterns, ionospheric models, e.g. the IRI model, sufficiently estimate corrections for the ionospheric effects on radio wave propagation. During a magnetic storm variability of the ionospheric parameters increases substantially and makes forecasting more complicated. In the present study we report observational results of strong-to-severe ionospheric storms that occurred in the period 1995-2005 over middle latitudes. A statistical picture of the occurrence of negative and positive phases during analysed stormy period show that the changeover from one type of the effects to the other is more common for winter than for summer, and the occurrence of such behaviour increases with decreasing latitude. We examine these storms in some details, focusing on when they occur, on ionospheric height profile of their effects, similarities and unexpected differences in their morphology. Presented results show that there are still problems unsolved, like occasional enhancements of F2 region peak electron density before the onset of magnetic storms, or forecasting of an alternation of the sign of the storm effect within stormy period over middle latitudes.

The complex diagnostic far rocket launches disturbed ionospheric plasma

Burmaka, V.P. (Institute of the Ionosphere, NASU and MESU, Ukraine); Chernogor, L.F. (Kharkov V.Karazin National University, Ukraine)

The large-scale disturbances in ionospheric plasma were produced space vehicles launches from Baikonur cosmodrom used experimental research results by incoherent scatter technique was analyzed. It is received in height range ∼100–600 km height–time dependencies of main plasma parameters (electron density N, electron and ion temperature $T_{e,i}$). It is shown the space vehicles launches and flying are accompanying wave-like disturbances (WLD) generation as N as T_e and T_i. It is found WLD relative amplitudes usually are 0.03–0.10, the oscillation period are 20–60 min. The N, T_e and T_i oscillations were lagging each other. The WLD propagation velocities are ∼0.5–0.6 and 1.5–2 km/s. The modern spectral analysis techniques for WLD parameters estimation, include wave-let analysis were applied.

Direction-finding of a rare phenomenon of a thunderstorm over Kamchatka on the registration data of VLF radiation

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A strong thunderstorm front passed over Kamchatka in August 2007. On August 27 strong thunderstorm discharges could be visually observed in Paratuka, Kamchatskiy krai. Visually observable thunderstorms are very rare in Kamchatka. This phenomenon is considered to occur 1-2 times a year. Moreover it is difficult to locate this phenomenon. In the region during thunderstorm formation and during its visual observation the registration of thunderstorm discharges was carried out by VLF-direction-finder in Paratunka. Hour dependence of thunderstorm discharges as well as azimuthal distribution is presented over the whole period of observation of thunderstorm activity. Comparison of direction-finding and meteorological characteristics was carried out. The analysis of thunderstorm dynamics according to the data of VLF radiation and meteorological parameters points to the fact that sudden change of wind direction entails the increase of quantity of thunderstorm discharges in a thunderstorm source.

Earth — atmosphere — geospace as an open dynamical nonlinear system

Chernogor, L.F. (V. Karazin Kharkiv National University, Kharkiv, 61077 Ukraine)

The Earth-atmosphere-ionosphere-magnetosphere (EAIM) system has been validated to be a complex open dissipative nonlinear dynamical system. The following main aspects of the system paradigm have been stated. 1) The Earth and the near-Earth environment constitute a unified system. It consists of subsystems, internal and external spheres. This study is concerned with the tectonosphere, atmosphere, ionosphere, and magnetosphere forming the TAIM system, and the ocean, atmosphere, ionosphere, and magnetosphere, forming the OAIM system, both of which form the EAIM system. The EAIM system has a hierarchical property. 2) The EAIMS constitutive parts interact between themselves via a myriad of various (direct, feedback,

positive, negative, and in combination with each other) mechanisms. 3) The EAIMS is an open system. Emissions, matter, energy are supplied from above and below, which give rise to entropy production. 4) The EAIMS is a dynamic system. Its parameters vary in space and time. Consequently, the system is governed by partial differential equations satisfying the initial and boundary conditions, which are known with finite errors. 5) The EAIMS is nonlinear, which is a consequence of the high-energy processes acting in it, and the nonlinearities, in turn, drive instabilities, produce irregularities, generate intense waves, etc. 6) The Earth and its envelopes have the property of self-developing, complicating, and self-organizing owing to the influx of energy, emissions, mass, etc. The main properties of the EAIM system include system's nonlinearity, self-development, randomness, and the appearance of triggering mechanisms for releasing energy with a triggering factor attaining $10^5 - 10^10$. The high-energy processes have been shown to be the cause of the complex processes acting in the EAIM system, to give rise to rearrangement of the character of subsystem coupling, and to energy buildup and release. It is important that the energy fluxes from above and below, as well as from anthropogenic sources can be commensurable. The basic principles of major processes acting in the TAIM and OAIM systems have been developed. Seismic sources and atmospheric processes affect the upper atmosphere, ionosphere, and magnetosphere via acoustic-gravity, electromagnetic, quasi-steady (electrical, magnetic) and particle precipitation channels. Wave processes play a special role in EAIM subsystem coupling. Active experiments have turned to be convenient and efficient tools for modeling subsystem coupling. Energetic electron precipitation at middle latitudes has been shown to be associated with the majority of highly variable processes operating in the EAIM system. Its fluxes can be of the order of $10^7 - 10^9$ $(\mathrm{m}^2)\mathrm{s}^{-1}$. The causative mechanisms for their precipitation have been revealed and validated. The system paradigm should become the basic principle of theory, method, and methodology in the studies of EAIM system, as a complex open dissipative nonlinear dynamical system.

Regional semi-empirical model of ionosphere based on the Kharkov incoherent scatter radar database

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Modeling of processes in geospace and space weather state are one of the most essential problems of the near-Earth medium investigations. Regional model of ionosphere based on the Kharkov incoherent scatter radar (ISR) database consists of two parts. Empirical part of model based on experimental data obtained with the Kharkov ISR during period 1997 – 2006 that is corresponding to the 23-rd solar activity cycle. This part of model allows calculating the main geospace parameters – electron density, electron and ion temperatures, and vertical component of plasma drift velocity. Theoretical part of model includes well-know theoretical relations and served for calculation of medium and dynamic process parameters. Parameters of neutral atmosphere calculated using the NRLMSISE-00 model. Results of theoretical modeling are values of heat and particle fluxe densities, input energy to electron gas as well as values of thermospheric winds, ion-electron and ion-neutral collision frequencies, heat conductivity and ambipolar diffusion tensors, plasma scale height. Modeling results of the ionospheric plasma parameters are presented in the tabular form. Each of the tables includes the diurnal ionospheric parameters variations for vernal and autumnal equinoxes, winter and summer solstices in the range height of 200 – 750 km. Dependence of ionospheric parameters on solar activity (SA) is determined by phase of SA cycle – minimum, maximum, descending and rising. Regional model is used for accurate definition of global models of ionosphere and for more accurate calculation of radio wave propagation conditions over the Central Europe region that allows decreasing transmission system power, improving noise immunity of radio communication, radiolocation and radio navigation facilities. Reduction of power inputs allows improving electromagnetic and ecological situation over the Central Europe.

Effects in the Ionosphere During the October 3, 2005 and March 29, 2006 Partial Solar Eclipses at Kharkov

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The observations during every solar eclipse allows revealing and making more accurate accompanied dynamic processes in geospace. These processes essentially influences on ionospheric radio wave propagation channel parameters (from VLF to UHF) and then on quality and accuracy of operating of different purpose radio-electronic systems. The aim of this study is analysis and modeling of effects in geospace accompanied two the October 3, 2005 and March 29, 2006 partial solar eclipses. The measurements have been carried out with the Kharkov incoherent scatter radar that is unique one in the Central Europe. Errors of obtained plasma parameters didn't exceed 1 – 10%. Solar eclipse of the October 3, 2005 at Kharkov was partial (about 24 %). It began at 08:36 UT and finished at 10:42 UT. Maximum phase of the solar eclipse was observed at 09:38 UT. Illumination of the surface and atmosphere decreased by a factor of 1.3. Nevertheless effects of the eclipse in variations of ionospheric parameters were registered sufficiently confidently. During the solar eclipse a decrease of 5 – 6% in the F2-layer peak electron density Nm and a decrease of 200 and 80 K in the electron and ion temperatures at the 410 km height were observed. The fractional density of hydrogen ions showed an increase by a factor of up to 2 in the 400 – 800 km altitude range and a decrease by a factor of up to 7 – 10 in the 900 – 1200 km altitude range. An increase in the downward plasma drift velocity Vz by near 20 m s^{-1} was registered in the 360 – 470 km altitude range. Solar eclipse of the March 29, 2006 also was partial (about 77.4%). Illumination of the surface decreased by a factor of up to 5. The eclipse at Kharkov has observed from 10:02 to 12:21 UT, maximum phase of the solar eclipse was at 11:12 UT. During this solar eclipse the critical frequency of the F2-layer decreased by 18%, electron density Nm decreased by 33% and the F2-layer peak height increased by 30 km. The electron temperature became approximately 150 – 300 K lower and ion temperature decreased by 100 – 200 K in the 210 – 490 km altitude range. The solar eclipse caused 25 – 20% an increase in the fractional density of hydrogen ions at altitudes of 900 – 1200 km. After eclipse onset the magnitude of downward velocity Vz showed an increase by about 50 m s^{-1} at the 490 km height. Detailed modeling of the accompanied dynamic processes in geospace plasma was also carried out.

Diurnal and seasonal dependences of parameters of wave disturbances in the mesosphere as inferred from Kharkiv MF radar data

Chernogor, L.F., Panasenko, S.V. (V. Karazin Kharkiv National University, Kharkiv, 61077 Ukraine)

The aim of this paper is to set out the results of studying parameters of wave disturbances (WDs) in the mesosphere with periods between 5 and 120 minutes, depending on the time of day and season. The observations were made by MF radar. The new techniques were suggested and developed for detecting WDs in the electron density and for estimating their relative amplitudes, periods, and durations. The techniques are based on the spectral analysis of time dependences of radio wave intensities. Both MF radar backscattered signals used in active radar observations and broadcasts of MF radio stations used in passive radar observations are analyzed. The MF radar observations were made during 2000 – 2008, including all times of the day and all seasons. The duration of continuous observations within a day was no less than 5 – 6 hr. The fine spectral structure of the processes under study has been determined by applying the wavelet analyses, the Fourier Transform with fixed window and the Fourier Transform with variable window (so called adaptive Fourier transform). Over the 300 hr of active radar data for ordinary and extraordinary polarizations were collected from 2 or 3 altitudes, and thus the total record duration exceeded 700 hr. Over the 400 hr of passive radar data were analyzed as well. The following main results have been obtained. 1. The results of radio measurements in the mesosphere showed that the WDs whose periods fall into the 5 – 120-min interval are observed during all times of the day and all seasons. 2. The distribution of relative amplitudes follows a near-Rayleigh law. The mean relative amplitude is equal to 2 – 4%. The WDs with maximum relative amplitudes of 10 – 15% are observed during individual time intervals. 3. The WDs do not show obvious seasonal variations. At the same time, their relative amplitudes tend to increase by 3 – 5% during nighttime. The adaptive Fourier Transform and the wavelet analysis have per-

mitted the high precision in localizing WDs in the time domain and in estimating the wave period, as well as in detecting characteristic features of oscillation relative amplitudes and periods. 4. The WDs observed can be divided into two groups. First, the WDs with 5 – 25 min period are observed occasionally. Their total duration does not exceed 20 – 45% of the total record duration. Such WDs can be attributed to local wave sources. Second, the WDs with periods of 30 to 120 min are present almost always. They are apparently associated with global processes occurring in the atmosphere at mid and high latitudes.

Upstream waves/turbulence and ground Pc3 pulsations: new look

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The turbulent magnetosheath (MSH) region between the bow shock (BS) and magnetopause is of special importance to the solar-terrestrial physics, because in fact the magnetosphere interacts not with the solar wind (SW) and IMF, but with the MSH. MSH turns out to be not merely a homogeneous turbulent layer, but a structured medium with complex dynamics determined both by interplanetary parameters and internal processes. Using the high-resolution magnetic and plasma data from Interball (IB) satellite, we have marked out several typical turbulent layers upon IB crossing of BS: (a) foreshock (FSH); (b) post-shock downstream the BS; (c) transitional region; and (d) inner MSH. According to the existing paradigm, the upstream waves in the FSH is the primary source of magnetospheric 3 pulsations. These waves supposedly transmit somehow through the turbulent MSH into the magnetosphere. In contrast to this view, we suggest that the actual source of Pc3 pulsations is not upstream waves, but a turbulence in the MSH. Analysis of simultaneous observations at both sides of the BS by IB and Geotail spacecraft shows that the MSH turbulence together with ground Pc3 pulsations are controlled by the IMF cone angle. Despite a limited number of the events considered we suppose that this hypothesis gives a possibility for a new look on the problem of ULF wave origin, and deserves a further validation.

Theory and modeling of ELF/VLF chorus emissions in the magnetosphere

Demekhov, A.G. (Institute of Applied Physics RAS, Nizhny Novgorod, Russia)

We discuss the theoretical model of generation of ELF/VLF chorus emissions in the Earth's magnetosphere, based on the backward wave oscillator (BWO) regime of the cyclotron interaction of electrons with whistler-mode waves, and compare the theoretical results with numerical simulations. The BWO regime is realized due to the absolute instability of whistler-mode waves in the near-equatorial region of the magnetosphere. For realistic fluxes of energetic particles, the instability of parallel-propagating whistler-mode waves can become absolute if a step-like distortion exists in the distribution function of energetic electrons. Both analytical estimates and numerical modeling allow us to reproduce the main features of chorus emissions, such as their typical amplitudes, characteristic size of the source region, temporal pattern as quasi-periodic or chaotic sequences of wave spikes, and frequency drift. The predictions of the model seem to be confirmed by recent analysis of both statistical and case studies of chorus properties based on data from Magion-5 and Cluster spacecraft. The magnetic-field inhomogeneity is significant for the generation regimes of whistler-mode waves. In particular, this inhomogeneity determines the size of chorus source region, and it ensures the preference for rising-tone emissions under typical magnetospheric conditions. The frequency variation in chorus emissions arises due to the combined effect of the adiabatic deceleration of electrons moving from the equator and nonlinear modification of the velocity distribution.

The Earth's magnetosphere as a cyclotron maser

Demekhov, A.G. (Institute of Applied Physics RAS, Nizhny Novgorod, Russia)

Pioneering work of Professor Victor Trakhtengerts who passed away in December 2007 is reviewed. He developed the deep physical analogy between the wave generation in space plasmas and in laboratory lasers and masers and fruitfully applied it to the theory of wave processes in the Earth's magnetosphere. On this basis, self-consistent models of many types of natural whistler-mode and ion-cyclotron electromagnetic emissions arising from resonant wave-particle interactions were elaborated. They explain quasi-stationary and quasi-periodic emissions, quantify the wave effects on radiation belts, and elucidate the origin of coherent waveforms under natural conditions.

Two dimensional model of magnetic field transition through the magnetospheric tail due to plasma stream in the plasma layer

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For the transition of magnetic field through the magnetospheric tail a two dimensional steady state model is developed. A kinematic MHD approach is used, in which the velocity and conductivity distributions are taken as given. The velocity distribution in the plasma layer is defined in accordance to satellite data.

A new mathematical formulation for the kinematic MHD model is introduced for a homogeneous conductor. A use of new potentials instead of the usual vector potential permits to set up a boundary value problem with a symmetric positive definite operator. The principle of energy minimum is valid for such a problem. Such a principle is used to invent an effective finite element method for numerical solution.

The magnetic field in the magnetospheric tail is calculated for different values of the effective electric conductivity of the plasma in the plasma layer. It is shown that the conductivity ought be in a narrow interval of values to give the magnetic field distribution that corresponds to the observed magnetic field.

Secular and large-scale changes in solar activity, cosmogenic isotopes and climate changes

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Presently, there is a grows body of evidence from a multi-proxy paleoclimate records that medium-lived (hundred years) and long-lived (millennial years) periodic climatic events have persisted during the last 10000 years, as for instance the well-known "little ice age" and cold episodes about 2800 cal yr BP separated by about 2400-year time interval. Ice rafted debris in marine cores of the north Atlantic, which are attributed to changes in the north Atlantic deep water formation and probably forced by changes in solar activity, demonstrated about 1500-year cycles. These Holocene climate oscillations rather appear to reflect atmospheric circulation variations, ice sheet fluctuations and oceanographic changes. It is well established that the production of cosmogenic isotopes, such as radiocarbon and beryllium-10, is modulated by solar activity and may thus serve as a proxy for solar activity changes. The radiocarbon and beryllium-10 signals from well-dated samples show similar trends during the last 10000 years. Removing the effects of the Earth's magnetic field from the measured radiocarbon concentration in tree-ring yields the residual radiocarbon signal, which potentially reflects changes in solar activity. As demonstrated by spectral analysis of sunspot numbers and reflected in the radiocarbon and beryllium-10 proxies, solar activity displays a cyclic behavior with short-time, secular and large-scale periodicities. Hence, if solar activity is the driving force behind climate changes, these cyclicities should be observable in climate records. Evidence of warm and cold periods and of cyclic climate variability connected with secular and large-scale changes in solar activity are demonstrated by this work. Large-scale climate changes recognized as global events suggest periodicities of about 2400 years. The observed 210-year climate periodicity corresponds to secular changes in solar activity, such as the Maunder or Spoerer minimum. Direct solar forcing may account for a significant amount of the climate variations observed during the Holocene. Two indirect mechanisms: the Sun's ultra violet radiation and changes in the solar winds, which affect cloud formation, may amplify the role of the Sun in Holocene climate variability.

Substorms associated with different structures in the solar wind

Despirak, I.V., Yahnin, A.G., Lubchich, A.A., Kozelov, B.V. (Polar Geophysical Institute, Apatity, Russia); Biernat, H.K. (Space Research Institute, Graz, Austria)

On the basis of data from WIND spacecraft we investigated the difference in the behavior of substorm development during different types of solar wind streams: recurrent solar wind streams (RS), co-rotating interaction regions (CIR), magnetic clouds (MC), and the region of interaction of magnetic clouds with undisturbed solar wind (Sheath). The RS/CIR (MC/Sheath) structures were examined for the period December, 1996 — June, 1997 (January – December, 2000). All available auroral substorms observed by the Ultra Violet Imager onboard the Polar spacecraft during these periods were studied. It is shown that substorm expansion behavior is different for these four types of the solar wind. The strongest auroral bulge expansions are found for CIR and Sheath situations. In contrast to substorms during RS, during MC the latitudinal expansion of the auroral bulge is less pronounced, but longitudinal expansion is stronger. We suggest that later feature is explained by different configuration of the near-Earth magnetotail during RS and MC.

Excitation of Alfvén vortices in the ionosphere by the magnetospheric convection

Despirak, I.V., Lubchich, A.A. (Polar Geophysical Institute, Apatity, Russia); Trakhtengerts, V.Y. (Institute of Applied Physics, Nizhny Novgorod, Russia)

Excitation of ULF waves is considered in Ionospheric Alfvén Resonator (IAR), taking into account an inhomogeneous altitude profile of velocity of the magnetospheric convection, formed by interaction of the convective flow with the neutral atmosphere at heights 90-150 km. ULF waves include oblique Alfvén waves, trapped in the IAR, and drift ionospheric waves, which are in a resonance with each other. These waves together form strongly anisotropic closed current loops with the scale along the magnetic field much greater than the transverse one and can be considered as Alfvén vortices. The analysis is performed in the model of the ionosphere close to the real one, without using additional restrictions on the value of the growth rate, wave frequency and wave vector orientation. Neither are restricted the magnitudes of the such parameters, as a convection velocity, ion-neutral collision rate on the lower boundary of the resonator, ratio of particle densities in the magnetosphere and in the maximum of ionospheric F-layer, and Alfvén velocity in the maximum of the F-layer. The instability threshold with respect to the convection velocity and the altitude of ionospheric lower boundary is found and the optimum conditions for instability growth are obtained. Some estimations are applied to the auroras observations in Lovozero.

Kinetic structure of the electron diffusion region of magnetic reconnection

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In our work we employ particle-in-cell simulation of plasma for the study of magnetic reconnection process. We explore details of the diffusive process inside dissipation region which breaks fields line. In the case of undriven two-dimensional collisionless simulation such diffusion is provided by electron pressure tensor. Far from X-point electrons follow magnetic field lines (gyrotropy); in the vicinity of X-point gyrotropy is lost and electrons behave non-adiabatically. To guarantee quasistatic dynamics of the reconnection process, open boundary conditions are implemented in simulation. Electron diffusion region (DR) is observed to be stretched well beyond electron scales up to 10s ion inertial lengths and holding the thickness of 1/2 ion inertial lengths, what displays little similarities with the picture of Hall-mediated reconnection sketched by Birn (2001). Embedding of electron current within ion current, and intense in-plane electric field are typical features of DR. Moreover, pressure anisotropy changes sign in internal and external electron DR.

The role of neutral gas heating and cooling on the formation of the day-time equatorial neutral density minimum

Doronina, E.N., Namgaladze, A.A. (Murmansk State Technical University, Murmansk, Russia)

In this work we continue the research of the problem of the total mass density minimum near the equator at the height of 400 km found out by the CHAMP satellite. We have investigated this phenomenon using the Upper Atmosphere Model (UAM). In the UAM the temperature of neutral gas is calculated by the solution of the heat balance equation. We have studied the influence of various mechanisms of heating and cooling of neutral gas on the formation of the day-time equatorial minimum of temperature and density. For that we have sequentially switched off the sources of heating and cooling: the Joule heating, solar UV and EUV radiations, heat of chemical reactions, magnetospheric sources of momentum and energy, and cooling by IR radiations. It has been found that these minimums are features of the tidal structure generated by the solar ionizing radiation and the rotation of the Earth.

Survey of near-Earth dipolarizations with THEMIS spacecraft

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The THEMIS orbit geometry provides a vast of observations in the near-equatorial near-Earth plasma sheet suitable to investigate the properties of dipolarizations and plasma injections. Surveying the first half of THEMIS tail season 2007-2008 with a support from ground-based and geosynchronous observations we study the physical processes taking place during the dipolarization events. Particularly we concentrate on answering the following questions:

1) What is the longitudinal relationship between the dipolarizations and substorm current wedge?

2) Are there systematic differences of pressure and specific entropy in the dippolarised plasma tube with the distance?

3) How are the particle injections to geostationary orbit connected with dipolarizations observed at further distance in the inner magnetosphere?

Low frequency current sheet oscillations related to magnetic field gradients

Erkaev, N.V. (Institute of Computational Modelling SB RAS, and also: Siberian Federal University, Krasnoyarsk, Russia); Semenov, V.S. (Saint Petersburg State University, Saint Petersburg, Russia)

In a framework of one-fluid MHD approach, oscillations and instability of a current sheet are considered, which appears in a presence of a gradient of the normal magnetic field component. This type of oscillations is associated with the so called "flapping" waves, observed in the magnetotail current sheet. Solutions are found for different model profiles of electric current and particle densities across the current sheet. The obtained dispersion dependencies indicate the current sheet to be stable in the regions, where the normal magnetic field component (B_z) increases towards the Earth. And the current sheet can be unstable in the regions, where the B_z component increases outwards from the Earth. For a given electric current profile and a constant plasma density, the flapping frequency (or growth rate) is always less than those for a nonconstant plasma density with the same current profile. The wave group velocity depends very strongly on the behavior of the electric current velocity across the sheet. The group velocity is larger when the current velocity variation is stronger pronounced within the current sheet. The obtained dispersion function is used for calculation of the wave disturbances induced by the initial perturbation localized to the center of the current sheet. The calculated wave perturbations propagate to the flanks of the sheet in both directions. Typically they have a smooth, gradual front and an oscillating backside part, because the short wave harmonics propagate much slower than the long wave ones.

Location of proton precipitation during substorm: digital revision of data observed by cameras C-180-S

Evlashin, L.S., Kozelov, B.V., Kozelova. T.V. (Polar Geophysical Institute, Apatity, Murmansk region, 184209 Russia)

We apply the up-to-date digital technology to data of unique spectrometric observations of aurora by cameras C-180-S with registration at the photo tape. The observations were performed in 1970 at the Kola Peninsula (obs. Loparskaya) and Karelia (obs. Kem). The

location and dynamics of the proton precipitations relative to other auroral phenomena (discrete auroral arcs, diffuse aurora, electrojets) have been analyzed. The events corresponded to slow and moderate magnetic disturbances have been considered. Some of known features of the proton aurora have been supported. We found also that motion of the evening proton arc changes its direction with changing of the sign of the z-component of IMF.

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Compressional ULF mode at low altitudes: two mechanisms of generation

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The recent satellite observations (Orsted, CHAMP, ST-5) found the compressional component of the satellite magnetic field data, simultaneously with the H component disturbances on the ground.

The following possibilities of the ULF compressional generation are considered:

– the incident Alfvén wave upon interaction with the anisotropically conducting ionosphere generates an evanescent fast compressional mode;

– the transportation of the ULF wave energy from a distant source to the ionosphere predominantly occurs by a fast compressional mode. We estimate quantitatively the expected relationship between the Pc3 wave magnetic components above the ionosphere and on the ground produced by different mechanisms. The results of this model are applied to the interpretation of the satellite observations of Pc3 waves in the upper ionosphere and by mid-latitude ground stations.

Evolution and structure of current sheets in laboratory experiments

Frank, A.G. (A.M. Prokhorov Institute of General Physics of the Russian Academy of Sciences)

It is reasonable to suppose or even it is directly observed that current sheets (CS) are of a frequent occurrence at many astrophysical objects, such as the atmospheres of the Sun and stars, the magnetospheres of the Earth and planets. Evolution of CS can form a basis for the flare-type phenomena like solar flares and magnetospheric substorms. Studying of formation, evolution, and possible disruption of CS in the special laboratory experiments can shed light upon the physical processes, which are responsible for many events in space plasmas. In a context of laboratory modelling of astrophysical phenomena, we report the results on observations of the CS formation in a variety of 3D magnetic configurations. Effective plasma compression takes place in the presence of a strong magnetic field component aligned with the X-line. It was revealed earlier that CS can be rather stable; specifically the tearing-mode instability has no pronounced effect on the CS dynamics. The metastable CS should be treated as a pre-flare situation, while the flare itself is associated with a fast destruction of CS. Really, principal features of the flare phenomena: rapid change in the magnetic field topology, intense plasma heating, generation of plasma flows, bursts of accelerated electrons, have been observed in the course of disruption of the laboratory produced CS. Interrupting the metastable stage is usually triggered by formation of a magnetic island inside CS and super-fast increase in the thermal plasma energy, so that the CS transverse equilibrium is broken down. Experimental results lead us to the conclusion that CS formation, which can be followed by its explosive disruption, represents the necessary condition for realization of flare-type events, including gradual accumulation of magnetic energy, its fast release, plasma heating, mass ejection, and acceleration of charged particles.

Test of the OMNI data base for interplanetary discontinuities

Glotova, N.A., Shukhtina, M.A. (St.Petersburg State University, St.Petersburg, Russia)

In order to study the solar wind - magnetosphere interaction it is necessary to determine the time, when the structures, registered at a distance of 100-200 Re from Earth, come to the magnetopause. Until recently, the solar wind parameters were usually transferred by convection time dt = dx / Vsw, implying that the front of the structures is perpendicular to the Sun-Earth line and moves with the solar wind. However the discontinuity normals, as well as the normals to the solar wind phase fronts, are often tilted to the Sun-Earth line. Recently the OMNI data base (http://omniweb.gsfc.nasa.gov), was created. This base contains solar wind /IMF parameters, transferred to the Earth bow shock, taking into account phase front orientation. This base is created for smooth variations of solar wind parameters. The purpose of our work is to test the base OMNI for interplanetary discontinuities, using ground observations. We study the response time of the ground SYM-index to solar wind dynamic pressure (Pd) jumps, recorded by remote (100-200Re) spacecraft and transferred to BS according to OMNI and by convection time. Pd jumps can correspond to 2 types of discontinuities: tangential (TD) , and interplanetary shocks (IS). Time delays between Pd jumps, (1)taken from OMNI and (2)transferred by convection, and jumps of ground SYM- index (SIs), were studied separately for TDs and ISs. 66 SYM jumps, corresponding to 28 TDs and 38 ISs, were analyzed. Preliminary results are as follows: According to OMNI, TDs come to the bow shock on average 4 min before SIs on the ground. For convection translation the average delays are also 4 min, but the scatter is larger. Thus the OMNI procedure is better compared to the convection one. As for shocks, both OMNI and convection methods give unrealistic results: according to them, on average the Pd jumps come to the bow shock 4 min (OMNI) and 9 min (convection) after the ground Sis. We conclude, that the OMNI data base is good for TDs and can not be used for shocks.

The middle latitude D-region of the ionosphere response to the strongest Solar X-flares

Gokov, A.M., Tyrnov, O.F. (V. Karazin Kharkiv National University, Kharkiv, Ukraine)

In [Gokov A.M., Tyrnov O.F., Chernogor L.F. Experimental investigations by the partial reflection method of response of the middle latitude D-region of the ionosphere on the X-ray and optical flares. Space science and technology, 2005, v.11, p.56] the reaction of the middle latitude D-region of the ionosphere to the small and middle intensity Solar X-flares (classes C and M) is considered. In this report the results of experimental investigations by the method of partial reflections (PR) of the influence of strongest Solar X-flares (of class) on characteristics of radionoises, PR-signals (on frequencies of 2,3–2,4 MHz) and on the parameters of the middle latitude D-region are adduced . The probing of the ionospheric D-region was performed with the Kharkiv V. Karazin National University MF radar located at the Kharkiv V. Karazin National University Radio-Physical observatory (geographic coordinates: latitude = 49° 38'N, longitude = 36°20'E, elevation -156 m, inclination -66°36.8', declination -6°19.6', L$\sim$2.0) in the period of 4 X-flares: 10.11.2004 (01.59-02.13(max)-02.20 UT, 2.5), 17.01.2005 (06.59–09.52(max)-10.07 UT, 3.8), 19.01.2005 (08.03–08.22 (max)–08.40 UT, 1.8), 20.01.2005 (06.36-07.01 (max)-07.26 UT, 7.1). The measurements of the amplitudes of signal plus noise and of noise amplitudes of the ordinary and extraordinary polarizations were made within an altitude range of 60–126 km. The duration of observations was ten of minutes–hours both before and after the flares. The N(z) profiles were estimated over intervals of 5–10 min during the entire observation period with an error of not more than 30%. The experimental data analysis showed that for the considered events take place characteristic features both in variations of the PR signals and radionoises and in height-temporal variations of the electron density. On the whole they, mainly, have the same type and character, as well as the features set in work by Gokov et al. for the flares of less intensity, but they more expressed. In the report the basic features of variations of characteristics of radionoises, PR-signals and electron density in periods of strong X-flares is discussed. The calculations of changes of the ionization rate are made. The results of investigations are compared with data obtained in the undisturbed conditions and during the flares of less intensity (classes C and M). Basic differences and features are analyzed.

Scaling behavior of auroral and electric field fluctuations under substorm conditions

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A quantitative comparison is performed between the scaling properties of auroral luminosity fluctuations observed by the Auroral Large Imaging System (ALIS) and of small-scale electric fields detected by the Dynamics Explorer 2 satellite, both under substorm conditions. The ALIS images were obtained within $\pm 17°$ from magnetic zenith, which allowed investigation of auroral fluctuations at scales from 6.4 to 51.2 km. The narrow field of view intended to decrease the contamination from aspect angle broadening which leads to distortions of scaling characteristics in the horizontal plane. We compared the logscale diagrams (LDs) constructed by discrete wavelet transform of the data as well as the behavior vs. scale of standard deviation, kurtosis, and probability density functions (PDFs) of the two kinds of fluctuations. It is shown that in spite of obvious similarity, the scaling features, signifying the presence of a turbulent cascade of energy from larger to small scales, are better pronounced for substorm electric fields than for auroral fluctuations. This manifests in a more leptokurtic shape of the PDFs, larger values of kurtosis and its more rapid growth with decreasing scale in the case of electric fields.

Comparison of different methods of tail magnetic flux calculation

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One of the basic parameters, characterizing the state and dynamics of the Earth magnetosphere, is the magnetotail magnetic flux F. However, until recently only rare estimates of the F value were available. Petrinec and Russell (1996) proposed a method of magnetic flux calculation, based on measured tail lobe magnetic field and the magnetotail radius R value, calculated by model formulas, depending on the solar wind dynamic pressure and IMF Bz. However, the

same solar wind conditions may result in different magnetospheric states and, so, in different R values. Thus we propose an empirical method of R calculation, not using model formulas, but based on pressure balance on magnetopause. Recently global MHD modeling of magnetosphere became possible. It gives the opportunity to determine the magnetopause position (i.e. the R value), the tail magnetic field and, finally, the magnetotail magnetic flux. In the present study we compute magnetic flux for several simulated events. To determine the magnetopause, we compare three different methods, based on: 1) density gradient, 2) current density peak, and 3) fluopause, which is the surface of the boundary solar wind streamlines. All three methods demonstrate a good mutual agreement. Several simulated events (including substorms) are computed using MHD modeling and our empirical method. The results of two methods reasonably agree. Polar cap images from Polar and IMAGE spacecraft allow determine the polar cap area, i.e. the polar cap magnetic flux. The F value, obtained from polar cap photos in several events (including steady magnetospheric convection, substorms and sawtooth events), are compared with our prediction and show similar behavior, though the values differ. Each method has its drawbacks, which should be analyzed. In conclusion, all three methods demonstrate comparable results. It opens the opportunity of using these methods to monitor the tail magnetic flux on the regular basis, which is important for monitoring of the magnetosphere.

On solar MHD strong discontinuities interactions with bow shock - magnetopause system

Grib, S.A. (Pulkovo Observatory, St. Petersburg, Russia)

Different types of the interactions of the tangential discontinuities and fast shock waves of the solar wind with the bow shock and the terrestrial magnetopause are studied in the frame of the MHD splitting of an arbitrary discontinuity. It is shown that the solar wind tangential discontinuity with the increase of the proton density across it often gives the source for the appearance of the fast shock wave inside the magnetosheath and the magnetosphere of the Earth. The oblique fast shock wave interaction with the bow shock wave in many ways has dawn-dusk asymmetry affecting not only the sheath but also the magnetosphere of the Earth.The specific oblique case of the discontinuities interaction is one creating slow shock waves which may disappear due to the damping of Landau.The existence of the dissipative shock waves refracted inside the magnetosphere and the reflected from the magnetopause fast rarefaction waves is underlined for the solar shock waves colliding with the bow shock-magnetopause system. The obtained results are discussed in the frame of the in situ space data. The work is done with the support of the OFN–16 program.

Influence of secondary rarefaction wave on the development of Pc5 pulsations

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Belakhovsky, V.B. (Polar Geophysical Institute, Apatity)

It is known that the arrival of interplanetary fast shock wave to the Earth's magnetosphere causes SC event and development of Pc5 geomagnetic pulsations. Cavity mode may be responsible for the generation of Pc5 pulsations. It is formed by magnetopause, conjugate ionospheres and turning point (plasmapause). Frequency of pulsations depends on dimensions of this cavity and Alfven velocity. It was [Grib et al., 1979] shown that during the interaction of interplanetary shock with the bow shock-magnetopause system a secondary rarefaction wave in the magnetosheath will arise both for a rarefaction and a shock wave reflected from the magnetopause. This secondary rarefaction wave forces magnetopause to move in sunward direction. So dimensions of the cavity will increase and frequency of pulsations will decrease.

Real-time assessment of geomagnetic activity based on magnetic field measurement of CHAMP satellite

Gromova, L.I., Dremukhina, L.A., Levitin, A.E., Avdeeva, E.G. (Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, Troitsk)

The negative effect of Space weather on cosmic and ground-based technical systems can be weakened by using the real-time assessment of geomagnetic activity. The magnetic field measurements by low-orbiting satellites and modern magnetospheric magnetic field models may be used for real-time monitoring of the geomagnetic field and, as a result, the geomagnetic activity state. In our idea, satellite data of the magnetic field module and/or its components measured along each orbit (or any of its segments) should be compared with a magnetic field model for some external conditions. External conditions are to be arranged into groups according to geomagnetic activity states (quiet, weakly disturbed, disturbed, strongly disturbed conditions) which have been parameterized by Solar Wind/Interplanetary Magnetic Field and/or indices of geomagnetic activity according to the magnetospheric magnetic field model input. Model magnetic field calculated for all points of the satellite pass (or for chosen segments of the pass) for each geomagnetic activity state is compared with real-time satellite measurements. The geomagnetic activity state is chosen as "right" if it gives the best agreement of the observed data with a model. Some results of using the magnetic field measurements of CHAMP satellite and modern models of the magnetospheric magnetic field (Paraboloid model and Tsyganenko's model T96) for real-time monitoring of the geomagnetic activity states are presented. This work is supported by RFFI grants 06-05-64329, 08-05-00896.

On a new parameter of space weather and topology of the Earth's magnetosphere based on the form factor of the incoming solar wind particle velocity distribution function

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Space weather is at the beginning of a long chain of the electromagnetic events connecting the state of solar wind (SW) plasma with the state of the magnetosphere and finished by the state of the electrojet formed in the Earth atmosphere/ionosphere. Space weather is characterized by a limited set of geoeffective dimensionless parameters (indexes), which are determined from theory or observations as functions of the incoming SW plasma parameters: plasma concentration, flow velocity, temperature of the species, magnetic field orientation and form factor of the particle velocity distribution function (VDF) that we proposed here. We consider the physical parameters in dimensionless form as the result of theoretical analysis of the 3D global classical Chapman–Ferraro problem (CFP) where unmagnetized plasma flow inductively interacts with the resting magnetic

dipole. As a result, we obtain the 3D magnetosphere topology with a tail, magnetopause and the energy/pulse exchange with the SW flow. There are a phenomenological traditional MHD approach for the CFP with fluid-like incoming plasma flow and a more realistic kinetic approach to the CFP developed here and taking into account the VDF form factor to describe the incoming hot collisionless plasma flow. In the MHD approach for the CFP, the only dimensionless parameter for the incoming unmagnetized flow is the Mach number M which characterizes the formation of the electrostatic in nature shock wave part of the magnetosphere structure. The M number is not so sensitive to the choice between MHD and kinetic approaches for the plasma. The electromagnetic part of the magnetosphere structures (magnetopause and magnetotail) with large spatial scales of non-MHD nature are determined by dimensionless parameter G of the incoming SW flow. Parameter G is the ratio of the large-scale diamagnetic current to the resistive current in magnetosphere plasma and G is much more sensitive to the choice between MHD and kinetics. This parameter is determined by the kinetic effects of the moving plasma and depends on the VDF form factor. Calculations of G in the kinetic CFP are based on simplification of the nonlinearity by division of plasma particles into the "flyby" group forming a moving media and on the "trapped" group forming the resting magnetization. Parameter G that we introduced here is a new parameter of space weather, and it is related to the properties of the kinetic inductive electromagnetic mode of a hot collisionless moving plasma formed by the "flyby particles". Namely we find that parameter G governs the topology of the electromagnetic part of the structure: we get the adiabatic/bifurcation transition with return from the resistive state G1 — a long magnetic tail after reconnection to the diamagnetic dipolized compact state G1 which can explain in a new way the effects of the magnetic substorm. Parameter G is the ratio of the "pulse anisotropy" determined by flow of resonant particles, to the "energy anisotropy" determined by flow of non-resonant particles. The dimensionless parameter G as a function of the form factor of the VDF of the incoming flow can be rewritten via the ratio of the squared anomalous skin scale to the squared magnetic Debye scale. There are induced by the SW flow new dispersion scales in a plasma.

On the anharmonicity of ULF geoelectromagnetic waves

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The waves produced by plasma instabilities in many regions of space are inevitably nonlinear. A common property of the nonlinear waves is the appearance of time-averaged ponderomotive forces providing a specific nonlinear mechanism of the wave-particle interaction. In particular this results in the anharmonicity of the waves. The report is devoted to the relevant tasks, disputable issues, and unsettled problems related to the anharmonicity of the ULF waves. The relation between the theory and observations is emphasized. Two new methods for analyzing ULF wave data are presented. It is inferred that progress in the theoretical investigation of ponderomotive interplay between the waves and particles does not eliminate the necessity for careful study of unsolved problems posed in the past. As an example, we refer to the problem of the "gigantic" anharmonicity of the standing Alfven waves. The prolonged existence of unsolved problems of such sort is undesirable because it is a challenge to our capability for understanding the space physics. The work was supported by RFBR grants 06-05-64143 and 07-05-00696.

Stellar wind and magnetospheric parameters around the exoplanet HD 209458b

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Absorption in the stellar Lyman-alpha line observed during the transit of the extrasolar planet HD 209458b reveals high velocity atomic hydrogen at great distances from the planet. This has been interpreted as hydrogen atoms escaping from the exosphere of the planet, possibly undergoing hydrodynamic blow-off, being accelerated

by stellar radiation pressure. However, around solar system planets the production of energetic neutral atoms from charge exchange between solar wind protons and neutral hydrogen from the exospheres has been observed, and should also occur at extrasolar planets. Here we show that the measured transit-associated Lyman-alpha absorption can be explained by the interaction between the exosphere of HD 209458b and the stellar wind. This is the first observation of energetic neutral atoms outside the solar system and the presented method provides a completely new way of probing stellar wind and magnetospheric parameters at exoplanets.

Effects in the auroral ionosphere under the interaction of the Earth's magnetosphere with different solar wind streams

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Effects in the ionospheric E- and F-regions as a result of the interaction of the Earth's magnetosphere with the non-stationary solar wind streams (the edge of the high speed streams from the coronal holes, the magnetic clouds and the interplanetary shocks) have been studied. The ionospheric characteristics (the deviation of critical frequency in the region F2 from the undisturbed level - ΔfoF2 and the blanketing frequency fbEs) have been considered in the night oval using the Loparskaja observatory data. We have investigated the relations of these ionospheric characteristics with the solar wind parameters (the density n and the electric field E_y). It is shown, that for every type of the solar wind streams the parameters of the ionosphere disturbance are the superposition of the functions of E_y and n. This result shows the role of the main geoeffective parameters of the solar wind in the ionization of different ionospheric regions.

Response of the aurorae at subauroral latitudes to sudden increases of the southward IMF, solar wind dynamic pressure and substorms

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It is well known that a persistent southward Interplanetary Magnetic Field (IMF) produces increased geomagnetic activity. Recent studies of ionospheric convection have shown that sudden enhancements in solar wind dynamic pressure have significant effect on the transpolar potential and the coupling efficiency between the solar wind and the terrestrial magnetosphere (Boudouridis et al., 2005). The observations of the diffuse aurora (DA) and stable auroral red (SAR) arc are the informative investigation method of dynamic processes in the vicinity of plasmapause and inner boundary of the plasma sheet during magnetospheric disturbances. SAR arcs are the consequence of interaction of the outer plasmasphere (plasmapause) with energetic ions of the ring current. The DA is caused by the low-energy electron precipitation from the plasma sheet. During substorms we observe the intensity increase of DA and its equatorward extension up to the plasmapause projection that is mapped by the SAR arc occurring at that time (Ievenko, 1999).

In this report we present the new study results of the DA and SAR arc dynamics based on spectrophotometric observations at the Yakutsk meridian (199° E geomagnetic longitude). For individual events the relationship of equatorward extension of the DA in the 557,7 nm emission to the magnetospheric convection intensification after the turn of IMF B_z to the south is shown. The longitudinal dynamics of SAR arc formation during the substorm expansion phase is investigated. The connection of SAR arc occurrence with the substorm injection by the geosynchronous measurements during the main phase of a storm is analyzed. The fast shift of the aurora towards the subauroral latitudes during abrupt increases of the solar wind density up to 30 cm^{-3} is revealed for events, when the dawn-dusk e_y of the interplanetary electric field remains approximately constant. It is assumed that this phenomenon can testify to more considerable penetration of the interplanetary electric field into the inner magnetosphere during the high density of solar wind.

Pulsating precipitations of the ring current energetic particles at latitudes of diffuse aurora and SAR arc by the photometric observation data

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Ground-based observations of the diffuse aurora (DA) and stable auroral red (SAR) arc are the informative investigation method of dynamic processes in the vicinity of plasmapause and inner boundary of the plasma sheet during magnetospheric disturbances. It is known that SAR arcs are the consequence of interaction of the outer plasmasphere (plasmapause) with energetic ions of the ring current. The DA is caused by the low-energy electron precipitation from the plasma sheet. During substorms we observe the intensity increase of DA and its equatorward extension up to the plasmapause projection which is mapped by the SAR arc appearing at that time. At the recovery phase period of intense substorms at latitudes of SAR arc the luminosity pulsations in the 427,8 nm N_2^+ emission owing to the pulsating precipitations of the ring current energetic particles in the outer plasmasphere usually occur (Ievenko et al, Adv. Space Res., 2008). Here we present the new investigation results of the DA and SAR arc dynamics based on spectrophotometric observations at the Yakutsk meridian (199° E geomagnetic longitude). The detailed relationship of the development of pulsating variations of the N_2^+ band intensity (391,4 and 427,8 nm) to the formation of SAR arc equatorward of the DA boundary in the 557,7 nm emission is shown. The spectral and correlation analysis of luminosity variations has been carried out. The basic types of the luminosity pulsation spectra in the frequency region 0.02-1 Hz are analysed. The delay of 0.1-0.5 s in the particle pulsating precipitations development in the latitude interval $\sim 4°$ ($/DeltaL$ =0,5-0,7 R_E) has been revealed. It is supposed that the appearance of pulsating precipitations of energetic particles at latitudes of the SAR arc (outer plasmasphere) in these cases can be caused by the propagation of hydromagnetic waves from the region of source (pulsations in the diffuse aurora) inwards the magnetosphere.

Actual problems of thundercloud electrodynamics

Iudin, D.I. (Radiophysical Research Institute, Nizhny Novgorod, Russia)

The talk is tribute to Victor Trakhtengerts as a scientist and teacher. The essential progress was achieved our days in the experimental investigation of a thundercloud (TC) electricity on the base of complex ground based and balloon measurements. At the same time many important problems of TC electricity remain to be solved. At first it concerns some dynamic features in a large-scale electric field on all stages of a TC evolution. A very fast growth of the electric field amplitude and of sizes and charges of cloud particles before the first lightning flash does not find explanation in the classical models of TC electricity. Many puzzles exist in explanation of a many-layer TC electric field structure and of the preliminary stage of a lightning discharge. We consider some theoretical models, which can answer qualitatively and sometimes quantitatively on the questions formulated above. Victor Trakhtengerts participated directly in much of the results presented and encouraged me to continue our common work.

Time characteristics of the magnetospheric response to the B_z IMF turning

Ivanova, I., Gvozdeva, M., Dmitrieva, N. (St.Petersburg State University, St.Petersburg, Russia)

Time characteristics of the magnetospheric response to the abrupt isolated IMF B_z turning were studied. About thirty interplanetary discontinuities with sharp B_z turning were considered. The vector of the normal to the discontinuity plane $\mathbf{n}$ and the time of the first contact with magnetopause (t_c) were calculated for each event (the magnetopause shape was determined using the Shue formula). Afterwards the start time of the polar cap electric field increase (decrease) following the southward (northward) B_z turning was determined using magnetic variation data near the pole (t_{pc}). The time delay between t_c and t_{pc} was found as the first time characteristics of the magnetospheric response. The second time delay was determined between t_{pc} and substorm expansion phase onset (t_0) in the plasma sheet. The dependence of both characteristic times on the discontinuity orientation, and state of the plasma sheet was studied.

Application of reconstruction method based on time-dependent Peschek-type reconnection to THEMIS data

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Remote-sensing method based on time-dependent Petschek-type reconnection model is applied to a triple earthward propagating NFTE (nightside flux transfer event) observed by THEMIS B and C spacecraft on 10 February 2008 around 05:50 UT. The method utilizes magnetic time series as an input and provides the reconnection electric field and the location of X-line as an output. The recovered electric field consists of three successive pulses and reaches $\sim$1.5 mV/m at the maximum. The location of X-line is estimated to be around 40 Re in the tail.

On relationship tsunami and volcanic eruptions

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In last years was investigated impressive progress in forecasting earthquakes and volcanic eruption, first of all based on precursors observations these events. Primary outside factors (geophysics and space) of triggering influence on rise earthquakes and volcanic eruption may be: 1) Solar activity, 2) Earth speed rotation, 3) flux and reflux, 4) geomagnetic events, 5) meteorological factors.

Most interesting being precursors of the power volcanic eruption, what doing essential contribution in change blueness optical characteristic of atmosphere. Observing connection between solar activity (solar spots number) and volcanic eruption. Ejected to stratosphere volcanic material, on actinometrical observations, live in here more the one year. Mass-spectrometric analyze demonstrated, that water amount 95% of volcanic gases. Combined data handling on volcanic eruption and tsunami displayed what: volcanic eruption be left behind by tsunami for 3-5 days.

Observing correlation between changes Earth speed rotation and intensity volcanic eruption. Was investigate liaison amplitude of volcanic eruption (number power volcanic eruption and magnitude) and speed of change Earth frequently rotation. Especially distinctly this correlation observing for data, from 1860 to 1886. Earth axis experience recurrent oscillations and notations with harmonies, make conditional upon sun, moon and Earth. These harmonies having the periods: 13,4 days, 27,6 days, 6 month, 1 year, 18,6 years. Harmony 18,6 years having maximal amplitude.

Asymmetrical ring current development during magnetic storm on 6–14 November 2004

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Magnetospheric magnetic field variations produced by ring current its symmetrical and asymmetrical parts were analyzed during magnetic storm on 6–14 November 2004 with peak Dst= -373 nT. Partial ring current was represented by a set of current circuits consisting from equatorial westward current, field-aligned currents and eastward closure current in the ionosphere. The magnetic field of the partial ring current was calculated using Biot-Savart low. To estimate the total current flowing in this circuit ASYM-H index was used as quantitative manifestation of magnetospheric magnetic field asymmetry. The symmetrical ring current intensity was determined from Burton equation which describes ring current development as a result of injection and decay processes. The injection amplitude was determined from the best fit between Dst derived from observations and from magnetic field modeling in terms of paraboloid model of the magnetosphere. It was obtained, that total partial ring current is about 6 MA during storm maximum. Partial ring current demonstrates fast development and sharp decay up to pre-storm level on the time-scale about of 10 hours. Its contribution to Dst on the storm main phase is about -100 nT, while the symmetrical ring current effect is about -200 nT.

High-latitude trapped particles boundary dynamics

Kalegaev, V.V., Parunakian, D.A., Bobrovnikov, S.Yu. (Skobeltsyn Institute of Nuclear Physics, Moscow State University, Moscow, Russia)

Motion of charged particles and location of plasma domains in the Earth's magnetosphere are controlled by magnetic field created by both internal currents in the Earth's core and large-scale magnetospheric current systems. In the inner magnetosphere at low geomagnetic latitudes the radiation belt energetic particle motion is determined by the internal dipole-like magnetic field, while at high geomagnetic latitudes below the auroral oval external radiation belt dynamics is strongly influenced by the magnetospheric magnetic field.

The external boundary of trapped particles was found according to data on electron fluxes measured by the polar low-altitude Coronas-F and Tatyana satellites. It has been found that during magnetic storms the high-latitude boundary of the electron radiation belt shifts equatorward depending on the disturbance level. During the quiet periods the ionospheric footprint of the trapped particles boundary is shifted to the night side due to large-scale magnetospheric currents. Analysis of satellite data shows 24-hour variations of the form and the location of this boundary, which are caused by the non-dipole internal magnetic field rotation alongside with the Earth. Comparison with Polar UVI images shows that the external boundary of trapped particles adjoins to the auroral oval equatorward boundary, which has a non-circular shape during quiet periods and rotates in the solar-magnetic coordinates alongside with the Earth.

The method of the extraction of equatorial effects of thin magnetosphere layer of the Earth from results of geomagnetic measurements of low-orbit satellite MAGSAT, CHAMP

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One from new methods of extraction of equatorial geomagnetic field effects connected with the thin magnetosphere plasma layer on a hum noise of the geomagnetic field connected with the other ionosphere-magnetosphere and internal sources of the Earth are the methods differential spatial temporal analysis (DSTA). From the MAGSAT, CHAMP measured satellite geomagnetic field (Fe) data the main magnetic field (Fm) of Earth's core was previously eliminated. The residual geomagnetic field (Fr) is present in magnetic anomalies of tectonosphere origin (Fa) and variation of a permanent magnetosphere-ionosphere field (Fv). The private differential of a geomagnetic field per time from the schedules the vector components of the low-orbit satellite MAGSAT, CHAMP was calculated. The extraction of equatorial magnetic anomaly effects from the data of the private differential of vector component geomagnetic field per time is made better, than from a purely residual geomagnetic field. For extraction from the MAGSAT, CHAMP low-orbit satellite geomagnetic data of the equatorial anomaly effects of the magnetosphere thin layer and the tectonosphere effects we shall consider the formulas of differential spatial temporal analysis (DSTA), from which we leaned at computer calculations. For improving the situation with extraction of equatorial anomaly effect of magnetosphere thin layer from a hum noise of the MAGSAT, CHAMP low-orbit satellite geomagnetic data, the algorithm of high-frequency filter of the Lagrange to values of a combinational private differential of a geomagnetic field per time was applied. The activity is executed at support of Russian Foundation of the Basic Research by grant 07-05-90006 _a.

Reconnection-associated energy transfer

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Magnetic reconnection leads to well-known features which can be observed in the Earth's magnetosphere, as flux transfer events (FTEs), bursty bulk flows (BBFs) or travelling compression regions (TCRs). The compression of the magnetic fields due to the appearance of a plasma bulge can be observed in the form of a compression region, travelling together with the plasma flow regions. Also these regions carry energy. In this work we investigate the kinetic energy output of the reconnection process as well as the energy appearing inside TCRs. For this purpose, we use a time-dependent analytical Petschek model of magnetic reconnection and investigate the spatial and temporal distribution of the energy and the potential due to the reconnection process. We apply this method to a substorm event on September 19th, 2001, examining Cluster data. As input parameter, disturbances in Bz, associated with the appearance of six TCRs during this substorm, are used in order to determine the energy transport by these TCRs.

Modulation of the riometer absorption and ground VLF chorus by Pc5 geomagnetic pulsations depending on the solar wind dynamic pressure

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The case study (November 24, 2006) of simultaneous multi-points Scandinavian observations of pulsating energetic electron precipitation (riometer absorption) and ULF geomagnetic pulsations, as well as the burst of morning chorus emissions near Sodankylä observatory has been analysed and compared with the solar wind conditions. It was found that during the VLF chorus burst occurrence (04–05 UT) there were observed two stable maxima (near 2 mHz and at 3–4 mHz) in geomagnetic pulsations spectra, however, the riometer absorption spectra were time dependent. In the first half-hour interval the maximum of pulsating riometer absorption coincided with 3–4 mHz geomagnetic pulsation maximum, but in the following half-hour interval - with 2 mHz ULF maximum. The spectra of the chorus intensity variations were relatively similar to the riometer ones. In the first discussed time interval the solar wind dynamic pressure variations were turbulent in the large frequency range of ~1.5–4.0 mHz with maximum at 2–3 mHz. However in the second interval they demonstrated the oscillations with the clear maximum at 2 mHz. The same maximum was observed in the riometer, geomagnetic pulsation and VLF chorus data. We interpret that results as the VLF wave grow rate modulation by the compressional Pc5 range ULF wave exiting due to pressure oscillations. The 2 mHz geomagnetic pulsations in the first interval were, probably, by the Alfven resonant nature which could not modulate the VLF chorus exiting.

Magnetic storm effects in the atmospheric electric field variations

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The vertical component (E_z) of the atmospheric electric field variations, measured at middle (obs. Swider) and polar (obs. Hornsund) latitudes under "fair-weather" conditions, have been analyzed. In the middle latitudes the strong effect of sharp daytime E_z increasing (negative E_z anomalies) has been found during the main phase of the strong and moderate magnetic storms. The negative E_z deviation started simultaneous with the night side geomagnetic substorm onset. The observed effects could be interpreted as a significant changing in the global electrical circuit caused by the night side ionosphere conductivity increasing associated with substorm particle precipitation. For the first time we found the effects of night side high-latitude disturbances in daytime mid-latitude E_z variations. In the polar latitudes (obs. Hornsund) we observed the E_z enhancement coincided with similar IMF E_y variations. The E_z effects of storm sudden commencements (SSC) and magnetic storm initial phase have been also found. Sometimes the positive E_z variations have been observed during so called "polar substorm" development. The obtained results are, probably, associated with influence of local polar ionosphere convection disturbances.

The influence of the northward wind on the latitudinal location of the enhanced electron density regions in the nighttime ionospheric F2-layer and plasmasphere of the Earth

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Earlier, we showed that the main cause of occurrence of the nighttime middle-latitude enhanced electron density regions (EEDR's) is the equatorward thermospheric wind driving the F2-layer plasma to the higher altitudes thus decreasing the ion loss rate. The maximum of the vertical ion velocity induced by the northward wind takes place

at the $\pm 27^{\circ}$ magnetic latitude if the northward wind velocity is constant. At this work we have presented the results of the investigation of the influence of the northward wind velocity on the latitudinal location of the EEDR's. The global numerical model of the Upper Atmosphere Model (UAM) has been used in this investigation. We have calculated global distributions of the ionospheric F2-layer critical frequency under the condition that the equatorward wind velocity is constant at the night-time sector. The values of the velocity were changed from 0 to 100 m/s. It has been shown that the latitudinal location of the EEDR's does not coincide with the location of the maximum of the vertical ion velocity induced by the wind. The EEDR's are located at high latitudes when the equatorward wind velocity is increased. It has been proposed that the horizontal transfer of the plasma by neutral wind is the main cause of this displacement. The ions get a horizontal component vector of the velocity under the collisions with the neutral particles and the plasma removes to the lower magnetic latitude. It results in EEDR's forming at the higher latitudes.

Source of electron precipitation for breakup and pulsating aurora

Kornilov, I.A. (Polar Geophysical Institute, Apatity, 184209, Russia)

Previously developed procedure using TV camera data for the detecting of very weak wave of luminosity spreading upward along auroral arcs and beams was essentially modified and improved. This wave of luminosity produces by precipitating electrons velocity dispersion and differential atmospheric penetration of multi-energy electrons, and speed of wave gives direct information about the location of electron acceleration region in the magnetosphere. Procedure was tested with a lot of different model signals and applied for the study of pulsating aurora and auroral breakups. Applying this method for pulsating aurora (total about 30 events recorded in Lovozero, Barentsburg and Finland were processed) revealed definite velocity dispersion of precipitating electrons, and electrons source position were estimated to be at the distance about 5-6 Re in a complete agreement with a received opinion. Though electrons energy in pulsating patches is very high, and so the vertical extent of aurora is rather small, spreading upward wave of luminosity is well visible almost in all the data. Results of breakup study are radically different. More than 100 breakups were digitized and processed, and with the exception of some short and seldom events (0.2–0.3 seconds duration), needed more detailed investigation, not a single case of well-pronounced vertical wave of luminosity was found. Would we deal only with a strong additional acceleration of small energy magnetospheric electrons in the double layers above ionosphere, weak traces of electron velocity dispersion definitely would be detected. It should be inevitably concluded that all auroral breakup electrons are accelerated just above ionosphere, at the heights about 2000 – 4000 km. We can suppose that anomalous resistance generated in the upper ionosphere by strong field-aligned currents during the breakup phase produces very intensive parallel electric field accelerating local ionospheric electrons and creating breakup aurora.

Time delays between the moment of auroral breakup, VLF hiss, and magnetic pulsations activation

Kornilov, I.A., Kornilova, T.A. (Polar Geophysical Institute, Apatity, Russia)

More than 100 breakups of different types and intensities were studied on the base of Lovozero geophysical observatory data. We used digital magnetic pulsation recordings (H, D, Z components) in three frequency bands (periods 5–150 seconds, 0.5–15 seconds, inductive magnetometer data - about 0.05–20 Hz), and VLF. Available information about VLF emissions was in the form of the average wave intensity (input signal from VLF antenna was filtered by analog pass band filters with a bandwidth about 20% of the central frequency and digitized after integration with effective suppression of atmospherics and other impulse noises). Data on aurora brightness and dynamics were collected by TV camera (videotape a recording with 25 frames per second frame rate, and supported by ground-based photometers (4278, 5577 and 6300 emissions). TV data were digitized and processed with the using of different methods of image filtering allowing revealing the weakest luminosity variations inside and around the prebreakup arc, and marking the moment of auroral breakup with a high accuracy. For all the breakups under consideration it was found that magnetic pulsations in all frequency bands lag the moment of breakup for 0.5–3 minutes. VLF data interpretation was more complicated (parasitic interference with the different industrial and local electronic equipment, and almost free VLF emissions propagation under ionosphere from auroral activity in the other regions of auroral oval). Nevertheless, for at least 15 breakups we have detected that VLF emissions intensification leads the breakup moment for 3-10 minutes, and for another 30-40 breakups after special high frequency filtering for the better revealing very weak VLF intensity fluctuations, this fact was confirmed as well. No correlation between the luminosity variations inside and near prebreakup arc and VLF hiss was found, but in 3-4 cases very weak moving southward subvisual auroral structures correlating with VLF were detected northward from the arc, so some rather weak and difficult for observations, but important for the breakup physics process at the distant magnetotail precedes the moment of auroral breakup.

Observations of high frequency (5-10 Hz) optical pulsations (flickering aurora): Direct evidence of anomalous resistance mechanism operation?

Kornilov, I.A., Safargaleev, V.V. (Polar Geophysical Institute, Apatity, 184209, Russia)

On December 03, 2005 strong substorm started at the southern horizon of Barentsburg TV camera field of view about 15.00 UT, and quickly extended far towards North. About 16.00 UT after strong spiral deformation (so intense field-aligned currents existed that time) of very bright and active auroral forms unusually fast auroral pulsations (frequency 5-10 Hz) were detected in the zenith of TV camera. In spite of camera SIT-vidicon tube target inertia (about 100-200 milliseconds) pulsations were well visible without any special image processing, so the modulation of precipitating electrons was rather high (ON/OFF ratio at least about 10). Pulsations were mostly concentrating along the arc, though much weaker fast pulsations inside the area bounded by spiral arc have been observed as well. The size of individual pulsating element was about 10*10 km. Pulsating elements had an obvious tendency to concentrate in clusters, and very strong temporal and spatial correlation between the neighbour pulsating fragments was found. Earlier V.Safargaleev created the theory of high frequency pulsations of precipitating electrons basing on the fast variations of field-aligned currents and periodical fluctuations of anomalous resistance. Strong periodical variations of parallel electric field generated in this process accelerate electrons and produce pulsating aurora. Initially the theory was developed for the explanation of the ordinary pulsating aurora, but with any reasonable parameters predicted frequency of pulsations was less than 1 second (as known, period of pulsating patches is about 10-20 seconds). It was found that this theory could explain the physical properties of flickering aurora very well. We can also suppose that anomalous resistance mechanism can play an important role in auroral breakup development. Careful study of breakup activations really revealed weak traces of flickering aurora near the bright and active breakup arcs.

Spatio-temporal auroral dynamics during storm-time and isolated substorm inferred from tv observations

Kornilova, T.A., Kornilov, I.A. (Polar Geophysical Institute, Apatity, 184209 Russia)

The problem of storm-to-substorm relation has long been considered in space physics as one of the most controversial ones. Therefore, it is interesting to clear up if there is any difference between isolated substorms and the substorms occurring during magnetic storms.

We present a comparative study of aurora dynamics for the substorms observed during magnetic storms of different intensity and isolated substorms in the dusk-midnight sector based on the TV data of high latitude observatory Barentsburg and of auroral zone observatories Lovozero and Loparskaya. It is found that for isolated substorms, aurora dynamics in many aspects differs from that exhibited during substorms related to different phases of magnetic storm. Before the beginning of storm main phase, high-latitude substorms occur. The main phase of the storm is mostly characterized by development of weak, pseudo-breakup type activations, or small substorms spreading equatorward in the auroral zone latitudes. The substorms initiated at the end of storm main phase do not develop according to the classical scenario, that is, as step-like leaps of auroral arcs to the pole. Instead, they manifest as fast unstructured aurora luminosity spreadings over large areas. The substorms occurring at the beginning of storm recovery phase are rather intense, they develop in a large latitudinal range up to the polar cap latitudes. The double oval configuration, with its poleward boundary intensifying, and auroral streamers, separating from this boundary and drifting southward, are typical signatures of such events. At the end of storm recovery phase, in high latitudes weaker substorms emerge, which are characterized by polar arc development.

Analytical model of collisionless magnetic reconnection based on the solution of Grad-Shafranov equation compared to the PIC-simulation

Korovinskiy, D., Divin, A., Semenov, V.S. (St. Petersburg State University, Russia)

Two different approaches to the collisionless magnetic reconnection modeling are developed in the paper presented. First of them is the steady-state analytical model based on the Grad-Shafranov equation for magnetic potential developed in the frame of electron Hall-MHD. Another one is the PIC-simulation considering all kinetic effects. It is shown that solutions obtained by both approaches for electro-magnetic and dynamic plasma parameters demonstrate good qualitative agreement. Moreover, numeric values of the said quantities are found to coincide with the accuracy up to the coefficient of the order of 1. Thus, the analytical model developed has been confirmed to be an effective tool for investigation of the steady-state collisionless magnetic reconnection.

Analysis of CLUSTER and IRIS riometer data obtained during experiments on ionospheric modification carried out 16 February 2003 and 17 March 2004

Kotikov, A.L. (St.Petersburg State University), Odintsov, V.I. (IZMIRAN), Maulini, A.L. (St.Petersburg State University), Gavrasov, A.V. (Kostroma State University)

Work is dedicated to one of the actively developing line of investigation in space plasma physics such as artificial modification of the ionosphere. Experiments carried out using Tromso heating facility with pump wave frequency of transmitter 4.04 MHz with square modulation period 10 minutes in 16 February 2003 and 400 seconds in 17

March 2004 are considered. These events were selected because of orbits projections of CLUSTER satellites along magnetic field lines went nearby disturbed region in ionosphere according to Tsyganenko model (T96). Electric, magnetic field and electron density data from CLUSTER satellites and IRIS imaging riometer data using wavelet, short time Fourier transform and spectral time analysis developed in IZMIRAN are analyzed. It is shown that effect is clearly observed in IRIS imaging riometer data (16 February 2003) right in the beam where the heating spot is. Also effect of heating is observed in CLUSTER data when satellites cross magnetic field lines conjugated with disturbed region. Thus it is experimentally shown that functioning of heating facility affects not only ionosphere but also the ionospheric-magnetospheric interaction system.

Variations of optical and infrared transparency of the Earth's atmosphere under the impact of cosmic rays as a possible reason of solar variability and cosmic rays effect on thermodynamic parameters of the atmosphere and cloudiness anomalies

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The possible influence of solar activity and cosmic ray flux on climate has been discussed in many papers. The effect of cosmic rays on cloud formation is considered as one of possible mechanisms. It is known that anomalies of cloud cover at low altitudes (3,2 km) correlate with the intensity of galactic cosmic rays. We present a possible model for the effect of cosmic rays on cloud formation at various altitudes in the Earth's atmosphere. Our model takes into account the influence of cosmic ray flux on the transparency of the Earth's atmosphere in the visible and infrared range. The probable reasons of cosmic rays influence on atmospheric transparency are discussed. It is shown, that variations in the transparency of the atmosphere in turn result in variations in the temperature distribution in the Earth's atmosphere which finally effect the formation of water drops and ice crystals and change the growth rate of the drops in the atmosphere at various altitudes.

The results from the calculations show that possible variations of the growth rate of water drops and of the concentrations of active nuclei of condensation and crystallization in the atmosphere can reach several percent. In addition the results also show that the model allows explaining the correlation between variation in galactic cosmic ray flux and anomalies in cloudiness at low altitudes only.

This research was done in the frame of an exchange between the Russian and Finnish Academies (project No16). It was also supported by the Russian Foundation for Basic Research, (project No06-02-16268, 07-02-00379), by the Program of the RAS Presidium No16, and StPbSC RAS Scientific Program.

Study of the cause-effect relationships during geomagnetospheric storms (GMSs) main phases (MPs) with using cluster analysis

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The goal of our study is the elucidation of chief causes of the GMSs MPs of investigated intensities ($D_{st}^{min} = -37 \div -226\ nT$, hourly data are used). The study is based on the cluster analysis realized in the form of the "nearest neighbour" method. The scale D_{st} - clusterization of 31 MPs has allowed to select three MPs clusters ($C1$, $C2$, $C3$) with rather alike in form and scale of D_{st} index (in terms of mean values $\overline{D}_{st}$ and standard deviations $\sigma(D_{st})$ in MP time interval) and five MPs isolators ($I5$) with rather alike in scale of D_{st}^{min}. The obtained samples are characterized by the following (averaged over entire every sample events) parameters values - $C1$: $\overline{D}_{st}^{min} = -47\ nT$, $\overline{\overline{D}}_{st} = -21\ nT$, $C2$: $\overline{D}_{st}^{min} = -87\ nT$, $\overline{\overline{D}}_{st} = -39\ nT$, $C3$: $\overline{D}_{st}^{min} = -130\ nT$, $\overline{\overline{D}}_{st} = -84\ nT$, $I5$: $\overline{D}_{st}^{min} = -213\ nT$, $\overline{\overline{D}}_{st} = -130\ nT$. In other words, the weak (WS), moderate (MS), intense (IS), and very intense (VIS) storms MPs are separated, respectively. Using the correlativity clustering of 32 interconnected physical processes (IPPs) characterizing every MPs it has been found that the MPs of all samples has common part (CP) of tight IPPs (at clustering level with correlation coefficient between neighbour processes $|r| \geq 0,8$), and in turn the MPs of every sample has own common IPPs structure: $CP = [D_{st}]+[B_Z]+(B_Y)+B$; $C1 = CP+(B_T)+B_X+(\varepsilon)+(DCF)+(AE)$; $C2^* = CP + B_X + (V) + (AE)$; $C3^* = CP + (B_T)$; $I5 = CP + (B_T) + B_X + (V) + T$. It is evident that the samples IPPs structures differ one another. Hence theirs MPs are characterized by different physical development depending on D_{st} scale. The availability of CP testifies that the MPs magnetospheric activity $[D_{st}] = D_{st} + DR + Q + U_T$ (where $Q = dDR/dt + DR/6$) of all D_{st} scale is defined by the $[B_Z] = B_Z + VB_Z + E_{\sigma Z} \equiv V(\sigma_Z - B_Z) + VB_S + V^2B_S + F_M \equiv VB_S(m_p n V^2)^{1/3} + \theta_B$, $(B_Y) = B_Y + VB_Y$ groupings, and B - IMF. In this case, the relationship $D_{st}(V^2B_S)$ and $D_{st}(VB_S)$ or $Q(V^2B_S)$ and $Q(VB_S)$ are most tightly coupled. Note that in three MPs samples the B_X and B_T IMF components play essential role. The substorm activity $(AE) = AL + AE$ is important only during WS and MS MPs, whereas the velocity grouping (V) is important only during WIS MPs. As for the Akasofu parameter epsilon ε, its role less appreciable, but the relationship $D_{st}(\varepsilon)$ and $Q(\varepsilon)$ are in existence, however are more complex and not so intimately connected.

Analysis of magnetic field fluctuations in the Earth's magnetotail by spacecraft measurements

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Investigation of probability density function features for magnetic field fluctuations in the Earth's magnetosphere tail on different time scales from data of satellite Geotail (1997 - 2000 years) and Interball is carried out. Changes of shape and parameters of probability density function for the periods before and during the current disruption were studied. As an evolution characteristic for different time scales the changes of maximum probability density function values P(0) were investigated. Two asymptotic modes for P(0) corresponding to two different power lows were found: the changes of probability density function maximums correspond to Gauss process on the large time scales, and to Levy distribution on small time scales. The intersection of the two asymptotes corresponds to time scale value of 1 sec.

The proposed approach is universal and can be used for the analysis of fluctuations of other parameters being of other nature.

Storm-time Pc5 geomagnetic pulsations analysis based on a new ULF-index

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The new index of planetary wave activity in ultra low frequency range, which was called “ULF- index”, has been used for the statistical analysis of the intensity level of daytime geomagnetic pulsations of the Pc5 range with the periods of ∼3-8 min (f = 2–6 mHz) during the different phases both of strong (-150 nT Dstmin -100 nT) and moderate (-100 nT Dstmin -50 nT) magnetic storms. It is found the most intensive geomagnetic pulsations were observed in the morning-noon sector of auroral latitudes in the every storm main phase but not during the storm recovery phase, as this was earlier considered. It is shown that the geomagnetic pulsations, which are excited during and after morning substorms, introduce the basic contribution to the day ULF wave activity during the main phase of the magnetic storm. It is shown the storm sudden commencement, which is characterized by a jump of the solar wind density and velocity, is accompanied by the sharp increasing of the ULF-index. The ULF-index level decreases in the storm recovery phase, however, an appearance of the separate time intervals of the negative IMF Bz values leads to the short-time ULF-index enhancing.

Space physics hands-on exercises in Moscow State University

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Space physcics hands-on exercises are a part of space sciences education and outreach program was initiated in Moscow State University in order to enhance public interest in space exploration, to popularize basics of space physics and to incorporate modern space research in the university and high education. Within the frames of this program the First Russian University Satellite “Universitetskiy-Tatyana” (operated 20 January, 2005 – 7 March, 2007) was constructed and launched into circular polar orbit. The onboard scientific complex, as well as the mission control and information receiving center, was designed and developed in Moscow State University. The scientific program of the mission included measurements of space radiation in various energy ranges, and UV luminosity and lightening from the Earth. Four other educational and scientific missions prepared in cooperation with other Russian and foreign universities and agencies are going to be launched in 2008-2009. A multimedia lectures "Life of the Earth in the Solar Atmosphere" containing the basic information and demonstrations on the heliophysics (including Sun structure and solar activity, heliosphere and geophysics, solar-terrestrial connections and solar influence on the Earth's life) were created for upper high-school and junior university students. For the senior university students there was created a dozen of special computerized hands-on exercises (appr. 6-8 hours each) based on the experimental quasi-realtime data obtained from "Universitetskiy-Tatyana" satellite and other internet resources. For six hands-on exercises the special software was designed and developed. Two hands-on exercises were adopted for upper high-school and junior university students and the appropriate software was developed in English. Students specialized in space physics from a few Russian universities are involved in scientific work based on various scientific data. "Space Schools" for university teachers and students were carried out in 2004 – 2007. The main objective of these schools was to attract interest to space research. Tutors and students who took part in these schools had never before been involved in the space sciences. The idea of these schools was to join forces: Moscow State University scientists presented space science lectures, students from other universities performed the work, and their university teachers managed the students. After participating in these schools, both students and their teachers started to study space related topics emphasizing the success of these schools. This year we plan to carry out the international bilingual (in English and Russian) "Space School". For modern university world, it is very important to understand what skills future space scientists and space industry employees must be equipped with. Better communications should be practiced between universities and industry in the next years.

Nonlinear multi-scale magnetotail dynamics: interrelation of kinetic thin current sheets and mesoscale MHD turbulence

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Dynamics of the magnetotail plasma sheet (PS) features nonlinear structures on two totally different scales. There are very thin current sheets (CS) on kinetic scale of the ion gyroradius. And there are intense plasma flow and magnetic field variations on mesoscales (a few earth radii); those are interpreted as mostly 2D MHD turbulence. On the other hand, the specific nature of slow large scale magnetotail evolution leads to large differences in the PS properties and those of the lobe plasma. As a result, while fast reconnection bursts in the tail provide quasi-stationary fast mesoscale reconfigurations in the lobes, they cannot however be accompanied by restructuring of CS on the same fast time scale. Violations of force balance in the PS are thus generated. Simulation using a hybrid code and starting with such imbalance, provides an evidence of very thin kinetic CS structures formation, embedded into the much thicker PS. The momentum balance gets locally restored by means of ion acceleration up to the Alfvénic velocity. So the process provides an effective mechanism for transformation of magnetic energy accumulated in the magnetotail, into energy of fast plasma flows. The fast flows may drive turbulence on shorter spatial scales. In their turn, these motions may serve as an origin for new neutral line generation, and reconnection. Application to substorm phenomenology is discussed.

Adaptive magnetic field models and estimations of mapping accuracy

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We introduce a simple procedure to adjust a standard T96 magnetic field model for better fitting spacecraft in situ observations. The idea was to use the existing input parameters of the model (solar wind magnetic field and pressure and observed Dst index) as free parameters. Thus the input parameters were not taken from observations of solar wind and Dst, but were obtained from fitting observations

as parameters which give minimal deviation of the model field values from the observed ones. The approach like that allowed to reproduce smaller time scale variations of magnetic fields, which are usually averaged by the standard T96 model with standard solar wind based input.

The procedure was applied for interpretation of Themis observations during a number of substorms in February–March 2008. Isotropic boundaries, observed by low-altitude NOAA spacecraft during these substorms were used for independent verification of the magnetic field lines configuration. We compare the main features of observed and modeled fields, and of resulting spacecraft mapping to ionosphere. We show that the deviations in spacecraft footprints due to stretching and dipolarizations of magnetospheric configuration during a substorm may be as large as several degrees of geomagnetic (geographic) latitude.

We also discuss how the magnetospheric tail shift from solar-earth direction due to non-radial solar wind propagation will influence the spacecraft ionospheric footprints positions.

Implications of volcanism and geomagnetic field polarity reversals into the climate variability

Kuznetsova, N.D., Kuznetsov, V.V. (Institute of Space Physical Researches and Radio Wave Propagation FEB RAS, Kamchatka)

Increase of volcanism just as geomagnetic field reversals and excursions implications into large temporal paleoclimate variability are discussed. Stratosphere volcanic fine-grained submicron dust is considered to be a long-living barrier to the Sun radiation input to the Earth surface that is borne out by the high correlation between the Earth surface temperature and the dust content in the ice cores of Antarctica during the last 400,000 years. The ice core dust provenance, its varying content in ice-core layers and properties at different climatic periods wide debated give us occasion to develop our concept about effect of the volcanism increase on the large temporal climate variability. The link between climate changes and the geomagnetic field reversals and excursions has no unambiguous interpretation since both climate cooling and warming are known to run during reversals and excursions. Considering reversals and excursions to be processes being accompanied by penetration of the cosmic rays particles which are governing the atmosphere transparency we are substantiating a consequence of the reversals and excursions impact on climate to be determined by a presence or absence of dust in the stratosphere. Here we attempt to account increase of volcanism for the geomagnetic field excursions.

Long-term temporary changes in the interplanetary magnetic field and in the solar wind velocity at near-Earth space

Kuznetsova, T.V. (IZMIRAN, Russia)

We put as our aim to extract trends and long-term changes from data of the the Interplanetary Magnetic Field (IMF) and solar wind velocity V. We present results of our analysis of spectra of the IMF module and V calculated on the basis of spaced data at the Earth's orbit (1964 -1997). We use a method of nonlinear spectral analysis named by us as Method of Global Minimum (MGM). MGM allows self-consistent identification of trends from data and non-stationary sinusoids and estimation of statistical significance of spectral components. Spectrum of the IMF has main solar cycle at T=10.8 yr and its higher harmonics. The trend extracted from the IMF data selconsistently is described by stationary sinusoid at a period =(198 +-5) yr, amplitude of which R=7.94 nT is significantly higher than the amplitudes of the other spectral peaks (amplitude of the 10.8-yr cycle R=1.0 nT). Period of the 22-year magnetic solar cycle can be interpreted as the 9-th harmonic of the 198-year cycle. The reality of variations at T 200 yr beyond the studied time interval of spaced measurements was shown by spectral analysis of long data sets of C14. This allows us to extrapolate variations of the stationary sine wave with T=198 yr to the past. The IMF trend shows the 45% increase of the IMF strength for the time interval 1964–1997, extrapolation of its temporal variation to the past leads to the doubled IMF strength for the last 100 years. Component in the V spectrum described by high-amplitude sinusoid with with T=54+-4 years makes contributions to the long-term changes:the trend of V demonstrates a 55% increase in the solar wind velocity for the period 1964-1997. Besides, we detected periods of the Moon's orbital motion (and its higher harmonics) in power components of the IMF and V spectra: period =8.77 yr from the IMF spectrum can be interpreted as rotation period of the Moon's perigee, =9.3 yr – as the period of the second

harmonic of the sinusoid connected with rotation of the Moon's orbit at =18.61 yr. It is shown that the most power long-term component from the V spectrum with T=54 yr is a solar-lunar cycle. The 54-yr cycle includes whole number of the Moon's draconitic years, tropical solar years and also whole number of 10.8-yr solar cycles. The results point to considerable influence not only the Sun but the Moon on the long-term temporal changes of the solar wind and the IMF at 1 a.u. The study was supported by a grant of RFBR, n 06-05-64998.

Dependence of planetary and auroral geomagnetic activity from mutual orientation of the Poyting vector in the solar wind and the Earth's magnetic moment

Kuznetsova, T.V., Laptukhov, A.I. (IZMIRAN, Russia)

Geomagnetic activity is connected with mechanism of electromagnetic energy transfer from the solar wind to magnetosphere. Poynting vector P=[ExB] characterizes value and direction of the electromagnetic energy density of the solar wind . Orientation of the P vector relative to geomagnetic moment vector M changes during annual and daily motions of the Earth. We present our results of the effects of this mutual orientation changes on planetary (Dst, Kp indices) and high latitude geomagnetic activity (AL, AU indices). The P vector in GSE c. s. is calculated on basis of measurements of the IMF B and the solar wind velocity V for the period 1963-2005 (electric field E=[VxB]). We calculated orientation of the M vector in GSE c.s. for a year at each UT hour too. Three components of the P vector take into account geometry of interaction and connected with orientation of M: Pm is component of the P vector along the M vector; Pe is component of the P vector along the vector [B,[V,M], i.e. Pe is proportional to the E component transversal to the M vector at the plane perpendicular to the V vector (i.e. to the dawn-dusk Emv field); the third component Pmvm is projection of the P vector along the vector described by [M,[V,M]. We show that Pm has clear annual variation with extrema in May and November. We show that the phase of this variation is determined by pure geometric parameters and doesn't depend from the IMF sector structure sign. We present observational arguments to our results. For instance, annual variation of AL-index characterizing intensity of auroral westward electric jet has peaks in May and November. Analysis shows that dependence

Kp(Pm) is symmetric relative to sign of Pm (for Pm0 P is directed from the Earth at North Pole, for Pm0 P has opposite direction). Dependence Dst(Pm) has more complicated character. For Dst-70 nT Dst(Pm) is described by linear curve and doesn't depend from the Pm sign; for Dst-70 nT (up to its highest values) only Pm0 influences on linear increase of Dst(Pm). We interpret this result in terms of symmetric-asymmetri parts of DR-current and filed align currents (FAC) of zones 1,2 of Iijima and Potemra: for Pm0 FAC flow outward from the ionosphere at north cap and to the ionosphere at south cap. Function AL(Pm) is symmetric relative to the Pm sign that point to the direct connection of westward auroral jet with the solar wind independent from the FAC direction. Dependence AU(Pm) is asymmetric to the Pm sign, increase of AU(Pm) exists only for Pm0. This means that only FAC flowing inward to the ionosphere at north high latitudes is connected with eastward auroral electric jet. We present the other results of our study and discuss all results in terms of reconnection rate (calculated on basis of components of the P vector in our approach) and FAC of Iijima and Potemra. The study was supported by a grant of RFBR, n 06-05-64998.

Temporal changes of the solar wind electromagnetic energy flux applied to the magnetosphere during geomagnetic storms

Kuznetsova, T.V., Laptukhov, A.I., Petrov, V.G. (IZMIRAN, Russia)

In our approach causes of the geomagnetic storms are divided into temporal changes of the solar wind parameters (cause is the Sun) and the changes of the geomagnetic moment (M) orientation relative directions of the solar wind electric (E) and magnetic (B) fields connected with annual and daily motions of the Earth. In terms of reconnection a magnetic storm is initiated, if global requirements for process is satisfied. Efficiency of reconnection is determined by the rate which is described by components of the Poyting vector P in our paper. We study dynamics of rate of electromagnetic energy flux to the dayside magnetopause (based on calculations of the P vector component along the solar wind velocity Pv controlling the reconnection rate) at different phases of geomagnetic storms. We investigate also the rate of energy flux to the polar caps during storms (based on calculations of the P vector component along the geomagnetic moment Pm). In addition we introduce component of the P vector along the vector [B,[V,M] Pe, i.e. Pe is proportional to the E component transversal to the M vector at the plane perpendicular to the velocity V vector Emv (by the other way Pe is proportional to the dawn-dusk Emv component). Results allow to evaluate contributions of high and low latitude sources of electromagnetic energy to a storm development and also to clear mechanism of the energy transmission from the solar wind to the magnetosphere. The P vector in GSE c. s. is calculated on basis of data of the IMF B and the solar wind velocity V for the period 1963-2005 (E=[VxB]). To know the P vector components we calculated too orientation of the M vector in GSE c.s. during year for each UT hour. All analyzed large storms show the following features. Neither value nor sign of Pv component in the solar wind (for Pv_0 P is directed to the dayside magnetopause) are not necessary condition to initiate a storm; value of Pv0 can be even larger before a storm for several hours than during maximum of its main phase. The same conclusion concerns the Pm component. Necessary conditions of beginning of a storm are presence both of Pv_0 and Pe_0 components (additional presence of the dawn-dusk Emv component). The Dst depression follows by temporal changes of the Pv and Pe during main phase and reaches its maximal depression almost simultaneously with maximal values of Pe and Pv. Recovery phase is always accompanied by the value decreasing of Pv0 and Pe0 with tendency to be constant at the storm end (Pv_0 or Pv_0). At last we evaluate power of the electro-magnetic energy sources of the solar wind applied to magnetosphere during main phase of large geomagnetic storm 20-22 November, 2003. Its power N=2x10^{13} watt. The power is considerably larger than power of earthquakes (10^{11} watt) and less than the power of atmospheric processes. The study was supported by a grant of RFBR, n 06-05-64998.

Study of plasma dynamics of laboratory current sheets

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Results from studies of plasma acceleration and heating in current sheets in the CS-3D device are reported. Current sheets are used in laboratory modeling of magnetic reconnection. The impulsive magnetic reconnection phase is preceded by a sharp "explosive" increase in the plasma thermal energy that disturbs the transverse equilibrium of the sheet and provokes its disruption. The role of thermal explosion in the evolution of current sheets under laboratory conditions is similar to the role of "heat trigger" in solar flares. Thermal explosion was already observed in previous experiments in the CS-3 device, where current sheets were formed in the two-dimensional (2D) quadrupole magnetic field with null line. More recent experiments in CS-3D were conducted with quasi-planar current sheets formed in three-dimensional (3D) magnetic configurations. It is conceivable that flare phenomena will show also in the 3D case, where a uniform magnetic field Bz is applied perpendicularly to the quadrupole field. The objective of our present work is the study of the plasma acceleration and heating in current sheets formed in 2D and 3D magnetic configurations. The electron temperature Te in the sheet was determined by comparing experimental data on the temporal evolution of intensity of spectral lines (Ar II, Ar III, C III) with numerical calculations using a collisional-radiative model. The model takes into account the processes of ionization, excitation, and magnetohydrodynamic plasma flows. The ion temperature Ti was determined from Doppler broadening of Ar II lines. It is significant that a directed superthermal motion of these ions was detected. Our findings are as follows: (i) Ti Te (at the center of the sheet) in both 2D and 3D magnetic configurations and their temporal evolutions are different, which indicates different heating mechanisms; (ii) in 3D magnetic configurations, Ti is independent of Bz, whereas Te increases with increasing Bz; (iii) the energy of fast plasma flows along the sheet surface Wx is independent of Bz and Wx Ti Te; (iv) the effective ion charge Zeff in current sheet has been determined for the first time: Zeff =2.5-4.7.

GEO-6 Project for Galileo data scientific utilization

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The future GNSS Galileo system offer a number of benefits (e.g. availability of better accuracy positioning, new frequencies bands allowing the implementation of specific techniques, provable time-stamp and location data using SIS authorisation, integrity, better support ad-hoc algorithms for data analysis and other service guarantee for liability and regulated applications) are widely spread among different disciplines. Also applications, which are less interesting from the commercial and market point of view, could successfully contribute to the numerous social benefits and support the innovation in the international research. The aim of the GEO-6 project "Scientific research Using GNSS" is to propose and broaden scientific utilization of future GNSS Galileo system data in research. It is a joint project of seven institutions from six countries led by the Atos Origin Company from Spain. The core of the project consists from six projects in five priority areas: PA-1 Remote sensing of the ocean using GNSS reflections, PA-2a Investigating GNSS ionospheric data assimilation, PA-2b 3-D gravity wave detection and determination (both PA-2a and PA-2b are ionospheric topics), PA-3 Demonstration of capability for operational forecasting of atmospheric delays, PA-4 GNSS seismometer, PA-5 Spacecraft formation flying using global navigation satellite systems. Institute of Atmospheric Physics, Prague, Czech Republic is responsible for the project PA-2b, where we developed and tested (to the extent allowed by available data) an algorithm and computer code for the 3-D detection of gravity waves and determination of their characteristics. The main drivers of the GEO-6 project are: high levels of accuracy even with the support of local elements, sharing of solutions and results for the worldwide scientific community. The paper will present basic description of the project with more details concerning Czech participation in it.

Solar protons as a source of the outer proton belt: comparison of two trapping mechanisms

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Several strong magnetic storms accompanied by solar cosmic ray events create conditions for the trapping of solar protons into the outer proton belt. There are two injection mechanisms proposed to explain satellite observation of these events. First was suggested after magnetic storm of March 24, 1991, when satellite CRRES measured fast increase of the proton and electron flux at L$\sim$ 3–4 simultaneously with SSC. Theoretical consideration and computer modeling suggest that particle was injected by fast $\mathbf{E} \times \mathbf{B}$ earthward drift in electric field induced by SC pulse. Several publications of the last years re-

gard SC-injection mechanism as a main and only one responsible for the creation of new proton belts.

An alternative model was proposed based on particle measurements on board of polar orbiter CORONAS-F during and after magnetic storm of October 29–31, 2003. It suggests that solar penetrate directly to the low L-shells and became trapped at the recovery phase of the magnetic storm. Analysis of the measurements during several other magnetic storms supports this mechanism. Comparison of the temporal and spatial particle dynamics during the initial, main and recovery phases of the magnetic storms suggest that SC-injection mechanism works in a rare occasion while the majority of the solar proton belts was created by recovery trapping mechanism.

Solar activity effect on long-term geomagnetic variations measured by ground-based observatories and time-rate-of-change of the Earth's main magnetic field

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Rate of change of the Earth's main magnetic field is calculated on the base of ground-based and/or satellite geomagnetic survey or from annual amplitudes of the geomagnetic field measured by ground-based observatories. Amplitude of measured geomagnetic field generated by internal source is much greater than amplitude of the field generated by external sources such as magnetosphric and ionospheric current systems, so error of calculation of the Earth's internal dipole magnetic field is not great. But annual rate of change of IGRF model field is only about 15-20 nT/year and, if external field contribution into the annual rate is not taking into account, the error of calculation became more significant. The geomagnetic field variation caused by the solar activity 11-year cycle may effect on calculation of the change of annual amplitudes of geomagnetic field vectors with time. This effect was described by some scientists in the beginning of the XX century. It may be due to changing of the ionospheric conductivity and ionospheric electric field caused by wave and corpuscular radiation of the Sun that affect on annual variation of the geomagnetic field and telluric currents. It has been found a relationship of long-term variation of geomagnetic data measured by IZMIRAN observatory during 1946-2006 with parameters of solar activity. It has been established that taking into account the contribution of the Earth's external magnetic field into calculated rate of change of the Earth's Main magnetic field decreases the rate of change in 2-3 times. This work is supported by RFFI grants 07-05-13524, 08-05-00896

Variations in the VLF hiss spectrum depending on cold plasma density fluctuations from measurements by Cluster spacecraft

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Strong fluctuations of cold plasma density and whistler mode emissions were observed simultaneously near the plasmapause on the CLUSTER satellites. We present a case study of the event on December 08, 2001 when density fluctuations from ten up to hundreds cm-3 with a time scale of about one minute were detected by CLUSTER. VLF hiss emissions are registered by the WBD wave instrument in two separate frequency bands: the lower frequency emissions band at 200–700 Hz are positively correlated to the density while higher frequency emissions at 1–3 kHz are anticorrelated to the density.

In this report we discuss the modulation of VLF wave spectra by cold plasma density on the basis of cyclotron interactions between magnetospheric whistler mode waves and energetic electrons using the parameters of cold and warm plasma measured by the CLUSTER spacecraft. The density measurements were provided by the WHISPER wave analyser. The energetic electron data have been obtained with the RAPID energetic particle spectrometer which measured electron fluxes in 7 channels between 30 keV and 330 keV for 8 directions. The electron distribution function, anisotropy and energy spectra of electrons were estimated from the RAPID data.

The measured pitch-angle and energy distributions of energetic particles are discussed within the framework of the quasi-linear theory, i.e., on the basis of calculations of the linear temporal growth rate of the whistler cyclotron instability and the quasi-stationary solution of a self-consistent Fokker-Planck equation.

Spatial distribution of magnetic storm fields

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According to a summation of the Inner Magnetosphere/Storms Campaign (Geospace Environment Modeling) it is considered, that in models of geomagnetic storm fields the effects of interaction of plasma with magnetospheric magnetic and electric fields are not reflected enough. The using of Tsyganenko 01 model allows finding of features of magnetospheric disturbance magnetic fields topology. Therefore the maps of spatial distribution of model magnetic fields from the basic current sources in the internal magnetosphere (L 15RE) at the equatorial plane, along the Sun-Earth line and a dusk meridian for different phases of magnetic storms on May, 15th 1997 (Dst =-115nT), on March, 21st 1998 (Dst =-85nT) and on April, 6th 2000 (Dst =-287nT) have been constructed. The negative magnetic field region in the equatorial plane caused by ring current was displayed. It has the evening maximum caused by a partial ring current. It is found out that with the increase of the geomagnetic activity this maximum is displaced to evening sector following to intensification of a ring current asymmetry. With the distance from equator up to 4RE the maximum of a ring current magnetic field is displaced in northern and southern side differently reflecting the dependence on a geodipole inclination angle. The boundary of the region of a ring current magnetic field is extended along a morning-evening meridian. On an example of model magnetic storm fields the characteristics of the quasiwave longitudinal variations of a total magnetic field and its components (including a ring current field) have been determined also. The amplitude of these variations is increased with the growth of the geomagnetic activity (Dst) according to the displacement of the magnetic storm negative field maximum to the evening. The difference between experimental and calculated values of a ring current field in separate longitudinal sectors is obtained. Despite of quite good conformity of the measured and model magnetic field values at the geostationary orbit heights the distinction of the spatial distribution of calculated values of a magnetic field (including a ring current field) and Dst-variations during magnetic storms have been found. Local areas with positive values of Dst-variations in auroral latitudes during the main phase of the magnetic storm on May, 15th 1997 have been found out according to geomagnetic measures at INTERMAGNET observatories. These data aren't confirmed by Tsyganenko 01 model results.

Trapped radiation boundary collapse and related auroral electron precipitation during the May 15, 2005 superstorm

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We analyze the behavior of trapped radiation boundary and auroral electron precipitation region during the main phase of May 15, 2005 superstorm.

Data on electrons are taken from instrument onboard Meteor-3M. The main phase of a storm was only ~2 hours duration. During the first hour trapped radiation boundary and low-latitude peak of ~1 keV auroral electron precipitation fluxes have shifted to L~3. We compared behavior of above magnetospheric domains with the accompanying westward electrojet dynamics.

The model integration scheme of the Framework Atmosphere Model (FrAM)

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This work describes a high-level architecture of the Framework Atmosphere Model (FrAM), which is being developed on the basis of the global Upper Atmosphere Model (UAM), for the research of interrelation of the broad range of various processes and the phenomena in the upper atmosphere. The FrAM has been composed as an open framework, consisting of the controlling Model Manager and the set of independent Models of separate atmospheric regions and processes, and about the FrAM data structure. Using the unified interface the Model Manager organizes the information exchange of the connected Models and controls the execution of the modeling process according to the task configuration prescribed by a user.

The UAM model calculates the numerical values of physical parameters of the Earth's upper atmosphere: concentrations, temperatures and velocities of neutral and ionized atmosphere components, electric potential, field-aligned currents and some other parameters, depending on model configuration chosen by user. The model works by means of numerical time integration of the time-dependent 3D

continuity, momentum and heat balance equations for corresponding gases and the 2D Poisson equation for the electric potential. The starting state for the integration process is the full 3D distribution of corresponding parameters. It should be defined before the modeling process start, and during the calculation this state has being changed consecutively under the influence of external forcings and internal physical inter-relations. The UAM consists of a few separate modeling blocks: the neutral atmosphere block, the upper ionosphere and plasmasphere block, the electric potential block, the plasma drift block, the magnetosphere block etc. Every block solves its own equation system in order to calculate corresponding physical parameter set and uses its own co-ordinate system. The variable spatial grid steps can be used. The physical characteristics, which are calculated in another blocks, are the equation parameters and should be transferred from that blocks (if necessary — inter- or extrapolated from another co-ordinate grid nodes). This transfer is carried out on every time step.

The FrAM model is the extension of the UAM, and it inherits all thistraits. The difference is the possibility to use alternative modeling blocks instead of initially included into UAM ones. Accordingly, the main features of the UAM are the modeling block connection technology and data exchange standardization. It forms the open model interface for integration of new processes and regions into the already tuned self-consistent calculation scheme. It allows studying of the inter-relations of the wide range of processes in the upper atmosphere, including the feedbacks, by means of selective switch on and off of corresponding modules or re-direction of data flows.

First principles modeling of the polar ionosphere as the space weather forecasting tool and radio propagation instrument

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This report describes application of theoretical ionospheric model for diagnostics of the polar and adjacent mid-latitude ionosphere and for producing verifiable short-term forecast of the ionospheric parameters. University of Alaska Eulerian Parallel Polar Ionosphere Model (UAF EPPIM) has been developed as a computationally robust tool suitable for real-time simulation of the polar, sub-polar, and adjacent mid-latitude ionosphere. It covers 9,000x11,000 km area in the Northern Hemisphere, pole ward from the geomagnetic latitude of 50°N; and altitude range of 80 to 1000 km. The model solves equations of continuity, energy balance, and equations of motion, respectively, for seven ion species; for a number of minor neutral species, important for ionization balance in the lower ionosphere; for electron and ion temperatures Te and Ti; and for ion velocities Vi arising from ExB-drift. The electron concentration is determined in the model from condition of the plasma electro-neutrality. To eliminate the side boundaries problem, the absorbing side boundaries were selected at remote enough distance from any noticeable horizontal plasma drifts (ExB-drifts) inside the model domain. For rare (less than 3-5% of all times) occasions of severely geomagnetically disturbed conditions, when ExB-drifts approache side boundaries of the selected domain, the side boundaries allow for plasma outflux and influx. Photochemical equilibrium at the lower boundary and the empirically corrected plasma flux at the top are selected as the boundary conditions in vertical direction. The upper boundary flux is found to be a dominating source of the F2-layer plasma during nighttime. Complex parameterization for this flux as a function of local time, geomagnetic location, and season was derived by minimization of the data vs. model discrepancies. The derivation was based on statistically massive comparison with ionosonding data at different locations and seasons.

The EPPIM operates on-line (http://www.arsc.edu/SpaceWeather) in real-time for the last six years. The application uses remote on-line depositories at NOAA Space Environment Center (NOAA SEC) to obtain current and/or predicted geophysical parameters and data as inputs. The model inputs are solar and geomagnetic activity indices and characteristics of the solar wind, which are sampled in upstream position up to two hours in advance in terms of the solar wind propagation time. By forward shifting of the model time to accommodate the solar wind propagation delay, the real-time run performs short-term forecast of the ionospheric parameters, up to two hours in advance. Statistical validation shows that the forecast achieved a useful accuracy. Altogether, the validation is based on $sim1.5$ million of individual comparisons of the forecast with the measured data. The resulting RMS error of estimated critical frequency foF2 ranges from 10–15% (summer, daytime conditions) to 20–40% (winter, night), while the statistical biases tend to randomly oscillate around zero.

This indicates that the ionospheric model is largely free of systematic errors. Rather, the contribution of the random errors due to imperfect inputs and approximated model parameterizations are dominant in the overall accuracy of this forecasting method. The model WWW-site provides access to the comparison archive to demonstrate the forecasting accuracy achieved during various geophysical conditions.

The model high resolution and advanced numerical algorithms facilitate the gradient resolving capability for the electron density output. This makes the model applicable as the radio propagation instrument. The UAF EPPIM radio propagation module uses the electron density output for computations of the refraction index. The ray tracing is performed in interactive mode by solving full 3-D set of equations arising from condition of minimization of the propagation time in the refracting ionospheric media. This tool simulates and visualizes propagation characteristics in a wide range of frequencies from HF (3–30 MHz) to X-band (10 GHz). Refraction characteristics obtained by this method indicate that the ionospheric model approaches realistic estimates of the electron density gradients. Combined with additional modules, this ray-tracing tool can estimate other propagation parameters, such as radio scintillations.

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Waveguide propagation of ULF disturbances in the magnetotail

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The waveguide properties of two characteristic features of the magnetotail, plasma sheet and current (neutral) sheet, are considered. The account for a finite scale of ULF wave disturbance across the layer results in the occurrence of additional effects: change of the waveguide critical frequencies and excitation of field-aligned current at the layer's boundary.

Asymmetrical 1D configurations of thin current sheet in the magnetotail with constant B_z and B_y

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Numerical self-consistent model of the high-temperature collisionless thin current sheet (TCS) in the Earth's magnetotail, based on macroparticle method, has been used for investigation of asymmetrical 1D configurations of the TCS with constant B_z and B_y . The simplified 1D3V variant of the model is considered, when all functions are depending only on z coordinate in *GSM* coordinate system, electrostatic effects are not taken into account, plasma is considered to be electroneutral and only ion current is calculated. In this model TCS is formed by two plasma flows, moving towards along magnetic field lines from lobes with hydrodynamic velocity V_D , concentration n_0 and ion temperature T_0 . This plasma flows are simulated by generation of Maxwell distribution in lobes on small spatial scale enough far from the boundary of model region. Stress tensor is calculated and force balance boundary condition is used. In result of the simulation a few quasi-equilibrium asymmetrical configurations of the TCS were received.

Formation aerosol particles under effects of cosmic rays's ionization

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The discussion of the role of cosmic rays in variations of Earth climate is highly controversial. A major point of criticism is absent of an obvious physical mechanism linking atmospheric compounds with cosmic rays. However it is well known that atmospheric ions are produced mainly by cosmic rays. Nevertheless their role in aerosol formation is still not clearly determined. Here there are presented some of possible mechanisms of aerosol formation under effect of atmospheric ions.

Observation of ionosphere response to HF heating at Barentsburg

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A series of heating experiments have been carried out on 2006 at SPEAR heating facility at Svaldbard. The experiments on modulated ionosphere heating were mainly aimed on injection of the artificial MHD waves into upper ionosphere. Ground based observations of the artificial magnetic pulsations near heating site provided by Polar Geophysical Institute at Barentsburg show some interesting features. Probability of their excitation is rather small (∼10%) and independent from k-index of magnetic activity. Density of ionospheric current estimated from magnetic disturbances during intervals of the artificial emission generation being in the range 100–200 mA/m corresponds to moderate disturbances. The pulsation intensity does not vary significantly, only one case shows amplitude exceeded others by the order. Numerical modeling of the ground based artificial emissions could solve a problem of their effective generation.

On closing a gap in spacetime physics

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Maxwell and Michelson, the two pacemakers of Electrodynamics and Classical Optics, left us the best in-sights into light and space. Even though Maxwell's proposals on how to detect the Aether were both ambiguous and unconsciously correct in it's basic aim, and unsuited in their experimental promises, they have the absolute merit to stimulate the research on the utmost fundamental question that occupied Mankind long ago: Does the Aether exist or not? Continuingly, Michelson left to the world three prospects deserving thorough scrutiny. The first is a hint of a geometrical construction where, according to Huygens' principle in conjunction with the corpuscular view, the absolute paths of the light pencils in space after their trips to-and-fro in his interferometer don't exactly reunify. The second one is the actually observed null-result, surprisingly showing that the light rays perfectly reunify. The third fundamental is an elaborate proposing Aetherdrift detection by looking for a violation of the law of reflection. Nevertheless, it is strange to realize that just the obvious discrepancy between Michelson's ray-optical construction and the experimental null-result never attracted attention of the surveyors. As a consequence the third prospect was dropped in the past and was envisaged again recently.

Investigation of the scattering of VLF field at a three-dimensional ionospheric irregularity, associated with red sprites

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The paper is devoted to mathematical simulation of the Trimpi effect on the base of the studies of VLV field diffraction at a three-dimensional irregularity in the lower ionosphere. The Trimpi effect is a short-time variation in the amplitude and phase of VLF signal caused by appearance of a local three-dimensional perturbation in the lower ionosphere. The scientific community pays a great attention to studies of the phenomena related to thunderstorm activity. It became clear relatively recently that many of these phenomena are accompanied by local changes in the properties of the lower ionosphere (electron concentration and collision frequency). Sprites are rather rare phenomena and it is still impossible to reproduce them in laboratory, so for their studies all possible methods should be adopted including the VLF remote sounding method observing and studying variations in the fields of permanently operating VLF transmitters. The goal of this paper is by a mathematical simulation to obtain the tendencies of the electromagnetic field behaviour in the presents of such phenomenon as sprites.

In this paper to solve the problem of the vertical electric dipole field in the Earth-ionosphere waveguide with a local irregularity at the upper wall, an original method based on the integral equations theory is applied. The irregularity is chosen in the form of a finite by height cylinder without any limitations on the shape and dimensions of its cross-section. Though in publications there are indications to a presence of a fine structure of the sprites, our model does not take into account such structure, but models a sprite as a scattering volume.

Solving integral equation

$$\Pi(\overrightarrow{R}) = \Pi_0(\overrightarrow{R}) + \frac{ik\varepsilon_0}{P_0}\iint\limits_{S_p}\Pi(\overrightarrow{R'})\left[\delta_p(\overrightarrow{R'})\Pi_0(\overrightarrow{R},\overrightarrow{R'}) - \frac{\partial\Pi_0(\overrightarrow{R},\overrightarrow{R'})}{ik\partial z'}\right]dS' +$$

$$+\frac{\varepsilon_0}{P_0}\iint\limits_{S_l}\frac{\partial\Pi_0(\overrightarrow{R'})}{\partial n'}\left[\Pi_0(\overrightarrow{R},\overrightarrow{R'}) - \frac{1}{ik\delta_l}\frac{\partial\Pi_0(\overrightarrow{R},\overrightarrow{R'})}{\partial n'}\right]dS_l',$$

where $\overrightarrow{R}(r,\varphi,z)\notin S_p, S_l$ denotes the observational point, $\overrightarrow{R}(r',\varphi',z')\in S_p, S_l$ corresponds to the integration point, n' is the normal directed outside the waveguide volume, $\Pi_0(\overrightarrow{R})$ is the field of the initial source in a regular waveguide with a thickness of h and homogeneous walls with the impedances δ_g and δ_i, and $\Pi_0(\overrightarrow{R},\overrightarrow{R'})$ is the Green function. If the vertical component of the Hertz vector is known, one can obtain the electrical component E_z of the electromagnetic field $E_z = \left(k^2 + \frac{\partial^2}{\partial z^2}\right)\Pi(r,\varphi,z)$. In previous papers the attenuation function of the Hertz vector was considered.

On the base of the numerical simulation performed in terms of the field vertical electrical component, one can draw the same conclusions, as for investigation of the attenuation function. The calculation of the attenuation function is more compact and occupied less CPU time. Above conclusions are: 1) not only the forward scatter of the field but the backscatter as well are observed; 2) the irregularity impact depends on the propagation path orientation relative to the geomagnetic field, on the underlying surface properties, and the irregularity location and its geometric dimensions; 3) the found field variations are of a significant character and can be detected experimentally.

Solar Grand Minima and random fluctuations in dynamo parameters

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We consider to what extent the long-term dynamics of cyclic solar activity in the form of Grand Minima can be associated with random fluctuations of the parameters governing the solar dynamo. We consider fluctuations of the alpha-coefficient in the conventional Parker migratory dynamo, and also in slightly more sophisticated dynamo models, and demonstrate that they can mimic the gross features of the phenomenon of the occurrence of Grand Minima over a suitable parameter range. The temporal distribution of these Grand Minima appears chaotic, with a more or less exponential waiting time distribution, typical of Poisson processes. In contrast, the available reconstruction of Grand Minima statistics based on cosmogenic isotope data demonstrates however substantial deviations from this exponential law. We were unable to reproduce the non-Poissonic tail of the waiting time distribution either in the framework of a simple alpha-quenched Parker model, or in its straightforward generalization, nor in simple models with feedback on the differential rotation. We suggest that the disagreement may only be apparent and is plausibly related to the limited observational data, and that the observations and results of numerical modeling can be consistent and represent physically similar dynamo regimes.

The relationship of relativistic electron flux in the outer radiation belt at low and geostationary orbits with the solar wind parameters and geomagnetic indexes

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Dynamics and acceleration mechanisms of the relativistic electron flux in the Earth's outer radiation belt (ERB) (3.5L6.5) have been discussed for many years. However, there is still no established theory of the acceleration of electrons to relativistic energies describing all the principal features of their variations. These relativistic electrons are an important source of radiation damage and malfunction to the near-Earth spacecraft by producing a volumetric ionization in their electronic circuits. Here the relationships between the electrons with energies from hundred keV to several MeV measured by low-orbiting satellites CORONAS- I, -F and by geostationary satellites GOES and LANL, solar wind and geomagnetic indexes, including ULF–index, are statistically studied. Also, several events from the declination phase of solar activity of 22-th solar cycle (1994) and from the maximum of the 23-rd solar cycle (2001-2004) are analyzed in greater detail. The orbit of CORONAS-F satellite (initial altitude 500 km, inclination 82.5 degrees) enables one to monitor the relativistic electron fluxes of the Earth's outer radiation belt. We have found that significant enhancements of relativistic electron flux were observed not only during strong magnetic storms near solar maximum, but also after weak storms caused by the high speed solar wind streams. The solar wind cannot be a direct driver for the electrons in question, so the solar wind energy can be transmitted to seeding 10–100 keV electrons through the ULF hydromagnetic waves. The influence of the ULF wave activity on the electron fluxes in the outer ERB, as characterized by different ULF indexes for the magnetosphere and interplanetary medium, is examined. The relations between the solar wind velocity, ULF pulsations, and relativistic electron flux are studied in details at different solar cycle phases in order to estimate the specific role of each factor from mutually related parameters.

High latitude magnetosphere dynamics during magnetic storms: energetic particle data from low-altitude satellites and global magnetospheric modeling

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Variations of the energetic particle fluxes at high latitudes are an important part of the magnetospheric dynamics during magnetic storms. Experimental data obtained during magnetic storms by low-altitude satellites (polar circular orbits with 350-1000 km altitudes) permit to investigate the high latitude Earth's magnetosphere structure and its dynamics. We have compared the variations of the solar particle boundary penetration measured by CORONAS-F (altitude 350-400 km, inclination 82.5 degrees) and Universitetskiy-Tatiana (altitude 1000 km., inclination 83 degrees) satellites during magnetic storm on 15 May 2005 (Dst = -263 nT). Solar energetic particles have been used as test particles in the study of the magnetospheric structure. It was obtained that the penetration boundary was shifted to the Earth evening sectors of MLT up to 51 degree 15 May 2005 both at 350 km (CORONAS-F) and 1000 km (Universitetskiy-Tatiana) al-

titudes. Location of measured SEP penetration region was compared with the Polar UVI images. This comparison demonstrates that SEP penetration region corresponds to the polar cap. Variations of solar proton and electron fluxes at high latitudes reflect the auroral oval expansion during magnetic storms. SEP penetration boundary and high-latitude ionospheric footprint of trapped radiation have been compared with those calculated by the model of magnetospheric magnetic field. It was shown that during May 2005 events both SEP penetration boundary correlates well with geomagnetic activity. Spatial location of the outer radiation belt was reconstructed by mapping of the high-latitude boundary of trapped radiation to the magnetosphere. Measured variations of the radiation belt size during the magnetic storm were also investigated.

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Sub-relativistic electron precipitation at high latitudes: low-altitude satellites observations

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The precipitation of electrons with the energies more than 300 keV to the pole of external radiation belt is investigated. Results of observations of CORONAS-F satellite are used. Low altitude (350–500 km) CORONAS-F satellite was launched into a circular orbit with an inclination of $\sim$82.5° and with an initial altitude of about 500 km on July 31, 2001. It operated until December 12, 2005 with a final altitude of about 350 km. Its orbital period ($\sim$1.5 hours) corresponds to about 15 circuits per day. Charged particles in different energy ranges (protons with energy: 1–90 MeV, electrons: 0.3–12 MeV) were measured by semiconductor and plastic scintillator telescopes. Localized electron precipitations were observed to the pole from the external boundary of the external radiation belt. It is shown that such kind of precipitations can be observed for about a half of polar crossings. The most of them were observed during northward B_z component of interplanetary magnetic field. Results of CORONAS-F measurements are analyzed together with data of auroral satellite METEOR-3M to find the localization of observed electron precipitations. The nature of observed phenomena is discussed.

Absorption of electromagnetic energy of the MF-range in the bottom ionosphere

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The analysis of natural and antropogenous components flows of electromagnetic energy of MF range at the upper boundary of the channel Earth-ionosphere is presented. Comparison of outputs, emanated in SW-, MW- ranges by anthropogenic sources and lightning discharge shows, that the lower border of ionosphere receives in the first case $\sim$1 GWt, and in the second $\sim$1–10 MWt. The output that enters the lower ionosphere is close to the output of Earth kilometer emanation and is comparable to the output, emanated by the magnetospheres of Jupiter in SW and Saturn in MW ranges.

The maximal value of total capacity for a range 0.3–1.7 MHz falls at the European continent and a part of Asia adjoining to it (225 MWt). Further East Asia and Oceania (93 MWt) is allocated. Central (6.5 MWt), Southern (14 MWt) and Northern America (16 MWt) it is possible to group in separate region. Capacity distribution of MF radio emission to surfaces of Earth is extremely non-uniform and subject to sharp differences. So, for the Central European region in a small frequency interval ($\sim$1 MHz) the capacity comparable to capacity in all HF range ($\sim$30 MHz) is concentrated.

Besides absorption of electromagnetic emanation, lower ionosphere can play the role of a detector, emphasizing the low frequency component of the radio signal. The main type of modulation in MW, SW ranges is amplitude modulation. For the signal with modulation index equaling 30%, the share of the energy in envelope is $\sim$1.1%. If one assumes, that on absorption all the energy of low frequency envelope transfers into low frequency emanation, then we should establish, that in the lower ionosphere above European continent, there is a low frequency transmitter that works constantly in the frequency band 50 Hz – 5 kHz, emanating output of which is $\sim$2.5 MWt.

High velocity solar wind flows with V = 700–800 km/s within the outer and inner heliosphere

Nikolskaya, K.I. (IZMIRAN, Troitsk, Russia)

Stationary solar wind (SW) velocities measured in situ by Ulysses and observed using removed sensing IPS methods, respectively in the outer and inner extra-ecliptic heliosphere, are combined to extend the range of the heliocentric distances of data from $r = 2.5\,R_\odot$ to $r \approx 5\,AU$. Ulysses' measurements cover the period of about three its orbits around the Sun (~ 1.5 solar cycles) with three flights over south and north solar poles and three crosses of the ecliptic in perihelion. There were activity minima during Ulysses' polar passes on the first and third orbits and activity maximum on the second one. IPS SW observation in the inner high latitude heliosphere has been performed near minimum activity in 1994 and 1995 during Ulysses' flights over solar south and north poles. The general results of the analysis of the stationary SW speeds can be represented as follows:

1. in and around activity minimum the entire Sun apart from the regions within the streamer belt is a source of high velocity SW with uniform top speeds $700 \div 800\,km/s$;
2. SW outflow with stable velocities $700 \div 800\,km/s$ is a phenomenon of the quiet Sun solely;
3. in the high activity epochs heliosphere is dominated with low speed ($V \leq 500\,km/s$) SW;
4. SW acceleration has not been found within the heliocentric distances $2.5 \div 100\,R_\odot$, and conversely, in the IPS diagrams $V_{SW}(r)$ one can see features of SW speed increase from $750 \div 800\,km/s$ at $r \approx 10R_\odot$ up to $\sim 1000\,km/s$ near the solar surface.

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On a close relationship between the stationary solar wind velocities and the solar magnetic fields

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A linkage: stationary solar wind (SW) velocities $\longmapsto$ solar corona structures $\longmapsto$ solar magnetic fields has been investigated using in situ Ulysses' and ground based IPS measurements of the stationary SW speeds over 1.5 solar cycles with XUV – corona observations (Yohkoh and EIT/SOHO) and solar full disk magnetograms utilized. It has been found that in any phases of the solar activity the stationary SW velocities are in inverse relation with solar magnetic field (SMF) strength in the regions of flow escape: the weaker magnetic fields the faster SW. In and around activity minimum when weak background closed magnetic fields ($100\,G$) prevailed on the Sun only high velocity SW with uniform speeds $700 \div 800\,km/s$ was detected within the outer and inner heliosphere beyond the streamer belt. The slow SW flows ($300 \div 500\,km/s$) are associated with strong closed magnetic structures over the neutral line of the global solar magnetic field as well as with strong magnetic fields of the active regions dominating on the Sun of the high activity epoch.

The general findings are the following:

1. solar magnetic fields are not only responsible for the corona formation, they also control the solar wind velocities via SW plasma – SMF interactions inside of the source surface;

2. SW - SMF interactions occur within the real local magnetic features and SMF structures are imprinted into the SW flows as their velocity variations;

3. outside of the source surface SW flows move influenced only by the solar gravitation.

An analysis of SMF–SW velocity relationship together with some other SW properties can lead us to the understanding of the SW nature.

This study is supported by grant of Russian Fund of Fundamental Researches (RFFR) No. 08-02-00070.

A magnetic storm decreases coherence of electric potential oscillations of a human brain

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Plenty of technological processes are known to be damaged by magnetic storms. But technology is controlled by men and their functional systems may be damaged as well. We are going to consider the electo-neurophysiological aspect of the general problem formulated and investigated at first by V.I. Verdansky and A.L. Tchijevsky: men surrounded by geophysical fields including ones of cosmic origination. The effect formulated in the title was observed for a group of 13 students (practically healthy girls and boys from 18 to 23 years old). To control the main functional systems of the men under investigation, their electroencephalograms (EEG) were being registered along with electrocardiograms, respiratory rhythms, arterial blood pressure and other characteristics during a year. According to the EEG investigations during implementation of the proof-reading test in absence of magnetic storms, the values of the coherence function of time series of the θ-rhythm oscillations ($f = 4 - 7.9$ Hz, $A = 20$ μV) of electric potentials of the frontal and occipital parts of the head belong to the interval [0.3, 0.6] for nearly all of the students under investigation. (As the proof-reading test, it was necessary to choose given symbols from a random sequence of ones demonstrated at a monitor and to enter the number of the symbols discovered in a computer. Everyone was known that the time for determination of symbols is unlimited. On the other hand, nobody was known that the EEG and other registrations mentioned are connected with geophysical events). Let us formulate the *main result*: by implementation of the same test during a magnetic storm, $5 \leq$K≤ 6, or no later then 24 hours after its beginning (different types of moderate magnetic storms occurred, the data of the IZMIRAN were used), the values of the coherence function of all of the students of the group under consideration occurred to be decreased up to 0.1 or less including 0. The similar result was obtained for another basic low-frequency electro-neurophysiological rhythm δ ($f = 0.5 - 3.9$ Hz, $A = 20$ μV). The usual coherence function values from the interval [0.3, 0.6] were being registered, typically, about 48 hours after the magnetic storm end. The result about decreasing of the coherence of the brain low frequency bioelectric oscillations under a magnetic storm influence was obtained by two methods: 1) comparison of the time series of bioelectric oscillations of a given person without a magnetic storm and under its influence; 2) comparison of two sets of time series of oscillations: a) the set A of time series measured without a magnetic storm and b) the set B of time series measured under its influence, regardless to an individual. Surely, the total number of the EEGs available for the investigation by the set's approach (i.e. without personification) is more then the number of the EEGs available by the individual approach because there were ones investigated without a magnetic storm only as well as ones investigated under its influence only. By the EEG measurements with closed or open eyes, but without a functional load on the brain in the form of the proof-reading test, a distinctive decrease of the coherence function was not observed during a magnetic storm as well as for pairs of points from other parts of the head (see above) or other rhythms.

Common oscillatory modes in solar/geomagnetic activity, NAO index and surface air temperature records

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Detection and extraction of quasi-oscillatory dynamical modes from instrumental records of geophysical data became a useful tool in analyzing variability of observed phenomena reflected in complex, multivariate geophysical signals. Using the extension of the Monte Carlo singular system analysis (MC SSA), based on evaluating and testing regularity of dynamics of SSA modes against the colored noise null hypothesis, we demonstrate detection of oscillatory modes with periods of approximately 8 years in the long term records of aa index geomagnetic activity as well as in the records of surface air temperature from several mid-latitude European locations and in the NAO index.

Uncertainty in information on deep ocean water transport as a limiting factor for radiocarbon paleoastrophysics

Ogurtsov, M.G. (Ioffe Physico-Technical Institute of the RAS, St. Petersburg, Russia)

Data on 14C concentration in terrestrial archives have been successfully used for reconstruction of solar activity in the past. But in order to extract the most reliable information one have take into account limitations of radiocarbon paleoastrophysics as well as its advantages. It is shown that lack in knowledge on character and structure of water circulation in deep ocean prevents us from using radiocarbon proxies for reconstruction of long-term (period more than 1000 years) variations of the Sun's activity. Other possible sources of uncertainty are discussed.

Middle latitudes geomagnetic field variations of the magnetospheric and ionospheric sources during strong magnetic storms

Orlyuk, M.I., Sumaruk, Yu.P (Institute of Geophysics NAS of Ukraine, Kiev, Ukraine)

Geomagnetic variations at middle latitudes are generated by magnetospheric sources, such as magnetopause current (DCF), magnetospheric ring current (DR), tail current (DT) and also auroral ionospheric currents (DP) and ionospheric Sq-current system. Eleven powerful magnetic storms recorded at magnetic observatory "Lviv" during 1980–1992 years were investigated. As zero level we used mean per corresponding month five international quiet days variations. DCF-variations were calculated by means of Mead model. Variations due magnetospheric ring and tail currents were calculated as (Dst - DCF)*cosF, were F is geomagnetic latitudes of the observatory. We believed that differences between absolute values of horizontal component and Sq+DCF+(Dst - DCF)*cosF presents the variations generated by return current from auroral electrojets into middle latitudes, with Dst150 nTl and auroral electrojets when Dst150 nTl.

Interpretation of remainders and comparison to changes of corrected AU and AL indices fulfilled.

Polarization of ELF-VLF waves in the waveguide Earth – ionosphere

Ostapenko, A.A., Titova, E.E. (Polar Geophysical Institute, Apatity, Russia); Turunen, T., Manninen, J., Raita, T. (Sodankylä Geophysical Observatory, Sodankylä, Finland)

Ground based registration of ELF-VLF waves has been performed in frequency range from 0 to 10 kHz in Northern Finland in November 2006. Monitoring showed different behavior of waves with right-handed (R) and left-handed (L) circular polarization in the vicinity of critical frequency of waveguide Earth–ionosphere ∼2 kHz. From 1.6 to 2.3 kHz the L-power was much greater than R-power whereas between 5 kHz and 10 kHz R and L powers were equals. For these frequencies WKB-theory methods are inapplicable therefore we calculated attenuation of waves on base of "full-wave" equation

$$d\mathbf{e}/dz = ik\widehat{T}\mathbf{e}$$

where $\mathbf{e} = [Ex, Ey, Hx, Hy]^t$— column–vector of amplitudes of wave fields components, z — height in ionosphere, $\mathbf{k}$ — wave vector, matrix $\widehat{T}$ depends of parameters of ionosphere and of components of wave vector. The model IRI of the ionosphere was used in calculation. If we have in right side of wave equation source of wave field, this equation describe the processes of generation, propagation and linear transformation of waves. Boundary conditions of task consist of radiation conditions in the upper ionosphere and conditions for ideal conductor for the Earth. The task has unique solution when the condition

$$\begin{vmatrix} E_{x1} & E_{y1} \\ E_{x2} & E_{y2} \end{vmatrix} \neq 0$$

is satisfied on the ground. Here $E_{x1}, E_{y1}, E_{x2}, E_{y2}$— amplitudes of waves, after downward integration of upward waves from the Earth to upper ionosphere. Condition

$$\begin{vmatrix} E_{x1} & E_{y1} \\ E_{x2} & E_{y2} \end{vmatrix} = 0$$

for wave equation without source describes resonance modes for waveguide Earth–ionosphere. Our study relate to auroral latitudes and clearly shows that the appearance of maximum in spectra of VLF waves near critical frequencies 1.6–2.3 kHz due to small absorption of left (L) waves and excitation of resonance waves of waveguide Earth–ionosphere. The ratio between waves with right (R) and left (L)-polarization enables to locate sometimes the region of the exit to the Earth of magnetospheric VLF emissions.

Some properties of geomagnetic pulsation bursts generated by pulses of the solar wind pressure

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On the basis the Interball spacecraft observations of the solar wind ion flux with 1-s resolution along with observations of geomagnetic pulsations at three ground stations spaced in longitude for 70 degrees, peculiarities of pulsation bursts in the range of 0.2-5 Hz generated by strong pulses of the solar wind pressure are investigated. The comparison of the bursts parameters associated with the sharp increase of the plasma density and pressure at fronts of interplanetary shocks is performed. Under the northward direction of the interplanetary magnetic field, short (less than 5 minutes) pulsation bursts with a changing frequency are generated. A dependence of the starting frequency of the pulsations on the value of the solar wind ion flux (pressure) jump is noted. Possible mechanism of the pulsation burst generation is discussed.

SINP space monitoring data center portal

Parunakian, D.A., Kalegaev, V.V., Bobrovnikov, S.Yu., Barinova, W.O. (Skobeltsyn Institute of Nuclear Physics, Moscow State University, Moscow, Russia)

The current version of the SMDC portal is an adjustable tool for accessing various types of space weather related data. First and foremost, SMDC provides interfaces to SINP databases of satellite measurements; these include multiple Russian spacecraft experiments, such as Tatyana and Meteor-3M, as well as international and foreign experiments (Coronas-F, COHO, etc.). The experimental data can be retrieved as an archived table or as automatically generated charts. Each data retrieval procedure requires the user to specify the data channels to retrieve and the time interval. Detailed descriptions for many experiments are provided. The SMDC portal also provides interfaces to several online models, such as the paraboloid model of the Earth's magnetosphere and the COSRAD model. Users

can submit parameters to these models and receive results in a short time. Among other implemented services are database of magnetic storms with a Dst threshold selection capability, a massive database on solar flares (2005 - 2006) which includes multiple characteristics and charts; pre-rendered charts of charged particle measurements by the Coronas-F satellite. A recent addition to the SMDC portal is the space weather monitoring tool. This tool processes realtime measurements of the ACE spacecraft and calculates the magnetopause standoff distance. The history of magnetopause standoff distance during the last hour and the last day is displayed as charts, while tables containing numeric values are also available in one additional click. Another important feature of the portal is the up-to-date directory of space physics related links. The links are divided into distinct cathegories for easier navigation. The portal has two modes of operation: normal and authorised. The authorised mode requires the user to enable his browser's support of cookie and provides a substantial amount of additional services: new satellite databases, model source code, etc.

Study of cosmic rays cutoff variations during strong magnetic storms

Pchelkina, E.V., Vashenyuk, E.V., Pchelkin V.V. (Polar Geophysical Institute), Apatity, 184200 Russia)

A relationship between the cosmic rays cutoff variations and magnetic storm parameters, primarily, the Dst index, has been studied. A comparison of cosmic rays cutoff variations computed with the use of the T-2003 model with the effect of several midlatitude and low-latitude cosmic ray stations of the worldwide monitoring network has been performed.

Fast dynamic of magnetic Pi2 pulsation ionosphere sources

Petlenko, A.V., Kopytenko, Yu.A. (SPbF IZMIRAN, St.Petersburg, Russia), Pilipenko, V.A., Martines, V.A. (IPE, Moscow, Russia)

Ground-based magnetic field observations of magnetosphere Pi2 magnetic pulsations are realized by means on ionosphere currents associated with Pi2 FACs. That is the first reason of Pi2 source location problem where Pi2 source is interpreted as a magnetosphere FAC footprint in ionosphere. The next one is a fast movement of these sources at every Pi2 semi-period. Furthermore high-latitude Pi2 magnetic field analysis represented in this work on the base of “BEAR” network magnetic data observations shows that the real difficulty of this problem solution is caused by simultaneous operation of different ionosphere pulsations sources. Coherent turn-on/-off for different field aligned currents of the same sign as for up-ward currents so for dawn-ward ones is efficiently distort commonly accepted representation about unidirectional Pi2 FAC localization. But coherent turn-on/-off for field aligned currents of opposite sign is not contradicted to existing Pi2 model that allows treat it as equivalent current system of Pi2 magnetic pulsations at the most part ($\sim$75-80%) of their period. The prove of clauses mentioned above is based on the comparison of filtered magnetic pulsations components distributions with auroral intensifications obtained by “Polar” satellite and on the compliance of local extremes in distributions of magnetic Pi2 vertical component with the results of Pi2 supposed sources location from the evidence of generalized gradient analysis of magnetic pulsations field. As a consequence of this analysis a good correspondence of auroral and magnetic intensifications boarders were obtained. But peculiarities of Pi2 magnetic components distributions move irregularly during every Pi2 semi-period and their fast movement is obtained every time when Pi2 FACs change the sign.

ULF wave activity during a substorm onset as observed by Themis satellite and Antarctic array

Pilipenko V.A., Chugunova O.M. (Space Research Institute, Moscow); Martines V.A. (Institute of the Physics of the Earth, Moscow)

We analyze several ULF wave events in 2007 using the multi-spacecraft Themis magnetometer observations, and MACCS-CARISMA and Antarctic arrays of magnetic stations. Whenever possible, we augment the magnetometer observations with the data of Polar UVI. The ULF activity comprise Pi2 transient signal and Pi1 burst. The dynamic spectra reveal that Pi1 burst can propagate poleward into the polar cap, even across the geomagnetic pole.

Formation of local atmosphere field under the influence of ionization factors

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The influence of different ionization factors on the formation of local atmospheric electric field (AEF) in the near-ground layer is considered in the present work. Estimations of change of AEF strength (E_z) due to conductivity variations under the influence of radon and cosmic ray intensity are presented. It is shown that atmospheric conductivity changes due to ionization under the influence of radon emanations and it is determined by escalation and turbulent diffusion of the near-ground layer. While cosmic ray intensity affects the conductivity of the near-ground layer under the influence of change of ion recombination state. Atmospheric conductivity decrease, determined by cosmic ray flux, decreases E_z whereas radon sink decrease leads to E_z increase. Evaluation of influence of light conditions on AEF value due to the change of relative concentration of heavy and light ions under the influence of photodetachment and photoattachment processes is given. This process may, evidently, explain the morning maximum for the days with fair weather conditions in diurnal E_z variation. It is shown, that the effect of "spread current" potential from auroral electrojet region to mid latitudes during geomagnetic disturbances may contribute AEF variations of about 5%.

The PSUM 85-08 MODEL

Ponomarev, E.A., Sedykh, P.A., Urbanovich, V.D., and Mager, O.V. (Institute of Solar-Terrestrial Physics, Irkutsk, Russia)

Presented are the results of some attempts to develop the models describing the basic magnetospheric processes in terms of physics. The model consists of the following blocks (submodels):
– The model for the transformer of kinetic energy of the solar wind at the leading edge of the Bow shock to electromagnetic and gas kinetic energy.

– The problem of the penetration into the magnetosphere of electromagnetic energy generated at the leading edge of the Bow shock is described in terms of physics.
– The formation processes of convective motion of plasma are considered for the conditions of the interaction of BS-generated electric fields and currents with it and plasma losses due to the pitch-angle diffusion into the loss cone. The formation of gas pressure distribution, three-dimensional current systems and particle precipitations is described for the steady-state and unsteady cases.
– The model for the formation of irregularities that are responsible for break-up is suggested. The aforementioned blocks provide a consistent picture of the response of the magnetosphere to changes in the solar wind which is in qualitative agreement with the observe done.

Charged nano- and microscale particles in space weather events

Popel, S.I. (Institute for Dynamics of Geospheres RAS, Moscow, 119334 Russia)

Space weather refers to the conditions on the Sun and in plasmas of the Solar wind, magnetosphere, and ionosphere that can influence the performance and the reliability of space-borne and ground-based technological systems and can endanger human life or health. This presentation gives a review on the role of charged nano- and microscale dust particles in space weather events. In particular, the processes in innermost dust cloud in the Solar corona, in the interplanetary dust, in the dust of Solar wind, Earth's magnetosphere and ionosphere are discussed. Dust particle charging is considered. It is shown that the presence of the charged dust changes drastically the properties of the corresponding objects. This is related to the properties of the dust to acquire very big variable charges and a tendency of the plasma-dust system to self-organization and to formation of structures. The importance of the collective processes with participation of the charged dust and the process of dust particle charging is illustrated by examples of the interaction of Solar wind with a cometary coma and the dusty mesosphere.

Observational signatures of successive reconnection pulses

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We investigate model data produced by several successive reconnection pulses. It is shown that a serial of such pulses tends to induce a clear trend in the time-evolution of the x- and z-components of both, the magnetic field (Bx, Bz) and plasma velocity (vx, vz). More precisely, we observe for the Bz and vx components a characterisitic increase in time and for the Bx and vz components a vice versa behaviour. The characteristic signatures with a trend in time during the pulse propagation are seen only at moderate distances of the observer from the current layer. Observers closer to the current layer will see the direct effect of every single pulse onto the behaviour of the magnetic field and plasma velocity. Observers further away will see the pulses joined and this looks similar to a single pulse event.

Cosmic weather effects on the East-Siberian Railway (2004–2005)

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Modern electronic systems functioning on the Earth and in the space are affected by space weather: electromagnetic fields and plasma processes originating in the Sun–solar wind–magnetosphere–ionosphere–Earth chain. Intense geomagnetically induced currents (GIC) can hamper rail traffic by disturbing signaling and train control systems. In the present report we analyzed anomalies in operation of automatic signaling and train control equipment, occurred in 2004-2005 on the East-Siberian Railway located at mid-latitudes. The anomalies consist mainly in unstable functioning and false operations in traffic automatic control systems (rail chain, switches, locomotive control devices, etc.), often resulting in false engagement of railway tracks (red signals instead of green). It has been obtained that the total daily duration of failures and breakdowns during disturbed periods is controlled by geomagnetic activity. When a peak of geomagnetic

activity is reached during a storm, T increases in 2–4 times. It has also been found a significant correlation between the T and different indices of geomagnetic activity (Ap, Kp, Dst and local index A in the Siberian magnetic observatory Podkamennaya Tunguska) during disturbed periods.

Solar activity, cosmic rays, and climate change (on the 75th anniversary of M.I. Pudovkin)

Raspopov, O.M. (SPbF IZMIRAN, St. Petersburg, Russia); Veretenenko, S.V. (Ioffe Physico-Technical Institute of RAS, St.Petersburg, Russia)

A review of the data obtained by M.I. Pudovkin, his associates and followers on the problem of the influence of solar activity on atmospheric processes and climate change are presented. Later research activities in this field are described. Attention is drawn to the necessity to include into consideration the atmospheric circulation when analyzing the formation of the global pattern of the atmosphere—ocean system response to solar forcing.

On a combined influence of long-term solar activity and geomagnetic dipole changes on climate change

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The influence of variations in galactic cosmic rays (GCR) on climate change has been analyzed for the time intervals of thousands and tens of thousands of years. It has been shown that in the last millennium quasi-two-hundred-year variations in the GCR intensity (variations in the cosmogenic 14C isotope concentration in dated tree rings) modulated by solar cyclicity (the $\sim$210-year cycle) correlated well with similar climatic changes (temperature and precipitation variations). The correlation coefficient between variations in GCR and climatic parameters for different regions of the Earth has been found to range from 0.58 to 0.95. Analysis of variability in the concentration of the cosmogenic 10 isotope (that also reflects the GCR flux variability)

in Greenland ice for the time interval from 20,000 to 50,000 years ago has revealed that the 10Be concentration was modulated by the quasi-two-hundred-year solar cycle. Comparison of variations in the cosmogenic 10Be isotope concentration with changes in the magnitude of the virtual axial dipole moment (VADM) of the geomagnetic field has shown that the envelope of the 10 concentration amplitude correlated well with the VADM variations. Thus, it can be concluded that long-term solar activity and geomagnetic dipole changes exert a combined influence on the GCR fluxes that enter the Earth's atmosphere and affect the climate. A decrease in the geomagnetic dipole leads to the enhancement of the total GCR flux on the one hand and increase in the depth of modulation of the GCR fluxes caused by solar activity variability on the other hand. The work was supported by the Presidium of RAS (Program "Environmental Changes and Climate"), Presidium of St. Petersburg Science Centre of RAS, and the Russian Foundation for Basic Research (projects 06-04-48792a, 06-02-16268a, 06-04-64200a).

High frequency waves observation in the plasmaspheric region by WHISPER/CLUSTER experiment

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The Wave of High frequency and Sounder for Probing of Electron density by Relaxation (WHISPER) instrument records the natural waves in the 2–83 kHz bandwidth and makes a diagnostic of the electron density using the sounding technique on each of the four satellites of the CLUSTER mission. The various working modes and the Fourier transforms calculated on board provide a good time and frequency resolution and allow us to detect the fine structure of various emissions as well as their spectral characteristics in relation to the local plasma regime (gyro-frequency F_{ce} and plasma frequency F_{pe}). Intense electrostatic emissions with frequencies between the harmonics of the electron gyrofrequency, often referred to as $(n + 1/2)F_{ce}$ emissions, are routinely observed by the WHISPER instruments on board the CLUSTER constellation at magnetic equator traversals in the plasmasphere region. The $(n + 1/2)F_{ce}$ emissions appear to be strongly confined near magnetic equator, however with significant evolution of their fine characteristics with latitude.

The statistical study of these emissions, using a data set covering the three years time interval 2002–2004, shows that the confinement at the geomagnetic equator, $\sim \pm 2$ degrees, does not vary much from one case to another. The MLT dependence displays general features previously reported by precedent observations, like a larger occurrence at dawn sector. We investigate in detail the dependence of the intensity with MLT and with the closeness of observation with the plasmapause boundary. This leads to an estimation of the occurrence and position of most intense emissions, i.e. at levels above the reference level quoted by several authors as meaningful for strong pitch angle diffusion of 100 eV to keV electrons, leading to their subsequent precipitation into the auroral ionosphere.

Diurnal variation of cosmic ray intensity

Roldugin, V.C. (Polar Geophysical Institute, Apatity, Russia)

The morphology of diurnal variations of cosmic ray intensity is studied for data of 17 stations for 1985 and 1986. Theses variations are most intensive at geomagnetic latitudes between $40^\circ - 60^\circ$ and are controlled by magnetic local time. Their maximum occurs at 1300–1500 MLT . The amplitude is highly changeable and reaches to 0.8%, strong variations continue 1–3 weeks. Accordingly to the Apatitian neutron monitor data for 1985-2000, these periods are characterized reliably by Kp, Ap, Ae and WN indexes increase, but the correlation coefficients are not too large, they are about of 0.20–0.22. Their most probable reason is magnetospheric configuration change.

Natural oscillations of the magnetotail as a cause of "saw-teeth" events in GOES magnetic data

Roldugin, V.C., Pchelkin, V.V., Belakhovsky, V.B. (Polar Geophysical Institute, Apatity, Russia)

The tilt angle of the magnetic field lines, passing through GOES-8 and GOES-10 satellites, to the geographic equatorial plane is investigated for 2000 year. Sometimes the magnetic filed lines stretch to the tail.

The ratio of the earthward he-component to the parallel to Earth axis hp-component, exceeding 1, was observed in this year during 10% time at GOES8 and during 4% at GOES10. This stretching occurs near geomagnetic midnight and mostly at summer time. The slope has oscillation mode with period about of 2-4 hours, and geomagnetic activity at this time is known as "sawtooth event". The oscillations fall at planetary magnetic disturbances: Kp-index is between 4.0 and 5.1, but the stretching is not accompanied by substorm activity; a substorm appears in depolarization phase, or at reset of field line configuration.

We suppose that these hour-long oscillations are due to the wave motions of the Earth magnetotail, which have been forecasted by Yershkovich and Nusinov in end of the seventies. For several "sawteeth events" the expected by Tsyganenko magnetosphere model incline is calculated and compared with experimental data. The Tsyganenko model renders slow variations, due to changes of IMF, solar wind pressure and Dst, enough well, but the "saw-teeth" are absent in the calculations, and it confirms the idea about natural oscillation of the tail.

Empirical model for the description and prediction of magnetospheric electron dynamics

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The creation of electron flux prediction models is very important, because these particles pose the main hazard to the functioning of high-orbit spacecrafts. Commonly, relativistic electron enhancements in the outer radiation belt are associated with magnetic storms. However, the wide variability of the response and the puzzling time delay of two days between the storm main phase and the response of the radiation belt have frustrated the identification of responsible mechanisms. Moreover, some electron events may occur even without a magnetic storm or during very mild storms. The efficiency of these non-identified mechanisms of the energetic electron acceleration is strongly enhanced upon increase of solar wind speed. Because the solar wind does not interact directly with magnetospheric electrons, some intermediary phenomenon must more directly provide energy to the electrons. Rather surprisingly, ULF waves in the Pc5 band (few mHz) have emerged as a possible energy reservoir: the presence of Pc5 wave power after minimum Dst was found to be a good indicator of the relativistic electron response. In the literature it has also been shown, that auroral activity is of great importance for the appearance of electron enhancements (presented, for example, as AE index).

Partial least-squares (PLS) regression is a method that can deal efficiently with data sets where there are very many variables that are highly correlated and is gaining importance in many fields of science. An empirical model for the relativistic electron dynamics, constructed by means of the PLS method, will be presented in this work. The model uses as input parameters a set of heliogeophysical index values (Dst, AE, R, ULF, etc.) covering the previous three days of observation. It permits one to forecast the electron flux level and estimate the contribution of each input parameter to the result. The model has been applied to few years of data (1994–2003) and results indicate that ULF wave activity in the magnetosphere is found to play an important role in the relativistic electron flux increase. Furthermore this model is able to predict electron flux levels several hours in advance. The correlation coefficient of the predicted electron flux with the measured flux varies from 0.6 up to 0.8 for one hour averaged values.

Features of pulsating arcs inferred from ALIS triangulation measurements

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Pulsating auroras are characterized by repetitive intensity modulation in the auroral luminosity. In contrast to discrete auroras, the properties of pulsating auroras are less investigated, since one needs instruments of high sensitivity as well as rather high temporal and spatial resolution for their study. Over 10 years ago, the Auroral Large Imaging System (ALIS) was designed to handle short-lived small-scale auroral forms of low intensity. We present here results of an investigation of one type of pulsating auroras -pulsating arcs — performed using the capability of ALIS. The observations were performed during the recovery phase of a substorm, that is the most typical time for occurrence of pulsating auroras. During the interval, four ALIS digital cameras with fields of view of 57x57 degrees were operating, allowing us to estimate the altitude of the pulsating patterns in the overlap area (60x80 km) with high veracity. It is well known that the altitude of the aurora gives information about the energy of electrons causing the luminosity. The auroras considered looked like a series of thin faint stripes pulsating with a repetition period of a few tens of seconds and drifting slowly equatorward. The triangulation measurements showed that the altitude of the arcs was different for different arcs in a series but did not vary with the intensity variation in each individual arc within one "switch on/off" cycle. This means that the electron precipitation responsible for the arc formation was caused rather by scattering into the loss cone via wave-particle interaction than by field-aligned acceleration in a parallel electric field. In general, the finding is in the agreement with the theory suggested for another type of pulsating auroras - pulsating patches. The possible reason for the generation of the equatorward drifting series of pulsating arcs is discussed.

Interaction of oblique interplanetary shocks with the bow shock

Samsonov, A. (St. Petersburg State University, Russia); Nemeček, Z., Šafrankova, J., Prech, L. (Charles University, Prague, Czech Republic)

We continue previous studies of interaction between interplanetary shocks and the bow shock using a numerical MHD model. This is a first work where propagation of oblique interplanetary shocks from the solar wind through the magnetosheath is investigated by a three-dimensional MHD simulation. The oblique shocks are characterized by a normal diverged from the Sun-Earth line; they are usually driven by corotating interaction regions. We simulate variations in the dawn and dusk magnetosheath after propagation of an artificial shock and also reproduce one real event with an oblique shock observed by Themis and Cluster spacecraft. We show that MHD variations in the magnetosheath for the oblique interaction are similar to those for the direct interaction (i.e. when the shock normal is along the Sun-Earth line) that has been studied previously.

Observations of sudden impulses in the magnetosphere

Samsonov, A.A., Shatrov M. (St. Petersburg State University, Russia)

Sudden impulses are increases (or decreases) of the magnetic field magnitude lasting from a few seconds to a few minutes registered by magnetometers on the ground and in the magnetosphere. It is known that these variations result from interaction of interplanetary shocks with the magnetosphere. However, a direct reason of the magnetospheric variations is unclear. Propagation of fast shocks (or compression waves) inside the magnetosphere and earthward displacement of the magnetopause current would both result in an increase of the magnetospheric field.

We use a shock database of the MIT Space Plasma Group (http://cdaw.gsfc.nasa.gov/geomag_cdaw/data/cdaw1/ kasper/shockdb.html) obtained from WIND observations in the solar wind upstream of the bow shock. Using this database, we find a number of events when corresponding sudden impulses were observed by several spacecraft in the magnetosphere (e.g. Geotail, Polar, Interball, Cluster, Goes). We collect both magnetic field and plasma data and think that this information should help us to determine which explanation of sudden impulses is more correct.

Analytical investigation of 3D impulsive magnetic reconnection using Green function in the frame of incompressible MHD approximation

Sasunov, Yu.L., Semenov, V.S. (St.Petersburg State University, St.Petersburg, Russia)

Magnetic reconnection is the universal plasma process which is responsible for solar flares, magnetospheric substorm and solar wind – magnetosphere coupling. Petschek-type reconnection is distinguished from other models of reconnection such as tearing instability or Sweet-Parker regime, with a local generation of reconnection electric field along the X-line. The 3D time-dependent Green function corresponding to the delta-like behavior of the electric field, is found and investigated for the general current sheet geometry with skewed reconnecting fields and tangential velocities in the frame of incompressible plasma model. Distributions of the magnetic field and velocity components are obtained for different time moments. The wave fronts produced by a sharp pulse of reconnection are studied.

On the nature of plasma inhomogeneities in the magnetosphere

Sedykh, P.A., Ponomarev, E.A. (Institute of Solar-Terrestrial Physics of the Siberian Branch RAS, Irkutsk, Russia)

This paper is devoted to developing of the mechanism for convecting inhomogeneities creation in the geomagnetosphere. In earlier papers [Ponomarev, Sedykh, 1985, 2006] it has been shown that all attributes of substorm break-up can be described if we admit that convecting plasma flow directed from the tail to the Earth has non-uniform structure in the form of the “bunches” moving towards the Earth along with plasma convection. In this paper it is shown that the existence of spatial inhomogeneity of convection velocity and its sudden change in time can create in combine action the spatial–temporal formation which looks like heterogeneity of plasma density (pressure), moving at convection speed (in the direction of the Earth) or at Alfvén speed towards the magnetotail. We show that the structure appears on the magnetosphere night side at the distance of 10–20 Earth radii, because of peculiarities of the electric field of convection. Most likely, plasmoids observed during geomagnetic disturbances moving towards the magnetospheric tail, approximately at Alfvén speed, are Alfvén resonances. Even though mechanisms of generation of both convecting, and Alfvén wave perturbations are similar, conditions of excitation of the latter are harder. Therefore, not all substorms will be accompanied by generation of plasmoids. And may be intensive, but short pulses of south IMF B_z-component can generate plasmoids, but not substorms.

Molecular thermal conduction in numerical models of terrestrial thermosphere

Semenov, A.O., Shved, G.M. (St.Petersburg State University, St.Petersburg, Petrodvorets, 198504 Russia)

The parameterizations of molecular thermal conductivity coefficient, used in numerical models of terrestrial thermosphere at present time, are different. We present the comparison of these parameterizations that is done by the solution of the globally averaged energy balance equation for terrestrial thermosphere. We found the difference in calculated temperature of neutral thermosphere up to 300K and the corresponding density change up to 40% at 300 km, resulted by using different parameterizations. At present, that is the order of uncertainty in molecular thermal conduction arising mainly from different treatment of N_2 and O_2 internal energy transfer in the thermosphere in aforementioned parameterizations. We propose new approximation of temperature dependence of thermal conductivity coefficient for N_2, O_2 and O, based on the latest experimental measurements and theoretical estimations.

Diurnal behaviour of the ionospheric Alfvén resonator signatures as observed at high latitude observatory Barentsburg (L=15)

Semenova, N.V., Yahnin, A.G. (Polar Geophysical Institute, Apatity, 184209, Russia)

The signature of the ionospheric Alfvén resonator (IAR), so called spectral resonant structures (SRS) in the spectra of the electromagnetic noise in the range of 0.1-10 Hz is rather frequently observed with the search coil magnetometer at observatory Barentsburg on Svalbard (L=15). In this report we discuss some peculiarities of diurnal occurrence of SRS at this high latitude station. We show that the pronounced minimum of the SRS occurrence around noon can not be explained by the diurnal variations of the solar zenith angle (illumination of ionosphere). We conclude that the SRS occurrence minimum is the result of the enhanced variability of ionospheric parameters when the observing point enters (during the Earth's rotation) the region of the ionospheric projection of the dayside cusp and its vicinity.

Standard data-based magnetosphere models tuning for THEMIS project

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Empirical magnetosphere models have been used for years since enough amount of data was obtained from satellites (in situ) measurements. Nevertheless modern models still have some serious deficiencies: representation of average magnetosphere conditions, which might have great differences from given moment of time; no possibility to construct local distortions; dependency on solar wind parameters. Another problem is estimation of data error given by certain model, which cannot be calculated because one has nothing to compare model results with.

In order to achieve better tracing of space events to Earth's surface we've developed tool for routine tuning of existing standard data-based magnetosphere models. The tool uses only THEMIS spacecraft magnetic measurements which represent the big data set with good magnetosphere coverage. Also we tested the addition of the magnetic measurements from other spacecraft for the coverage increase and the system stabilization. At the moment we present on the web data we processed using our tool to the world scientific community.

On the problem of correct collocation of ground based (optical) and high-altitude satellite measurements

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The data of multi-spacecraft projects such as CLUSTER and THEMIS, when compared correctly with the ionospheric measurements in the conjugated area, could provide insight into nature of the number of magnetospheric processes. In our study we concentrate on the problem of satellite-auroras conjugation. This is the two-step process that includes (1) the mapping of auroras and (2) satellite projection to the ionosphere. The event considered is the passage of CLUSTER quaternion through the Lovozero all-sky camera conjugated area (L ~4.5) during the interval of pulsating auroras. For aurora mapping we used the package of procedures developed for the Auroral Large Imaging System (ALIS). The package Orbit Visualization Tool (OVT) provided the coordinates of satellite footprint for different models of geomagnetic field. Our study shows that the largest discrepancy (300 km) is between dipole+T96 and IGRF+T96 models, so in different models the satellite was probing quite different auroral situations. The IGRF+T96 and IGRF+T89 models gave the difference in satellite projection of about 100 km. This leaded to the association of the satellite measurements with different auroral structures. The smallest discrepancy in projection (few kilometers) was for IGRF+T02 and IGRF+T96 models. But even in this case, there was a doubt whether the satellite is inside or outside the auroral structure. We should note that Lovozero is on the closed magnetic filed lines, the shape of which is often regarded as a "dipole-like". The situation with detail association of the auroras with satellite measurements seems to be more dramatic if the satellite is in the distant magnetotail or in the lobes.

Observations of localized disturbances during ionosphere heating by ground based complex

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On February 16, 2003 heating experiment was carried out by means of EISCAT heating facility. A pump wave of 4.04 MHz in X – mode was used for the ionosphere modification from 19.55 to 23.59:59 UT in square modulation regime with 5 minutes ON / 5 minutes OFF cycle. During this experiment a complex of geophysical observations provided measurements of main ionosphere parameters. IMAGE magnetometers record series of localized disturbances of geomagnetic field for this period. Magnetometer data were used for computing ionospheric currents at 100 km altitude. Deduced electrojet current density for time interval from 20.00 to 21.00 UT demonstrates variations of intensity with frequency approximately equal to 1.67 mHz (modulation frequency of heating transmitter). These variations are observed at the Tromsö latitude with concurrent slow drift of the electrojet in northward direction. IRIS riometer absorption data was used to study the precipitation of high energy particles. 49 narrow beams of the riometer allow search localized precipitation in wide area of polar ionosphere. Fourier transform has been used for analysis of variations of cosmic noise absorption in different beams. For the first hour of the experiment we obtained pronounced spectral peak at 1.67 mHz in 9th beam immediately directed in the heated volume however in 4th beam directed in neighboring sector this peak does not observed. Pulsation magnetometers located at Lovozero, Sodankylä and Kilpisjarvi has recorded clear PiB activity for the interval under consideration. All-sky cameras (Kilpisjarvi, Kevo) also show substorm signatures and auroral arcs brightening occurs in the vicinity of the heating site. First significant intensification has been started at 19.30 UT. Substorm disturbances started before the heating experiment run make the interpretation more sophisticated. Therefore the facts mentioned above may be explained by natural disturbance development. Generation of the localized disturbances during ionosphere heating is discussed in terms of their artificial and natural origination.

Evolution of pitch angle distribution during a geomagnetic storm

Smolin, S.V. (Siberian Federal University, Krasnoyarsk, 660041 Russia)

The equation of pitch angle diffusion is offered, which also allows to model change of pitch angle distribution from time. Two examples are presented. The first example is evolution of pitch angle distribution of protons during a typical moderate magnetic storm. The second example is evolution of pitch angle distribution of protons during the 2–7 May 1998 storm. The received results are compared among themselves and to results of other works.

Research of interrelation between radial diffusion, magnetospheric convection and pitch angle distribution

Smolin, S.V. (Siberian Federal University, Krasnoyarsk, 660041 Russia)

The average quiet time structure of energetic Earth's radiation belt protons can be explained as an equilibrium balance among radial diffusive transport, losses due to Coulomb collisions, charge exchange with the ambient neutral hydrogen geocorona and drift of protons under influence of the magnetospheric convection. Therefore for research of interrelation between radial diffusion, magnetospheric convection and pitch angle distribution is used the steady state transport equation at arbitrary pitch angle in the Earth's magnetosphere. On the basis of the numerical solution of this equation are calculated different characteristics of the trapped protons for 1 L 6.6 and 1 keV E 750 keV. A comparison between theory and observations is made.

Dynamo in celesteal bodies and Earth

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Large-scale magnetic fields in various celesteal bodies (Sun, stars, galaxies etc.) as well as magnetic field of the Earth are thought to be supported by hydromagnetic dynamo which transfers kinetic energy of random motions of conductive media into magnetic one. Modern understanding of the physical nature of this process is presented. A particular attention is addressed to the long-term behaviour of dynamo generated magnetic fields.

Flapping-structures and bursty bulk flows in the magnetotail neutral sheet from MHD modeling results and from THEMIS multi-spacecraft observations

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Flapping-structures (kink-like deformations of the neutral sheet of magnetotail) have been investigated based on 3D MHD modeling results (using OpenGGCM code at Community Coordinated Modeling Center in Greenbelt). Modelling results confirm their presence in the magnetotail in association with bursty bulk flows (BBFs), although the presence of BBF does not provide a sufficient condition for flapping generation. Duration of flapping structures were of about 2-20 minutes. In some cases, the flapping-structure moved across the tail (being extended in X direction), which was probably caused by the cross-tail motion of the BBF. We also compare the modeling results with first observations of flapping structures at 10-30 Re in the magnetotail by THEMIS spacecraft. We confirm the kink geometry of individual structures having a few Re scale. We found that the lifetime of some structures extended along X exceed 5 min, they moved across the tail with average speed of 30–80 km/s. Most of flapping structures were observed at low magnetic activity and in some events fast jet currents have not been registered.

Natural electromagnetic ULF noise

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An origin of natural electromagnetic noise observed on the ground surface in the frequency range 0.0001-0.01 Hz was examined. MHD waves incident on the ionosphere and neutral gas flow in the altitude range of conducting E layer of the ionosphere is considered to be a possible mechanism for random current fluctuations. To relate the random fields in the ionosphere and neutral atmosphere, a suitably idealized model of the medium is constructed. A transfer matrix relating these fields is assumed to be deterministic function while the random current fields is supposed to be steady, uniform, and isotropic inside the ionosphere, which, in turn, implies that the spectral density

of the random process is delta-correlated. A correlation matrix and power spectra of the random electromagnetic fields were calculated. A correlation radius of the wind-driven ionospheric currents is supposed to be controlled by neutral gas transfer and by acoustic/gravity wave propagation inside the E layer. A proposal for the presence of flicker-noise, or 1/f noise, in the spectral density of the ionospheric wind-driven currents provides an explanation for ULF ground-based observations. It was shown that the large-scale 2D random fluctuations of the wind-driven currents are capable of sustaining generation of the ULF magnetic noise that can be detected on the ground. In such a case the predicted spectral index of the power spectrum of the ULF magnetic noise was found to be 3, which is consistent with ground-based observations. The experimental data was demonstrated to be sandwiched between two theoretical lines, which correspond to daytime and nighttime ionospheric parameters.

What plasma fills the ring currents of terrestrial magnetosphere?

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The hypothesis about constant existence “a quiet ring current (QRC) over an atmosphere of the Earth” on L=3,8±0,8 R exists 90 years [Schmidt A., 1917]. Originating during magnetic storms the toroidal “disturb ring current (DRC)” placed on L = (10-7) R [Chapman, Ferraro, 1930; 1931; 1933, Kalinin, 1939] and on L = (3-5) (Ben’kova, 1939). Magnetometers of space vehicles Luna-1,-2 in 1959 at first have detected signs of existence RC on depression of geomagnetic field on L = (3-4) [Dolginov et al., 1959, 1960]. After half-of-year of satellite EXPLORER-6 has registered the same effect, but on L = (5-6) [Sonett et al., 1960]. Intensive ion fluxes of QRC with energy density $\varepsilon_p = nE$, commensurable with density of energy of local geomagnetic field $\varepsilon_B = B^2/8\pi, -\beta(\varepsilon_r/\varepsilon_B) = 0,1$ have unexpectedly been detected with the centre on L=3,5 by EXPLORER-12 in 1961 [Davis, Williamson, 1963]. Also it was observed in 1962-1964 on artificial satellites EXPLORER-14,-15,-26 and Electron-1,-3 [Davis, 1965; Davis, Williamson, 1966; Soraas and Davis, 1968; Bolyunova et al., 1965; Temny, 1966]. In 1966 on satellite OGO-3 has been registered DRC, filled by protons with $\mathbf{E}_p \sim 10$ keV during geomagnetic storms

[Frank, 1967]. RC at once have appeared in the field of interests of plasma physics because it's stable equilibrium with β ~0,1 in the field of a geomagnetic dipole [Kadomtsev and Rokotyan, 1960]. Experiments specified 1962-1964 show possibility of filling RC plasma with density of energy to $\beta_{KT} > 0,2$. In 1970 on satellite ATS-5 it is gained $\beta_{KT} \geq 0,2$ on L=6,6 and $\beta_{BKT} \approx 2,7$ [DeForest and McIlwain, 1971]. It means that RC with $\beta \geq 0,1$ may fill all shells $3 \leq L \leq 6,6$ [Temny, 1966; 1977]. Experiment of 1984 AMPTE (satellite CCE) has allowed defining energy spectra and concentration n ion component of plasma RC. Before the beginning of experiment AMRTE/CCE the prognostic model QRC has been developed [Temny, 1984]. It proved to be true known before characteristic QRC: $\beta_{QRC} \geq 0,1$, it's mainly proton composition and growth of intensity of ions O^+ in DRC. QRC Results of registration O^+, He^+ and molecular ions NO^+ [Klecker et al., 1986] serve as the certificate of ionosphere source of RC. On the basis of the energy spectra from experiment AMRTE/CCE-MEPA [McEntire et al., 1985; Krimigis et al., 1985] taking into account CCE-CHEM [Gloeckler et al., 1985] and HPCE [Shelley et al., 1985] have been received bi-Maxwell distribution functions of ions for hot (hot) and cold (cold) plasmas $-f_{p,i}(\text{cm}^{-6}\cdot\text{c}^{-3})$ [Temny, 1987]. On them temperatures of ions plasma ($T_{p,i}$), their concentration ($n_{p,i}$) and energy density $\varepsilon_{p,i} = n_{pi}$. $T_{p,i}$ were defined. It has appeared, as for QRC, and for DRC $T_{p\,hot} \sim 50$ keV, $T_{p\,cold} \sim 3$ keV. It has been established, that always $\varepsilon_{i,\,hot}(\sim 100 \text{ keV cm}^{-3}) >> \varepsilon_{i,\,cold}(\sim 0,5$ keV cm^{-3}). Similar parameters of plasma KT at planets-giants are gained on vehicles PIONEER-10,-11 and VOYAGER-1, - 2. In RC Jupiter ($L_J \leq 7$) the hot plasma with $\beta \sim 1$ and energy density of cold plasma [Frank et al. 1975; McNutt, 1988] $\varepsilon_{I\,cold} \geq 5$ erg cm^{-3} it is negligible small in comparison with $\varepsilon_{i,\,hot}$. In Saturn RC in the Reia orbit ($3 \leq L_S \geq 8,7$) $\varepsilon_{i,\,hot} \approx 2.10^{-9}$ erg$\cdot$cm^{-3} [Krimigis et al., 1983] also more than cold $\varepsilon_{i,\,cold}$ [Frank et al., 1980, Richardson, 1986.]. Total $\beta_P \leq 0,3$ or $\beta_{0+} \leq 2$. RC Uranium are filled hot [Mauk, 1987] and cold [McNutt et al., 1987] plasma with total $\beta_{e+p} \leq 0,1$. In RCU molecular ions H_2^+ with $E/m \leq 0,6$ Mev/nucleon are detected. In RC of Neptune (on $L_{Np} \geq 10$) two components of ionic making plasma are detected: hot [Krimigis et al., 1989, 1990] and cold [Richardson et al., 1991]. At them $\varepsilon_{i,\,hot} \approx \varepsilon_{i\,cold} \sim (0,1-1)$ keV$\cdot$cm^{-3} $\beta \sim 0,2$. During IHY-2007-2008 and after it is expedient to define quantitative magnitudes β_{RC} into terrestrial magnetosphere.

Orientation of the anisotropy of F-region irregularities and direction of plasma convection in the polar cap

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Scintillation data recorded at the polar cap station Barentsburg are shown to occasionally exhibit two and more peaks in the latitudinal profiles of the amplitude dispersion. Comparison with concurrent SuperDARN radar convection maps indicates that the multi-peaks occur when Barentsburg is located within the area of strong changes in the plasma flow direction. When parameters of the ionospheric irregularities are inferred from the scintillation data, the orientation of the irregularity anisotropy in a plane perpendicular to the magnetic field is found to coincide well with the **E**x**B** flow direction, individually for each peak of the scintillation data. The differences were found to be mostly less than 20 degrees for a data set comprised of 104 events. Conclusion is made that processing of scintillation data allows one to infer the direction of plasma flow with certain degree of detail.

Solar wind influence on atmosphere processes in winter Antarctica

Troshichev, O., Egorova, V., Vovk, V., Janzhura, A. (Arctic and Antarctic Research Institute, St.Petersburg, 199397, Russia)

Galactic cosmic rays altered by the solar wind are traditionally regarded as the most plausible agent of the solar activity influence on the Earth's atmosphere. Meanwhile, it is well known that severe reductions in the galactic cosmic rays flux, known as Forbush decrease (FD), are caused by the solar wind of high speed and density, which sweeps the galactic cosmic rays on its way. Since the FD beginnings are registered at the Earth's orbit simultaneously with dramatic disturbances in the solar wind, the atmospheric effects, assigned to Forbush decreases, can be, in reality, result of the solar wind influence on the atmospheric processes. The paper presents the summary of the experimental results demonstrating the strong influence

of the interplanetary electric field on atmospheric processes in the central Antarctica, where the large-scale system of vertical circulation is formed during the winter seasons. The influence is realized through acceleration of the air masses, descending into the lower atmosphere from troposphere, and formation of cloudiness above the Antarctic Ridge, where the descending air masses income into the surface layer. The acceleration is followed by sharp increase of the atmospheric pressure in the near-pole region, which gives rise to the katabatic wind strengthening above the entire Antarctica. The cloudiness formation is resulted in the sudden warmings in the surface atmosphere, since the cloud layer efficiently backscatters the long wavelength radiation going from the ice sheet, but does not affect the adiabatic warming process of the descending tropospheric air masses. When drainage flow strong strengthening the circumpolar vortex about the periphery of the Antarctic continent decays, the surface easterlies typical of the coast stations during the winter season are replaced by southerlies and the cold Antarctic air masses rush in the Southern ocean.

Relation of substorms to polar cap magnetic activity: evidence for threshold-dependent mode of magnetosphere response to solar wind influence

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Relation of the polar cap magnetic activity (characterized by the PC index) to magnetic disturbances in the auroral zone (the AL index) was examined for the isolated, periodic, and sawtooth substorms. It is shown that the growth phase is typical of all substorms. The growth phase beginning is seen first of all as the PC index persistent increase starting 15 minutes, on the average, ahead the appropriate growth phase in the auroral zone, which beginning statistically coincides with such spacecraft substorm identifiers as dipolerization of the nighttime magnetosphere and injection of energetic particle flux at geosynchronous orbit. The growth rate and the substorms intensity are determined by the energy pumping into the magnetosphere (characterizing by the PC value) during the growth and expansion phases. For conditions when $2 \leq PC \leq 4$ mV/m the growth phase duration lies in the range from 60 to 15 minutes. For conditions of $PC > 6$ mV/m the growth phase can shorten up to zero. The PC index reaches the

maximum just before as well as after the AL maximum, implying that the polar cap magnetic activity, being related to the solar wind energy input, does not practically respond to the substorm development. The most powerful substorms, being associated with the extremely high conducting channel in the auroral ionosphere, act on the magnetosphere like a short circuit. They discharge "the magnetosphere capacitor", which supplies the field-aligned currents in the polar caps and the dawn-dusk voltage across the magnetosphere. As a result, it takes a certain time to charge "the capacitor" again and initiate a new substorm. It is just this mechanism that determines the cycle time (1–3 hours) of periodic and sawtooth substorms. Our results suggest that neither driven mode no loading-unloading mode of the magnetospheric substorm do work in pure form, but rather the threshold-dependent mode is realized. Indeed, the incoming energy is continuously removed while the field-aligned current closing in the polar ionosphere. Only when the energy input rate exceeds the energy loss rate (for conditions PC>2 mV/m), the energy store process starts. If the energy input rate is extremely high (PC>6 mV/m), the energy lost can be neglected, and the magnetosphere begins to respond immediately to the energy input. In this short time the driven mode is realized. The extremely high energy losses (mainly on the heating in the auroral ionosphere) are typical of the expansion phase, when the powerful westward electrojet depletes the energy supplies in the magnetosphere up to limit in 2–3 hours, and the next loading stage can start only after the substorm finish on condition that the external energy input exceeds the certain threshold. Thus, the mode of the magnetosphere response to the external influence is dependent on the varying ratio between the energy input and energy loss rates, the energy input being displayed by the PC value.

Formation of the relativistic electron belt during the superstorms: case-comparative study

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We study how the most prominent geomagnetic storms of 22–23 solar activity cycles change the relativistic electron population of the outer radiation belt. The storms of $|Dst|_{max}$ >300 nT are selected, including the greatest storm of Space era March 13–14, 1989.

We demonstrate the shock-and storm-injected cases of radiation belt formation. Comparison of the cases confirms that an intensity of the storm-injected relativistic electron belt do not correlates with the storm amplitude $|Dst|_{max}$, whereas an L-peak (L_{max}) of such a belt very strictly obey the previously estimated formula $|Dst|_{max} = 2.75 \cdot 10^4/L_{max}^4$. Possible mechanisms of the relativistic electron acceleration in inner magnetosphere are discussed.

Cosmic climate and historic data of the Russian magnetic network: retrospective analysis of the September 1859 superstorm

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The study of space climate involves both long-term average characteristics as well as extreme deviations from the average behavior. Long-term magnetic data series of Russian observatories could be very important for both types of the studies. The Russian network of magnetic observatories was founded in 1830, when regular measurements in St. Petersburg, Ekaterinburg, Barnaul, Nerchinsk and Sitka were started. However the analysis of historical magnetic data is often difficult, since it is necessary to analyze possible errors, to estimate the accuracy of historic devices, to find out how the units and the time used in the observations correspond to those used today. It had required additional retrospective analysis and usage of different archives, including one from St. Petersburg (Voeikovo) magnetic observatory. Here we consider extreme solar-terrestrial event on 1–4 September, 1859. September 1859 magnetic storm is notable both for its association with the first solar flare ever reported (observed in white light on 1 September) and for its severity. We present hourly geomagnetic data (H-component) for 1–5 September 1859 observed by magnetic stations St. Petersburg, Ekaterinburg, Barnaul, Nerchinsk. For St. Petersburg and Ekaterinburg also 5-min data for the most disturbed periods were available. The presented data demonstrate complex structure of the geomagnetic storm, which comprises several disturbed periods. On 2 September between 4 and 6 UT all stations register very strong short magnetic disturbance

(duration $t_1 = 1 - 2$ hours). Magnetometers at all stations except Nerchinsk went out of scale. RRanges of H-component variations during this disturbance were in Ekaterinsburg and Barnaul >1000 nT, in St.Petersburg >700 nT, and in Nerchinsk ≈400 nT. The durations of next two disturbances were $t_2 \sim 14$ h and $t_3 \sim 22$ h. The most clearly these last disturbances are seen in the most high-latitude station St. Petersburg: maximal range of H reached up to 1000 nT for the second and ~500 nT for the third disturbance. The observed complex severe geomagnetic storm could be due to multiple events on the Sun — severe flare triplet. The observed disturbances in H-component were positive. It indicates that large electrojet intensification and magnetospheric currents were present during the extreme September 1859 storm.

Multiscale complexity in Earth's magnetosphere

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In this talk, we provide a review of experimental and theoretical results in the growing field of multiscale magnetospheric complexity, starting with the works initiated at St. Petersburg State University under the scientific guidance of Prof. Mikhail I. Pudovkin.

Earth's magnetosphere is known to generate complex spatiotemporal patterns of activity reflecting its nonlinear response to the solar wind driver as well as the inherent stochasticity of plasma dynamics in the near-Earth environment. The multiscale behavior of the nighttime auroral oval reveals a wide range of dynamical processes in the magnetotail, including but not limited by substorm expansion onsets, pseudobreakups, steady magnetospheric convection events with or without substorms, bursty bulk flows, and sawtooth events. Despite the diversity of physical conditions associated with each particular type of the auroral activity, their net energy output obeys a set of apparently universal statistical power-laws signaling the existence of a unifying dynamical principle arranging intermittent magnetospheric dissipation across vast ranges of spatial and temporal scales. We show that on average, and over time scales involving many typical susbstorm loading-unloading times, the magnetospheric activity tends to self-organize into a nearly critical dynamical state reminiscent of the behavior of critical avalanching models. We also take a step toward a better understanding of the relationship between the scale-free auroral precipitation statistics and the underlying central plasma sheet morphology. Our recent results suggest that the inner and outer magnetosphere are characterized by substantially different scaling regimes of bursty energy dissipation which can be associated with the magnetic reconnection and the current disruption scenarios.

Grand minima and maxima of solar activity over millennia

Usoskin, I.G. (University of Oulu, Finland), Kovaltsov, G.A. (Ioffe Phys.-Tech. Inst., St. Petersburg); S. Solanki (Max-Planck Inst. for Solar System Research, Germany)

Statistics of the occurrence of grand minima and maxima is presented using an updated reconstruction of solar activity from the 14C data by means of a physics-based model.

A list of grand minima and maxima of solar activity is presented for the Holocene (since 9500 BC) and the statistics of both the length of individual events as well as the waiting time between them are analyzed. It is concluded that the occurrence of grand minima/maxima is driven not by long-term cyclic variability, but by a stochastic/chaotic process. The waiting time distribution of the occurrence of grand minima/maxima deviates from an exponential distribution, implying that these events tend to cluster together with long event-free periods between the clusters. Two different types of grand minima are observed: short (30–90 years) minima of Maunder type and long (110 years) minima of Spörer type, implying that a deterministic behaviour of the dynamo during a grand minimum defines its length. The duration of grand maxima follows an exponential distribution, suggesting that the duration of a grand maximum is determined by a random process.

These results set new observational constraints upon the long-term behaviour of the solar dynamo.

Revealed history of solar activity variations on the millennial time scale

Usoskin, Ilya (University of Oulu, Finland, and Ioffe Physical-Technical Institute, St.Petersburg); Solanki, Sami (Max-Planck Institute for Solar System Research, Katlenburg-Lindau, Germany)

An overview of the present status of long-term solar activity reconstructions is presented, including discussion of the reconstruction methods, their advantages, drawbacks and uncertainties as well as the results.

Despite some uncertainties in fine details and, probably, overall normalization level, several robust features can be clearly identified in the solar activity evolution during the Holocene (last 11,000 years):

- The sun spends about 70% of time in a state of moderate activity, while 15–20% and 10–15% in the states of Grand minima and maxima, respectively;
- It does not depict a simple multi-periodic but rather stochastic/chaotic behavior;
- Grand minima of activity occur not regularly, but seemingly sporadically;
- Grand minima correspond to a special case of the solar dynamo.

Particularly important is the fact that the modern epoch (since 1940's) is characterized by an unusually high solar activity level – a Grand maximum. We also discuss implications of these observational facts for solar physics, solar-terrestrial and terrestrial science.

Ion dynamics in high-latitude reconnection event: Interball-Tail observations

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Interball Tail satellite was in the northern tail lobe on October 19, 1995 when CME with regular flux rope structure passed the Earth.

Magnetopause crossed Interball location after IMF turned northward. High-latitude reconnection signatures specific to northward IMF were observed within several hours. Open magnetic flux tubes were observed when spacecraft crossed magnetopause. Magnetospheric and magnetosheath plasmas were seen crossing magnetopause along magnetic field lines within there flux tubes. Magnetic field of open flux tube showed rotational discontinuity signature. Ion velocity distribution of magnetosheath plasma entering the tail has velocity cut-off (D-shape) and acceleration specific to magnetic flux tube with deHoffman-Teller velocity (in accordance with Cowley diagram). Both magnetosheath and magnetospheric transmitted components are heated by factor of two. Two regions of reconnected magnetosheath tube are indicated by ion velocity distributions. Observations of extended reconnection region are discussed.

Magnetosphere models in the calculations of cosmic ray trajectories

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Calculations of trajectories of the charged particles in the geomagnetic field are widely used in cosmic ray physics for definition of asymptotic approach directions of cosmic rays to the magnetosphere border. Asymptotic directions of arriving protons are usually calculated by tracing the trajectories of negative particles of the same rigidity moving away from the Earth in the model magnetosphere. In wide use now are magnetosphere models of Tsyganenko, 1989 (T89), 2001(T01), and 2003 (T03) "storm model". It can be shown, that under quiet geomagnetic conditions (Kp 3) use of all three models gives close results. However during superstorm conditions such as observed on 29.10 and 20.11. 2003, calculations with models T01 and even "storm" model T03 gives not realistic values of asymptotic directions. The probable ways to updating models T01 and T03 are discussed that they could work in conditions of large disturbances.

Solar activity effects on the characteristics of frontal zones in the North Atlantic

Veretenenko, S.V., Dergachev, V.A., Dmitriyev, P.B. (Ioffe Physico-Technical Institute RAS, St.-Petersburg, Russia)

Long-term changes of the characteristics of frontal zones, which are the regions of high temperature contrasts and influence significantly extratropical cyclone formation and development, were studied in the North Atlantic, the reanalysis data NCEP/NCAR being used. It was found that in the cold half of the year (the period of most intensive cyclogenesis) the oscillations of the temperature gradients in the layer 1000-500 hPa near the south-eastern coasts of Greenland (the Arctic frontal zone) reveal strong ∼10-yr and ∼22-yr periodicities. The results obtained provide evidence of the influence of solar activity and related phenomena on the structure of the thermo-baric field of the troposphere at middle and high latitudes resulting in the enhancement of temperature contrasts in the frontal zones. In turn, the found changes of the frontal zone characteristics may be a reason for the long-period effects of solar activity and cosmic ray variations on the intensity of extratropical cyclogenesis.

The formation of the field-aligned currents during dipolarization of the Earth magnetic fields

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The appearance of the currents in the ionosphere and magnetosphere of the Earth during the expansive phase of the substorm have been studied in this work. It has been shown that the formation of the field-aligned currents and westward Cowling currents in the ionosphere can be generated by dipolarization of the magnetic field lines. The model distribution of the plasma pressure, balanced with magnetic field, has been taken during the growth phase of the substorm. The conditions of the formation of the currents wedge have been received. The effect of the charge particles precipitations on the pressure of the plasma sheet has been studied also. According to the evaluations the effect of the particles precipitations is negligible. In the work the density of the field-aligned currents in the midnight sector of the auroral ionosphere has been estimated within the adiabatic approach.

Theoretical models for localized electrostatic structures associated with electron and ion beams in the space plasmas

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Electrostatic structures of the different types have been observed in the various regions of magnetosphere and these structures play a important role at research of physical processes in the magnetospheric plasma. Basing on the MHD system equations for multicomponent plasma, some theoretical models of the formation of the electrostatic solitary structures and the distributions of the density of the charged particles are calculated analytically and numerically. Taking into account the effects of dispersion, nonlinearity and non-isothermallity plasmas the evolutionary equations, which are the modified Korteweg-de Vries-Zakharov- Kuznetzov (MKdV-ZK) and nonlinear type Schrodinger (NLSE) equations are derived. The mathematical methods for the solution of these nonlinear equations with different degree of nonlinearity are developed. Basing on the analysis of the evolutionary equations, the necessary and sufficient conditions of existence of the certain types of solutions such as solitary waves, double layers or modulated wave are found It has been shown that the order of the non-isothermality and nonlinearity of plasma plays a unique role. Various models have been proposed to explain the formation of the different type of electrostatic structures: solitary waves, double layers, spiky, explosive solitary wave and modulated wave packets. The characteristics of these solitary structures: the velocity, width and the ratio of the parallel scale to the perpendicular scale relatively of the magnetic field are estimated. The basic results of the numerical models are in good agreement with experimental data obtained by satellites POLAR and GEOTAIL, CLUSTER.

Nighttime subvisual auroras in high latitudes

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Special methods of TV images processing, which enable recognizing rather weak signals confidently, were used to examine polar auroras at high-latitude observatory Barentsburg (Spitsbergen). Faint subvisual auroras (SVA) appearing 3-4 of latitude poleward of bright auroral forms of the ordinary auroral oval were found in the nighttime sector from 1900 to 0400 MLT. The SVA forms were observed moving to the equator with the velocity changed from 0.1 up to 1.4 km/s with the average of about 0.6 km/s. The average living time of a single SVA form was approximately 7 min. The SVA events were observed during rather quiet periods generally for the northward direction of the IMF Bz component. However, the SVAs are not the sun-aligned polar cap auroras, for they are more extended in the east-west direction. Ground based optical observations showed that the intensity of SVAs was about 0.1-0.3 kR and 0.2-0.5 kR in the 557.7 nm and 630.0 nm emissions respectively. According to direct DMSP spacecraft observations the SVA precipitating electron spectra have the maximum in the energy between 0.4 and 0.8 keV. It testifies that the SVA height makes about 180-200 km. At that the SVA energy fluxes were in ten and more times lower than within the ordinary auroral oval. It is suggested that energetic coronal electrons, which are associated with the central region of solar coronal holes can play an essential role in the SVA generation.

Influence of the solar wind dynamic pressure on dayside aurorae during unusually large northward interplanetary Bz

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The daytime auroral features observed with the meridian scanning photometer (MSP) and all-sky TV camera at Heiss Isl. ('=75.0 N, MLT=UT+4.6) were studied along with interplanetary magnetic field and solar wind plasma parameters. Optical observations were examined from 06 to 12 UT on January 14, 1988 during unusually large

(18-24 nT) northward interplanetary Bz associated with the interplanetary magnetic cloud event on January 13-14, 1988. Throughout all dayside sector from 10.30 to 16.30 MLT the stable red auroral band with the intensity of about 1–2 kR in the 630.0 nm emission was registered in the latitudinal range from 74 to 80 CGL. Dynamics of boundaries of the red band was in a good agreement with the changes in the solar wind dynamic pressure. The appearance of bright rayed arcs (up to 6-7 kR in the 557.7 nm emission) within the red band coincided with the turn of interplanetary By from positive to negative direction. The occurrence and intensification of bright auroral forms in most cases followed increases in the solar wind dynamic pressure. It was determined auroral electron precipitation zones under magnetic activity conditions during observations.

ULF noise on ground and in space. Extra- and intra- magnetospheric control parameters

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Narrow-band Pc pulsations occur from time to time in the magnetosphere and on the ground, while the broad-band noise is the ubiquitous manifestation of the geomagnetic activity. The geomagnetic noise was continuously recorded for several decades at hundreds of ground stations and many satellites. However, noise parameters have not been still analyzed and summarized in a systematic way. In this study we analyze the parameters of the geomagnetic noise and pulsations with in the frequency range 1-4 mHz (Pc5/Pi3) from more than 50 observatories from the polar to middle latitudes and in a wide range of MLT in the following way:

1) spectral parameters are estimated in 2-hour running window at each station;

2) signal is decomposed into an elliptically polarized and randomly polarized noisy components;

3) for each component the spectrum is presented in a log-log scale and expanded over Legendre polynomials;

4) for all the coefficients the diurnal and latitudinal distributions are calculated and factors influencing each of Pi3 parameters in the

magnetosphere and in the interplanetary space are analyzed.

It is found that Pi3 amplitude and higher spectral moments are mostly controlled by CGM latitude and MLT. A noticeable difference in diurnal variations for polarized (P) and non-polarized (N) components exist at all latitudes growing from polar to auroral latitudes. L2 or the spectral form parameter demonstrates systematic variation with such external factors as solar wind dynamical pressure and B_z. On the other hand, Pi3 spectral slope is only weakly influenced on extra-magnetospheric factors. Actually, it is the most stable among the parameters of the geomagnetic disturbances. At the same time it has pronounced diurnal and latitude variation depending on signal polarization. It is sensitive only to the disturbances resulting in redistribution of field-aligned Alfvén velocity, i.e. fluxes of supra-thermal and energetic particles in the magnetosphere.

Evidence for subauroral proton auroras as the result of the ion-cyclotron interaction

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Recent observations from the IMAGE spacecraft revealed several types of proton aurora equatorward of the main auroral oval. These auroras are due to precipitation of energetic (E20 keV) protons. It was suggested (but not proved) that the precipitation is the result of scattering the ring current protons into the loss cone after the interaction with electromagnetic ion-cyclotron (EMIC) waves in the equatorial plane of the magnetosphere. In this report we prove this suggestion for three types of the subauroral proton aurora (proton spots in the day-morning sector, proton flashes on the dayside, and proton arcs in the evening sector). The consideration is based on comparison of the IMAGE observations with ground-based observations of geomagnetic pulsations Pc1, which are a signature of EMIC waves. 1) We found that when the proton spot is nearly conjugated with the ground station equipped with a pulsation magnetometer, the station always observes narrow band Pc1 emissions. The frequency of this Pc1 varies inversely with the proton spot latitude. Moreover, there is a good agreement between appearance/disappearance of the spot and beginning/end of the associated Pc1. 2) The proton aurora flashes well coincide in time with pulses of wide-band Pc1 at the nearby ground station. The upper frequency cutoff in the Pc1 pulse anti-correlates with the lowest latitude of the proton aurora. 3) The intensity maximum of the IPDP power is associated with the location of the subauroral proton arc, and the increase of the IPDP frequency correlates with equatorward movement of the arc. This strong correlation between proton auroras and ground pulsations in the Pc1 range (and its violation when the ground station is away from the location of the proton aurora) clearly indicates that, indeed, the ion-cyclotron interaction is the source of proton auroras. We conclude that the subauroral proton auroras are images on the ionospheric "screen" of magnetospheric regions where the ion-cyclotron instability develops leading to an intense scattering of energetic protons into the loss cone.

The relationship between subauroral proton flashes and Pc1 pulsation bursts

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A series of subauroral proton aurora flashes equatorward of the auroral oval was observed at 07-13 UT of 31 May 2005 with the IMAGE EUV imager. At the same time a sequence of short-lived bursts of geomagnetic pulsations within the Pc1 range (0.7-2 Hz) were observed on the ground stations located in the same MLT sector. Low-altitude spacecrafts NOAA located at the same time and latitudes in the day sector observed the energetic proton precipitation simultaneously with Pc1 bursts and aurora flashes. The proton aurora flashes well coincide in time with the wide-band Pc1 bursts. The frequency correlates and upper frequency cut-off of the pulsation burst anti-correlates, respectively, with latitudinal width and lowest latitude of the proton aurora at the meridian of the ground station. Observations at the meridional network of pulsation magnetometers show that maximum of the pulsation spectral density is detected at stations conjugated with proton flashes. The close relationship between pulsations and proton precipitation (aurora) means their common source. We conclude that the source is the cyclotron instability of the ring current ions that is stimulated by the impulsive magnetosphere compressions leading to the increase of the hot proton anisotropy. The magnetosphere compressions are confirmed by the plasma data from the Geotail spacecraft in the dusk-side magnetosheath that show a series of the plasma pressure pulses during the time interval of interest.

Laws impact events of the historical past

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The created base of historical certificates on flight of comets and bolides, falling of meteorites and meteoric "rains" totals more than 840 messages from the past. These data are borrowed from lines of annalistic sources of the European and East Asian origin for past 2000. The data resulted in annalistic sources have been distributed on three groups. In the first the data on supervision of bright comets, in the second - about falling meteorites and flights bolides and in the third - intensive meteoric streams are concentrated. What communication between comets, meteorites, bolides and meteoric streams? It has been established in XIX century after a windfall caused by a stream Leonid in 1833 Then V.Clark and D.Olmsted have assumed, that it is connected to a certain comet. In the beginning of 1867. K.Peters, D.Skiaparelli and T.Oppoltser have independently proved this communication, having established similarity of orbits of a comet 1866-I "Templ-Tuttl" and a meteoric rain of a stream Leonid in 1866. The same dependence gives the claster-analysis of mutual relations inside three groups of our database. Close communication between comets and their derivatives is distinctly traced - by meteoric streams whereas meteorites and bolides only is remote are connected to the main set. It completely corresponds to existing representations that meteoric streams is the rests collapsed comet's nucleus. Construction of a cumulative curve has shown obvious of subperiodicty fluctuations comet's activity in rather recent historical past of the Earth. Intervals 0-500, 1000-1250 and 1450-1750 abound messages on occurrence of comets. It is curious, that in them known minima of solar activity, by Oort, Volf and Maunder are stacked.

The conclusion:

1. The fact of existence of fluctuations comets on different time intervals speaks activity about co-periodicity change of external conditions. It is possible to admit, that the Solar system in the movement around of the center of the Galaxy is periodically immersed in gas and duster clouds. If the cloud is generated by explosion ancient supernewstars it can contain the caked dust conglomerates which subsequently increase environments from a dust and snows in the structure, moving in gas and duster cloud. The size of these firm bodies can reach significant size. At galactic movement of Solar system there is an intrusion of such bodies into its space that should be shown as occurrence of a lot of hyperbolic comets, is abnormal bright bolides and, accordingly, a lot of impacts.

2. Correlation of variations of quantity of comets with a level of solar activity testifies for the benefit of change of conditions of formation and supervision comet's tails at various parameters of a solar wind.

The model of multiscale thin current sheet with two-temperature plasma components: the comparison with experimental data

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The self-consistent theory of current sheets in double-temperature collisionless plasma is developed taking into account two kinds of magnetotail plasma: the more cold ions and more hotter ones. Quasi-adiabatic approximation is used for description of ion populations, whereas the fluid approximation is found to be more appropriate for electrons. The Grad–Shafranov like equations are obtained for 1D current sheet. It is shown that its self-consistent equilibrium solutions exist in a wide range of parameters of the system. The corresponding profiles of current densities and magnetic fields might be quite variable dependently from the relative plasma density and temperatures characterizing plasma sources. These solutions might describe one-, double- and triple-peaked current sheets. The thicknesses of the received solutions are several times more thicker in comparison with the model with a single plasma component. This work demonstrates that characteristic profiles of double-temperature current sheet are in good agreement with experimental observations. This modified model allows to explain the observation of thin current sheets with thicknesses about several gyroradius in the Earth's magnetotail.

Pc5 frequency waves triggered by magnetospheric compressions in geostationary orbit

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We analyzed the spectral composition and polarization of the Pc5 period waves (150–600 s) registered in the geostationary orbit immediately after fourteen SI events, accompanied by dayside aurora brightening. An analysis of original satellite data showed that continuous (40-80 min duration) amplifications of Pc5 frequency waves were registered after SI by both of the satellites in 10 cases, by one of them - in 3 cases. The observed pulsations constitute two distinct groups: dayside and nightside. The most part of SI associated dayside emissions is broadband and multicomponent. High-frequency part of these emissions is very weak and exhibits the following properties: (i) a wave period inversely depends on magnetic field strength, (ii) in a plane perpendicular to mean magnetic field a direction of wave magnetic field rotation reverses at the noon, which means the change of the azimuthal wave number sign. Both features agree with the excitation of the Alfvén waves by the resonant interaction with the fast mode, generated by a mechanism like Kelvin-Helmholtz instability on the edge of the magnetosphere. Contrastingly, an intensity of the most part of nightside narrowband emissions is distinctly higher than this of a noisy background. Their period also inversely depends on magnetic field strength, but a ratio between the observed and calculated with dipole model wave periods is almost 1.5 time smaller than this for the dayside waves. This may be a consequence of a magnetic field line stretching as well as a high density of plasma.

Alfvén waves generated by substorm injection: theory and experiment

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It is suggested that Alfvén waves can be generated by substorm injected plasma inhomogeneity drifting in the magnetosphere in the azimuthal direction. It is shown that in the case when the drift velocity grows with the radial coordinate, the wave polarization changes: mixed (between toroidal and poloidal) - poloidal - mixed. It is accompanied by a change of the polarization ellipse orientation. These features were observed by geostationary satellites GOES 8 and 10 located east and west of the place of the substorm onset that happened on September 17, 2000. It means that these satellites detected the wave excited by substorm injected ions (GOES 10) and electrons (GOES 8).

Model interpretation of the unusual F-region night-time electron density behaviour observed by the Millstone Hill incoherent scatter radar on April 16–17, 2002

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The numerical experiments with the global numerical Upper Atmosphere Model (UAM) have showed that the mechanism of the unusual night-time F-layer electron density enhancement over Millstone Hill was related to the plasma drift caused by the convection electric field. The electric field values observed during the night hours of April 16 in Millstone Hill corresponded to the "anomalous" convection pattern with the converging zonal plasma flow, which succeeded to increase the night-time F2 electron density. Such convection pattern could occur when the FAC2 had intensified and extended to the middle latitudes. The UAM produced the "classical" convection pattern with diverging zonal plasma flow, which decreased the electron density over Millstone Hill during that period. This explained the fact that the model F2-layer electron density strongly underestimated the

measurements performed by the Millstone Hill radar during the night hours of April 16-17.

Aurora research at high-latitude stations after sc events in the prenoon sector

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The behavior of aurora at high latitudes just after SC events was analyzed. There were considered following events: 18 Dec.1985 (SC at 06.47 UT); 28 Nov.1989 (SC at 07.43 UT) and 28 Nov. 2000 (SC at 05.31 UT). For the study the data of all-sky camera, spectrophotometer, meridian–scanning photometer and TV- all-sky observations separately at Heiss Island (HIS, =75.0 N; MLT=UT+4.6) and Barentsburg (BAB, =75.15 N; MLT=UT+2.5) stations were used. Each event has its own peculiarities. For instance just after SC at 06.47 UT on 18 Dec. 1985 the intensification of 5577 nm emission was observed on the all sky. This indicate that the precipitation of kV electrons occurs at latitudes higher of the auroral oval. In detail we considered SC event on 28 November 2000 at 05:31 UT. The behavior of aurora was analyzed using all-sky TV camera data at high-latitude Barentsburg station. WIND spacecraft observations show that SC was caused by rapid enhancement of solar wind dynamic pressure from 2.5 nPa to 8 nPa. The peculiarity of this interplanetary disturbance is characterized by simultaneous rapid changing of the IMF Bz component from southward to northward and backwards for about 30 min. Before SC the interplanetary Bz component was relatively constant of about -4 nT. During this period the aurora were observed southward of BAB zenith at 71-72 CGL. Just after the SC moment a new auroral arc with long rays appeared northward of previous auroral forms. The maximum brightness of this rayed auroral arc was observed in 5 min. The duration of auroral intensification was about 9 min. At 05:40 UT practically all auroral luminosity disappeared possibly as a consequence of positive IMF Bz component influence and next rapid auroral oval widening after IMF Bz component southward changing.

The spatial-temporal model of Earth's magnetic field derived from CHAMP satellite vector data

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A simple method for obtaining a spatial-temporal model of the magnetic field for the high-precision satellite survey data is described. At the first stage, the CHAMP satellite data for one-day interval are expanded into the spherical harmonics with constant coefficients. This yields a set of daily mean spherical harmonic models (DMSHM) over the survey interval of a few years (may 2001 to September 2007). At the second stage, the coefficients of this set are used as source data for expansion into the natural orthogonal components (NOC). It is shown that the NOC series converges rapidly. NOC1 is a good approximation to the secular variation of the field, NOC2 - to the acceleration of the field, NOC3 - to the Dst-variation on the interval analyzed. This separation of the magnetic field on different parts gives the possibility of the creating of the spatial-temporal model.

Section NLM. NonLinear geophysical Methods

Influence of tidal strengths in the Earth–Moon–Sun system

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It was shown [Avsjuk, 1996; Avsjuk et al., 2005, 2007, 2008] that vibrational regime in tidal evolution of the Earth – Moon –Sun system results in periodical changes of velocity rotation and angle incline of the axis rotation.
The increase of the Earth rotation angle velocity should be accompanied with increasing ocean level in low latitudes (equatorial) and decreasing in high latitudes (polar areas). Another situation has to be observed with decreasing of the velocity rotation Earth. According to these principles the latitude shift have to take place in distribution (in geological scale of time) of some geological processes in the lithosphere of the Earth (we mean only Fanerozoic epoch), namely basins of sedimentation (areas of regression and transgression), areas occupied by magmatism and at last – areas of folding phases. These areas were calculated based on the Atlas of lithological – paleogeographycal formations and geotectonical Map of the World [Ed. by acad. V. Khain, 1989]. The results of the study are follows:
the intensivity relative change of sedimentary areas are minimal in Yurassic and Cretaceous and especially in Triassic and Cenozoic. Maximum areas were observed in latitude intervals 20–40° in the North hemisphere for all studied geological epochs; Folding epochs [Bertrans' cycle] coincide with the periods of the fast changes rotation. It is connected with the influence of tidal strengths acting lithosphere.
It was began to study an indignations (with the Sun) of month's orbital motion of the Earth during global nature processes. It has been demonstrated that shifts of the Earth's axis rotation are happened during periodical indignation its orbital motion. It was began an investigation of 1.5 one-half delay of ocean tide on data of observations in Murmansk and Polyarny stations (1977–1996).
It has been distinguished intervals of magmatic activization in Fanerozoic stage according geological data. These are compared with precalculated of changes of velocity and the axis of rotation of the Earth

(in accordance with cyclical motion model of tide evolution in Earth-Moon-Sun system). It was observed a steady trend of high tectonic activity of the Earth on Fanerozoic stage in the Northern latitude zone 20°–40°. It was established the increasing of folding areas from Herzinides to Kimmerides and Alpine stages. Maximum intensivity for these folding stages is noticed in the range of latitude 20–40° in the North hemisphere.

As it was demonstrated above the tidal strengths in the Earth – Moon – system may influence greatly the intensivity and latitude zoning of geological (geodynamical) processes in the Earth lithosphere.

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Integrated analysis of geological-geophysical and satellite images for gold prospecting in the Western Uzbekistan

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In the paper the method and the results of gold-ore mineralization prognosis on the territory of one gold-ore field of Western Uzbekistan based on the integrated analysis of geological-geophysical data and high-accuracy satellite survey materials are presented.

The works were executed in the specialized RAPID GIS environment that has been developed in the National Mining University (Ukraine) and which is a universal tool of prognosis and decision-making support for solving problems of natural and man-caused object prognosis and searching. The system includes the methods of pattern recognition (deterministic, statistical, logical and neural networks algorithms), image (binary and half-tones) processing, geostatistics, spatial analysis including lineament analysis and it is aimed at establishing of direct connections between spatial regularity of studied objects location and structural and morphological features of geological-geophysical fields that describe them.

The works were conducted in two stages. At the first stage the results of 6 geophysical fields observations on 1:50000 scale (Vz, dTa, gamma-field and others) and the digitized geological maps of the territory with area about 300 square kilometers were used as initial data. Multidimensional feature space was preliminarily formed using different transformations of initial fields and geological maps formalization by special characteristics calculation – distances from geological boundaries, amount of points of fault intersection, etc. The prognosis and perspective sites detection consist in implementation of territory ranging, recognition and clustering operations with corresponding prognosis maps construction.

At the second stage the detailed lineament analysis of QuickBird 2 satellite images (panchromatic channel resolution is 0.6 m, 4 multispectral channels – 2.4 m) was executed within the bounds of perspective sites with area of 50 square kilometers. For this purpose on the satellite images the lineament systems were detected for which lineament network spatial characteristics were calculated (for example lineaments and their crossings density, rose-diagrams statistics etc.). The majority of gold appearances are confined to the areas of sublatitudinal flexure-fault zones of foundation which are feebly marked on the initial images but are confidently enough detected on their characteristics. Analysis of the last ones allowed to detect within the bounds of perspective sites zones with structural-tectonic situation favorable to gold-ore mineralization detection (on 1:5000 scale).

Dynamic percolation on cellular-automaton networks

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In the presentation dynamic percolation on a simple cubic cellular-automaton network with stochastically growing potential is discussed. We consider random-growth model where random additions with a generalized Brownian spatial distribution are added to the potentials at the lattice sites at each step of the model time. In the case the dispersion of a potential relief linearly depends on both time and space scales. The potential difference growth between neighbors sites is limited by some critical value. As soon as this critical value is reached for any two neighboring sites on the lattice, breakdown or avalanche between the sites takes place. We assume that such a fine scale crash or an accident can initiate breakdowns of the neighboring lattice bonds ("infect" the neighbors), if the potential difference between the cells exceeds some activation level, which is less than critical one. We show that this system reveals, in a wide range of parameters, the features of universal self-organized criticality behavior typical for dynamic percolation.

Effectiveness of Genetic Algorithm method and its applications in determination of shear-wave velocity distribution

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Genetic algorithms (GA) are a search method which can be successfully applied to solve optimization problems. GA can provide a robust and efficient search technique in solving complex problems. GA works with a population of models and unlike any other optimization methods it works with models that are coded in some suitable form. There are four main steps in GA applications which are coding, selection, crossover and mutation.

Accurate calculation of the shear wave velocities is an important subject in geophysical applications. The shear-wave velocity profiles are calculated, based on the surface waves, by using GA method. In this study, the power and the effectiveness of the GA method with several case studies will be discussed in the applications of MASW and microtremor experiments.

Rascaled range analysis (Hurst exponent)

Kiselev, B.V. (St.Petersburg State University, Russia)

A major problem in statistical physics investigation is the study of long range dependence phenomenon presented in natural, technology, economic and humanitarian processes. In present report the role and the meaning of rescaled range (R/S) analysis (Hurst exponent) for theoretical and applied researches are discussed.

Multifractal and topological analysis of solar magnetic field complexity

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The purpose of this work is the searching the solar X-flares predictors. Topological complexity analysis of Active Regions with using

Michelson Doppler Imager Magnetograms (MDI) is used as the precursor. We use microcanonical multifractal formalism to estimate of Hölder's exponents. Obtained maps of singular manifolds is used for computing of topological invariants (Betti numbers). Numerical experiments of several Flaring Active Regions indicate that the Betti numbers exhibit the sharp variations not less then twenty-four hours before the X-flares. These effects are missing for Flare-Quiet Active Regions.

An investigation of the complex geophysical objects (GO) by means of pattern recognition methods (PR)

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The work is devoted to questions of comprehensive (theoretical and empirical) investigations of such complex geophysical objects as the geomagnetospheric storms (GMS), the earthquakes (EQ), and the separate geological objects (SGO) by means of modern scientific methods. A distinguishing characteristic of the investigation of those GOs is that the data on studied objects processes are getting in different space-time regions by sets of different instruments and apparatus. The data are processed a great variety of methods. The complexity of investigated GO requires address to a new methodological approach — system approach (SA), setting a plan for scientific investigation of studied complex GO as integrity in which the set of processes of different modality is considered as tight interconnected complex in space and in time. In system analysis of GO we have used a pattern recognition methods, which include the sequential and cluster analysis, and which are most adequate to system methodological arrangements. The essence of a new approach is demonstrated on example of the GMS of August 27, 1978 with Dst=-226 nT. The GMS is considered as complex interconnected set of 29 physical processes in the interplanetary - geomagnetosphere system. An application of this new approach based on PR in analysis of data of the EQ and of complex geophysical monitoring of SGO is discussed. It is pointed out principal moments drawing nearer the state of the affairs in these fields (EQ and SGO) of science and the state of the affairs in GMS physics. In particular, the main dignity of offered approach is that all EQ processes of very different nature may be not only considered on the common base, but in principle — lead to reconstruction of an EQ as a complex GO on the base of developed techniques of dendrite (or dendrogram) presentation of interconnected processes, just as it was done for geomagnetospheric storm. Therefore it will be realized statement of an EQ forecasting on the base of all available data complex and their interconnection. The suggested approach is also applicable to the analysis of the available data about complex geophysical monitoring of SGO.

Relative order of auroral transient structure during substorm activation

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The most popular approaches to dynamical complexity in space plasma are based on turbulence or self-organized criticality (SOC) paradigms. The coexistence of signatures of SOC scaling and intermittent turbulence has been noticed for auroral structures and for solar flare activity. Power-law scaling are characteristic features which are common for the output from models of turbulence and models and of avalanching systems exhibiting SOC states. However the usual approaches to turbulence and SOC employ different methodological frameworks, therefore a direct link between the two paradigms is still missing. We analyze the dynamics of two numerical models to demonstrate this problem. One of the models is the 2D Zhang model widely used to study SOC dynamics [Zhang Y.-C., Phys.Rev.Lett. V.63, N 5, P.470-473, 1989]. The second model is based on NVIDIA CUDA implementation of a simple fluid solver for the Navier-Stokes equations for incompressible flow [Goodnight N., CUDA/OpenGL Fluid Simulation, NVIDIA Corporation, 2007].

As an alternative we use an approach based on the S-theorem by Yu.L. Klimontovich. This approach allows us to compare the order which characterize the current (non-equilibrium) state of the system with experimental data. The considered characteristic is an analogy of entropy which has been extended to non-equilibrium states. Television observations of the auroral structure during substorm activation at the Barentsburg observatory (Svalbard) have been used as a data set. Dependence of the relative order on spatial scale has been analyzed. We found that the order of aurora structure increases during the substorm development. The same approach has been applied to data sets generated by cellular automata model of the substorm activity in the magnetospheric-ionospheric system [Kozelov and Kozelova, Ann.Geophys., V.21, P.1931, 2003]. Evolution of the systems in time and dependence on external control parameters are compared and discussed.

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Structure of thermal convection overlapped by velocity shear: fluid experiment

Kozelov, V.P., Kozelov B.V. (Polar Geophysical Institute, Apatity, Murmansk region, 184209 Russia)

Complexity of plasma dynamics restricts usual considerations to relatively simple elementary processes. Not only the processes itself but and interactions between the processes are interesting too. Many analogies between plasma and fluid dynamics are known, partly, convective processes. Here we present first results of laboratory observation of fluid thermal convection overlapped by velocity shear. The velocity shear was orientated perpendicular to the temperature gradient. The fluid used is oil with aluminum dust. The fluid motion has been recorded by digital HD video camera. The structure of the convective cells has been extracted by gradient filter. Visco-elastic features of the convection structure in the region of reconfiguration of thermal convection cells to shear motion have been considered. Gradual decrease of the fluid temperature gave us possibility to follow an increase of the shear motion zone with increase of viscosity. Possible analogies of observed structure with geophysical objects are discussed.

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Impact krater Zhimanshin and Biological crisis late Pleistocene – early Holocene

Levi, K.G. (Institute of the Earth's crust SB RAS, Irkutsk)

In 2007 in the foreign periodical press the hypothesis explaining fast destruction mammoth's fauna on a boundary of pleistocene - holocene, followed was discussed as a result of explosion comet's nucleus above Northern America in vicinities of Great Lakes. However impact structure corresponding to this event it has not been founded. The author of the report, having an extensive collection of radiocarbon dates of various geological, geoarchaeological and biological objects, has decided to check up this hypothesis on the basis of the statistical analysis ^{14}C datings. In result it was found out, that in Northern Eurasia catastrophically fast extinction of mammoths began about 10-11 thousand years ago. It was accompanied by strengthening mood flow and landslide activity both co-phase display of seismicity and volcanics activity shown usually in an antiphase. Begun holocene warming was sharply replaced by a cold snap continued about 1000. In our opinion, the reason of such sharp natural reorganization explosion comet's nucleus, but not over Northern America, and above Northern Eurasia really could be. After this accident it is necessary to count impact crater Zhamanshin near Aral sea, in details investigated by E.P. Izokh in 90th years of the last century. Explosion comet nucleus was accompanied by loss tectite's "rain". Diameter of a crater - 14 km, capacity of explosion - 10^{18}-10^{20} J. Time of explosion - the end late pleistocene - the beginning holocene (10-11 thousand years ago).

Multifractal methods of Markovian prediction — extremal cases

Makarenko, N.G. (The Central Astronomical Observatory of the Russian Academy of Sciences at Pulkovo, St. Petersburg, Russia)

This lecture is an introduction to the methods of stochastic Markovian time series prediction. Non-linear time series prediction by the embedology methods is based on the idea of low dimension dynamical chaos and fit to the situation where the share of deterministic observations is high. However, these conditions are breaking very often. In these cases, Markovian models are very useful. A random dynamical system which defined on a compact set serves as a basis for such models. The estimation of invariant measure could be received directly from the time series by the methods of symbolic dynamics. In the case when the measure have multifractal properties, it can be constructed with the help of the model of Iterative Function System (IFS) functions with probabilities. This model allows us to calculate the matrix of transition probabilities for Markovian forecast. The common approach and applications to a number of geomagnetic indices are produced.

Wavelet transform with physical point

Matjushkin, A.V. (Geological Institute, Apatity, Russia)

Wavelet analysis like Fourier analysis represents expansion of signal in a series of basis function. However, basis functions of Fourier analysis – sine and cosine are infinite and have no physical meaning. Unlike Fourier transform, in wavelet analysis we can choose quite different basis function, which, of course, must satisfy some specific conditions. General formula provides us that wavelet transform represent convolution of wavelet basis and the analyzed signal. In potential field analyses are used many different types of basis wavelet functions with quantity different characteristics. In this paper we investigate some wavelet basis witch constructed from potential function. The result of convolution of such wavelet basis and the analyzed field contain in explicit form location of singular point both signal and basis functions. This investigation have been supported by project 6 Earth Science Division RAS.

Nonlinear analysis of causal relationships between solar and geomagnetic time-series by means of symbolic dynamics

Oposhnyan, O.L., Ponyavin, D.I. (Institute of Physics, St.Petersburg State University); Makarenko, N.G. (GAO RAN, Pulkovo, St.Petersburg)

Causal relationships between geomagnetic indices and sunspot numbers were analyzed over a period 1868–2007. Firstly we studied the structure of time series by nonlinear dynamics. The idea consists in the presentation of time series in the symbolic form, with the use of their ordering relationship between readouts, and the words statistics. The method was tested using the well-known model of the logistic maps. It was shown that the method can be applied to detect regularities in a row structure, internal correlations and comparison of time series according to their semantic complexity. At the second stage relationships between indices based on Granger causality were tested. The results will be presented and discussed.

Method of generalized gradient analysis and its application to the field of high-latitude magnetic pulsations

Petlenko, A.V., Kopytenko, Yu.A. (St.Petersburg Filial of IZMIRAN, St.Petersburg, Russia)

Specific method of generalized gradient analysis is developed and applied to investigate the features of high-latitude magnetic pulsations field. The method is based on the assumption that continuous time-series of magnetic pulsations components data could be represented as superposition of magnetic pulses with unknown turn-on/-off functions. That means these data are consisted of different magnetic sources contributions and everyone of them is supposed to be localized in space and in time. The next point concerns considering the magnetic pulsations source term as ionosphere Hall-current drifting above observation point as a stationary configuration. For high-latitude irregular pulsations this excludes possibility of considering them as a set of plane waves. As turn-on/-off functions for magnetic pulsations sources are undefined we don't know are their contribution coherent or not. To resolve this problem we shall work with narrow-band filtered components data that allows represent them as impulses response superposition with quite simple model. We shall consider few pass-bands being close to each other as spectral linkage which avoids time-phase uncertainty that is proper to these responses. Besides of traditional spatial linkage being character for gradient analysis this linkage becomes efficient for responses parameters resolution. Generalization of the linkage term explains our pretend to the call of our gradient technique. On the other hand phase resolution for impulse response means that parameters of associated ionosphere source movement could be defined. In practice we could not determine positions of Hall-current borders. It is too complicated problem for our

representation. But usage of evident property that two pulses with short time delay between them looks like a single pulse, allows to find internal "center" of the same sign Hall-current domain being formed during every semi-period of irregular magnetic pulsations. We can treat this point as footprint of corresponding FAC (field-aligned current) in the ionosphere. Correctness of our construction is verified by comparing these points with local extremes in distributions of magnetic Pi2 vertical component on the base of "BEAR" network magnetic data. Their good compliance not only supports hypothesis on the localization of magnetic pulsations but also allows discovering their unknown properties, which possibly permit understanding the origin of their generation. Thus we can conclude that our generalized gradient analysis is a useful tool for investigation the definite class of data time series of physical origin.

Intellectual multi-layer approximation of potential fields: algorithm and its application for the analysis of the North Caucasus magnetic field

Shur, D.Yu., Tikhotsky, S.A. (Institute of Physics of the Earth RAS, Moscow, Russia)

The pseudo-intellectual algorithm is developed for the spatial reconstruction of the potential fields by their measurements over the irregular network of points. The method was specifically designed to be used with very irregular 3D survey geometries particularly in mountain areas and fields with the spatially uneven frequency content, which is the common feature of the anomalous magnetic fields. It is also suitable for the construction of the 3D analytical field approximations using the "old-style" paper maps.

The idea behind our approach is the successive approximation of the different frequency components of the field from the longest-wavelength's to the shortest-wavelength's by the layers of equivalent sources (monopoles or dipoles) located at different depth's from the deepest to the shallowest correspondingly. This idea was first proposed by V.I. Aronov with co-authors in 1970s and then further developed by V.M. Gordin with co-authors in 1980s. We have extend and developed this approach to overcome some existent shortcomings that made the technique useless in the extreme cases such as the North Caucasus aeromagnetic survey, performed in 1960s – 1970s.

Algorithm pseudo-intellectual behaviour includes the automatic analysis of the field non-stationary frequency content and adaptive distribution of the equivalent sources. Program logic includes following key features: (i) no pre-averaging of the field values, original data points are used instead at all stages, but those field values that are considered to contain high-frequency signal are filtered out while constructing deep layers; (ii) all sources from the current layer and all deeper layers are involved in the inversion at each stage; pre-conditioning is used to prevent the re-distribution of the anomaly from deeper layers to shallower ones; (iii) horizontal sources positions are also adapted for the shallowest layer; (iv) a priori information about the real sources distribution may be used by introducing the spatially variable upper bound for the sources distribution (for example, relief or crystalline basement surface may be used for this purpose). As a result, those field areas that contain only long-wave components are well approximated by the deepest layers with the given accuracy, no additional sources are placed under this areas at the shallow depth's and thus no high-frequency content is present here. Other areas are approximated in full detail by the next layers. Adapting the horizontal sources position for the shallowest layer prevents from the high-frequency artifacts. Algorithm performance is demonstrated by the synthetic examples.

The algorithm was applied for the construction of the 3D analytical field approximation for the North Caucasus magnetic field. The aeromagnetic survey was performed here about 40 years ago and possess strong difficulties for its interpretation because of mountain relief, different flight heights over different areas, as well as because of strong irregularities in the field structure and presence of the very high-amplitude high-frequency anomalies. These data is available as the paper contour maps of the field intensity and flight heights. We have digitized both datasets to obtain the vector map and then apply the described algorithm. The reconstructed 3D field was used to compile a set of field maps over different heights as well as field transforms. The magnetization intensity was estimated. Obtained results are analyzed in terms of North Caucasus tectonics and active faults.

Multiscale intermittency in nature and simulations

Uritsky, V.M. (Institute for Space Research, University of Calgary, Calgary, AB Canada); Muzalevskaya, N.I. (Russian State Pedagogical University, St Petersburg, Russia)

In this talk, we present a novel approach for quantifying multiscale intermittency in complex natural systems. The approach is based on spatiotemporal decomposition of a continuum time-dependent turbulent field into a set of discrete dissipation events, as well as on advanced time series analysis methods providing higher-order intermittency statistics for integrated activity measures such as global geomagnetic or physiological indices. The proposed approach is illustrated by a variety of examples, including flaring activity in the solar corona, electron precipitation dynamics in the auroral zone, multiscale fluctuations in human cardiovascular system, and bursty magnetic energy transport in turbulent MHD simulations. We show that in each of these applications, the intermittency measures provide significant new information about the scaling regimes, predictability, correlation patterns and the underlying thermodynamic states of the studied systems.

Solar wind fractal dimension in the last solar activity minimum

Val'chuk, T.E. (Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation (IZMIRAN) RAS)

The fractality of the solar wind (SW) plasma flow is widely discussed nowadays. Self-similar structures in the solar wind are present as elongated flow tubes that contain plasma streams with interplanetary magnetic field (IMF) propagating from the Sun all over heliosphere. These streams escape the Sun in radial directions and reach distances up to 10 solar radii R_s. The Wind and ACE spacecraft data obtained in near-Earth space can be used to perform the fractal analysis of the solar wind plasma parameters in years 2005–2008. SOHO and LASCO data on solar active events allow a deeper insight into the prehistory of SW flows that reach the Earth orbit. MDI solar magnetograms make it possible to reconstruct the position of large unipolar regions in the solar equatorial belt, which manifest themselves in the sector structure of IMF parameters of the solar wind flows reaching the Earth orbit. The object for calculating the fractal dimension is the solar-wind plasma medium. Fractal dimension values are calculated for the plasma density N and radial solar wind velocity component V_x in GSM co-ordinates. The time digitization equals ∼95 s, the sliding-scale window equals 6 hours, and the step is 3 hours. Only a few elements of strong sporadic phenomena exist at the minimum of solar activity. The solar minimum is especially suitable for the study of high-speed streams and transitions of the heliospheric plasma layer. These long-lived phenomena of solar activity are reflected in variations of the fractal dimension of the solar wind plasma parameters: the fractal dimension values equal ∼1.7–1.9 in the high-speed streams in coronal holes and fall down to ∼1.5 in the regions of transition of the heliospheric plasma layer.

Fractal characteristics of the Solar and magnetospheric activities and feature of the air temperature dynamics

Zotov, O.D., Klain, B.I. (Geophysical Observatory Borok, IPE, RAS, Borok, Russia)

Series of daily values of solar activity (Wolf's numbers), magnetospheric activity (A-index), air temperature and global seismic activity for 1930–2000 were analyzed. Dynamics of the Hurst exponent and dynamics of the average for all series of the data were defined. The comparative analysis of geophysical environments characteristics has been made. Correlation in dynamics of the fractal dimensions of investigated series was found. Feature near 1960 year in dynamics of the Sun activity and the magnetospheric activity was found. It was revealed that till 1960 dynamics of the air temperature does not correlate with dynamics of the magnetosphere activity, and after 1960 high correlation is observed. The hypothesis probably explaining features of investigated processes dynamics is considered. The change of a chaotic mode of the Sun activity there was near 1960. It has led to change of the geospheres dynamics character. This phenomenon can be interpreted as the noise induced phase transition in the Sun – Earth system.

Influence Sunspot numbers chaotic component on creation of the magnetospheric activity peculiarities

Zotov, O.D., Klain, B.I., Kurazhkovskaya, N.A. (Geophysical Observatory Borok, IPE, RAS, Borok, Russia)

Relationship of average daily values dynamics of solar activity chaotic component (Sunspots number) and dynamics of average daily values of the Earth magnetospheric activity (Ap-index) was investigated. The magnetosphere can be viewed as the system which there is in a metastable state. Influence of external noise on such systems will lead to occurrence of casual switching between attractors of the system. As a result the geomagnetic activity will be defined by properties of the external noise. It was shown that exactly chaotic component of the solar activity define features of magnetospheric activity dynamics. It was shown that using a method of nonlinear dynamic scanning it is possible to explain the dynamics of magnetosphere by the effect of a stochastic resonance. The simple model which explains statistics of the Ap-index was suggested. In this model the Gaussian noise (the solar activity chaotic component) has an influence on an input of the system (magnetosphere). On an output of the system (-index) the noise has properties of the distribution with a "heavy tail".

Section P. Paleomagnetic reconstructions, paleointensity and rock magnetism as physical basis of paleomagnetism

Dependence of the remanent saturation magnetization of the single-domain particle ensemble on stresses

Afremov, L.L. (Far-East state university, Vladivostok, 690950 Russia); Panov A.V. (Institute for automation and control processes, Vladivostok, 690041 Russia)

We study the effect of mechanical action on the remanent saturation magnetization within the framework of the model of a single-domain particle ensemble. It is shown that the longitudinal remanent saturation magnetization $I_{rs}^{\|}$ increases (the transverse one $I_{rs}^{\perp}$ decreases) with an increase in tensile stresses. It is connected with the reduction (growth) of the angle between the applied magnetic field and the effective axis. Moreover, with a rise in tensile stresses longitudinal remanent saturation magnetization reaches maximum, and then monotonically decreases to a certain asymptotic value. The compression causes the monotonic fall in $I_{rs}^{\|}$. The behavior of transverse remanent saturation magnetization with the linear tension (compression) is similar to the behavior of longitudinal with the compression (tension).

It should be noted also that the longitudinal remanence increases (transverse one decreases) linearly with a growth in small tensile stresses. The rate of change of remanent saturation magnetization under the small longitudinal action is the half of the corresponding rate of change in these parameters under the transverse action. The obtained results agree well with the experimental ones.

The palaeomagnetic study of two Neoarchaean sanukitoid intrusions from different provinces of the Fennoscandian Shield

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This study aimed to establish the assumed age of breakup of Baltica, that was the part of oldest and single Neoarchaen Kenorland continent. We have obtained a palaeomagnetic data for two Neoarchaean sanukitoid intrusions located in Fennoscandian Shield: Hizhjarvi intrusion (64.3 N, 32.6 E) having U-Pb zircon age of 2.74 Ga and Tuloma intrusion (68.8 N, 32.8 E) having U-Pb zircon age of 2.73 Ga. Conventional termodemagnetizotion technique was used for all samples. In Hizhjarvi intrusion (64.3 N, 32.7 E) five groups of distinct remnant magnetization components were divided. Component A yields palaeomagnetic pole 42.2 N, 211.0 E, magnetic age of this component is ca 1.85 Ga. Component C yields palaeomagnetic pole 15.3 N, 261.0 E. Age of the component C is 2500 Ma and seems to be the result of emplacement of Hizhjarvi intrusion. Component D yields palaeomagnetic pole 27.3 S, 272.9.0 E, magnetic age of this component is ca 2.45 Ga. Component F yields palaeomagnetic pole 11.7 N, 336.7 E, magnetic age of this component is ca 2.2 (1.2?) The fifth component A1 yields palaeomagnetic pole 51.1 N, 328.9 E. At present we can not establish an age of this component and apparently it resulted from adding of various components. In Tuloma intrusion (68.8 N, 32,8 E) three distinct remnant magnetization components (A1, D, F) were divided. Component D yields palaeomagnetic pole 28.6 S, 258.6 E, magnetic age of this component is ca 2.45 Ga. Component F yields palaeomagnetic pole 32.0 N, 327.6 E, magnetic age of this component is ca 2.2. Third component A1 yields palaeomagnetic pole 73.8 N, 239.5 E Early Proterozoic components D and F established in both intrusions are in agreement within a confidence circles and with a pole positions of 2.45 and 2.2 Ga on AWP. Coincidence components D and F in Tuloma intrusion of Kola-Norway province between of those in Hizhjarvi intrusion of Fennokarelian province evidences that rifting of Baltica in time interval of 2.45-2.2 Ga did not result in breaking up of that part of continent.

Phase transitions in systems of monodomain particles. Spin glass and magnetic viscosity of rocks

Belokon, V.I., Nefedev K.V. (Far Eastern National University, Institution of Physics and Informational Technologies)

The system of monodomain interacting particles is one from the simplest models, which allow simulate the different types of remanent magnetization of rocks and their interplay with each other. Here the key role here plays the circumstance that at the temperatures near Cure temperature T_c (ferrimagnetism), time of relaxation is small and properties of ferromagnetic particles are similar to superparamagnetic properties. The distribution function of random fields of interaction in system of such grains approximately is

$$W(\overrightarrow{H})d\overrightarrow{H} = \frac{4H^2}{\sqrt{\pi}B^3}\exp\left\{\frac{H^2}{B^2}\right\}\frac{1}{4\pi}\sin\theta d\theta d\varphi, \tag{1}$$

where H — module of random field, θ and φ — orientation of vector $\overrightarrow{H}$. (Small external field $H_0 B$ practically does not break of uniform distribution of random fields over angles θ and φ.)

$$B = 2n\int f^2 dV, \tag{2}$$

f — the projection of field on detailed axis (for example, axis Z. External field $\overrightarrow{H}_0$ is coincides with one.), n — volume concentration of grains. It is important that the origin of field f is thermodynamical magnetic moment of grain, which is in random field $\overrightarrow{H}$, therefore the equation for definition of field B is self-consistent.

Thus, in system of grains it is possible the following phase transitions:

1.) The paramagnetism-ferromagnetism transition at temperature T_c in each grain;

2.) The superparamagnetism-spin glass transition in system with dipole-dipole interaction between particles at temperature $T_f \sim \dfrac{mB_0}{k}$, where m — magnetic moment of particle (grain), k — Boltzman constant, B_0 — value of parameter B at $T = 0$ (of course, here $T_f T_c$).

In the same time the magnetic moment of grain could be blocked at some temperature $T_B \cong \dfrac{mH_c}{k\ln f_0\tau}$, where H_c — critical field of grain, f_0 — frequency parameter, $\tau = 1$ s.

If $T_f T_B$, that system in interval of temperatures $T_c T T_f$ has properties of classic spin glass (SG): magnetic moment of particles is “frozen” in random field $\overrightarrow{H}$. If $T_f T_B$, in result of blocking of grain with high coercivity, the transition into SG-state could not take place in real time. The estimation at $t \to \infty$ and $\dfrac{mB}{kT} \gg 1$ give that the distribution function over orientation of magnetic moments in external field for system of grains with mean value of the critical field H_c

$$W(H_0, \theta) \approx 1 + \frac{H_0}{B}\left(1 + 2\ln\frac{B + H_c}{\dfrac{kT}{m} + H_c}\right)\cos\theta \to \tag{3}$$

$$1 + \frac{H_0}{B}\left(1 + 2\ln\frac{B + H_c}{H_c}\right)\cos\theta, \tag{4}$$

Correspondingly, at $mH_c kT$ the remanent magnetization

$$I_r = \frac{1}{4}nI_s\frac{H_0}{B}\left(1 + 2\ln\left(1 + \frac{B}{H_c}\right)\right). \tag{5}$$

In case of weak interaction

$$I_r = \frac{1}{4}nI_s\frac{mH_0}{kT}. \tag{6}$$

In any from these cases the equilibrium could be arrived only at $t \to \infty$; in creation of I_s take part the grains with more and more high coercivity in accordance with $H_c \sim \dfrac{2kT}{m}\ln f_0 t$; even in system of grains with the same m and H_c the interaction “stretch” the time of equilibrium arriving.

From (5) follows, that the weak interaction practically has not influence on the remanent magnetization value in field H_0; the same result could be obtained and for system of non-interacting grains. In case of strong interaction the main chaotic parameter is random field $\overrightarrow{H}$. The $\dfrac{1 + 2\ln(1 + B/H_c)}{B}$ plays role of parameter $\dfrac{m}{kT}$.

Some disparities in paleomagnetic stratigraphy of the Chinese Loess Plateau deposits

Bol'shakov, V.A. (Moscow State University, Moscow, Russia)

The loess-soil sections of the Chinese Loess Plateau are the most widely used for correlation between terrestrial and oxygen isotope deep-sea global paleoclimatic records. However, there is the well known paleoclimatic disparity in this correlation: whereas the paleomagnetic Matuyama-Brunhes (MB) boundary mainly coincides with the *interglacial* 19-th oxygen isotope stage in deep-sea sediments, its position in Chinese loess-soil sections is usually fixed in the 8-th loess horizon which is correlated with *glaciation*. Similar paleoclimatic contradiction of the MB boundary position takes place in some other loess regions. It is commonly believed that this contradiction is due to secondary magnetization connected with chemical or post-depositional processes. These processes made the paleomagnetic record appear older, shifting the MB boundary down the section relative to its true position in time (lock in depth, or delay of paleomagnetic record). Zhou and Shackleton (1999) evaluate this lock in depth to be equal to 170–250 cm. However, in my opinion, post-depositional processes can not be the reason of such great lock in depth. Secondary chemical changes, connected with soil forming processes may be the more possible cause of the above mentioned lock in depth. The intensity of soil forming processes may be evaluated by the measuring of the value of magnetic susceptibility (MS) of different soils and parent loess horizons. The higher is the MS of soils the more intensive are the soil forming processes. According to MS and some other datum, the soil forming processes are much more intensive in central and south-east regions of the Loess Plateau, than in west and northern-west region. This conclusion is supported by the fact that the Blake excursion in the Loess Plateau sections was mainly discovered in western areas of the Plateau, whereas this excursion was virtually undetected in central and eastern areas. This fact can naturally be associated with pedogenic processes leading to the formation of the secondary (bio)chemical magnetization. In central areas, where these processes are much more intense and involve loesses to a greater extent, excursions records are smoothed not only in soils but also in loess horizons.

So, the influence of soil forming processes on magnetization must be minimized in west regions of the Loess Plateau. According to this conclusion, the record of MB boundary should be lest distorted in this part of Plateau, i.e. it should be found inside soil horizon S7, as was proposed by Zhou and Shackleton (1999). However, the MB boundary is shown inside loess L8 in paleomagnetic correlation diagrams for the outcrops of the west region of the Loess Plateau. This fact leads to the conclusion that soil forming processes in west part of the Chinese Loess Plateau do not influence paleomagnetic record of excursion, but do influence paleomagnetic record of inversion. It is obvious that such conclusion is illogical. This contradiction may be resolved, if we assumed that MB reversal was synchronous with formation of loess horizon L8. However, the last supposition leads to mentioned above paleoclimatic disparity in MB boundary position. So, paleomagnetic study of the Chinese Loess Plateau outcrops needs further careful investigations. These investigations should include careful magnetic measurements of the loess and soil specimens. For instance, I revealed the termomagnetic effect, which nobody mentioned earlier for loess samples of the Chinese Loess Plateau, last year. Besides, this investigation should include also different geological methods to resolve some other problems. One of them is the correlation of soil S5 with marine isotope stages (MIS). Soil S5 was correlated with MIS 13 when it was believed, that MB boundary was inside soil S8 (Heller, Liu, 1982, 1984). However, this soil was correlated with two oxygen isotope stages, MIS 13 and 15, when it was shown, that MB boundary is fixed in loess L8. In other words, soil S5 for the first time was correlated with one interglaciation only, but later it was correlated with two interglaciations and one glaciation, without any supplementary paleogeographical evidences. Different approaches to the solving of the above shown disparities should be considered (Bol'shakov, 2004).

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Kinematics of Phanerozoic Terranes of the Bureya-Khanka Orogenic Belt

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The Bureya-Khanka orogenic belt (BKh) is a collage of terranes of different age and genesis. In combination with other orogenic belts – super terranes (the Argun, Mongolo-Okhotsk and Sikhote-Alin ones) they form the eastern part of the Central-Asian belt, the so-called Amur Plate (AP). Occupying the central part of AP, the BKh orogenic belt covers the Matveevka-Nakhimovka (MN) and Kabarga (KB) Early Paleozoic metamorphic terranes, the Spassk terrane (SP) – a fragment of the Early Paleozoic accretionary prism, the Maly Hingan (MH) terrane – a fragment of the Paleozoic continental margin magmatic arc superimposed on a more ancient accretionary complex, and the Sergeevka terrane (SE) – a fragment of the Paleozoic-Mesozoic passive margin. As a result of paleomagnetic studies of metamorphic and terrigenous-carbonate complexes of rocks new paleomag-netic results are obtained (paleomagnetic pole positions) for Late Proterozoic and Early Cambrian rocks of the AP terranes, which are compared to the data for the Siberian (SP) and North China (NChP) plates. There have been estab-lished low paleolatitudes for the formation of ChRM of the studied rocks in the Late Riphean and the Early Cambrian. Also, the calculated geographical coordinates of the initial paleopole positions have been obtained for the corresponding geological time intervals. These results are supported by different tests (the conversion, fold, pebble ones) which, to a great extent, affirm the priority of the ChRM distinguished. On the whole, it is notable spatio-temporal stability of the paleolatitude positions for the above terranes located in the Northern and Southern Hemisphere near equatorial areas during the Late Riphean till the end of the Early Cambrian. "Intermediate" paleolatitude position of terranes between the Siberian and North China plates (which is geographically "remained" up till now) and a relatively compacted location of the above geoblocks (for the assumed variant of polarity) could be determined due to their belonging to a unique super continent during the Late Proterozoic up to the Early Cambrian. Along with this, significant "intraplate" rotations of the above geoblocks (terranes) and also those of the SP terrane and NChP with the Euler poles are revealed in sampling areas without a significant latitudinal relative displacement. The Cambrian poles for the objects of MH terrane, and for those of the MN, SP and KB terranes close in view of their territorial location, and also of the SE terrane, are positioned practically on a single arc of a smaller circle as a point cluster thus characterizing successive rotations of intermediate paleopole positions of the geoblocks relative to one an-other between the MH and MN-SP-KB terranes on 50.5° and between the latter and SE terrane – on 63.3°. In the first approximation, one can find possible interpretation of similar rotations within the framework of an analysis of complicated geoblock kinematics at displacements of different orientation (mainly left-lateral) which take place along the Tan-Lu and Sikhote-Alin fault systems thus creating an intricate mosaic of displacements in space and time. It should be noted that the northwestern and sublatitudinal trending of fold structures is predominant for the MN-SP-KB terranes and the submeridional, more rarely, northeastern one – for the MH terrane. To substantiate an assumption on the primary "block integrity" for the above terranes it should be suggested either left-lateral rotation of the Khanka Massif (the MN-SP-KB terranes) relative to KH terrane, or right-lateral rotation of the paleostructures of the latter, correspondingly. In principle, the data on the SE terrane can be interpreted in a similar way. However, at this stage of investigations they are not representative enough. For the Cambrian objects of NChP similar rotations of the geoblocks are observed, the radius of a small circle is larger to some extent and an intermediate Euler rotation pole is positioned also in the sampling area. Late Paleozoic (Carboniferous) and Mesozoic (Jurassic) paleopole positions with confidence circles are similarly observed in areas located within the borders of arcs of small circles (with large radii for the Carboniferous and the smaller ones – for the Jurassic). The intermediate paleopole positions for AP are close to the analogous positions for NChP. They are close to the Mesozoic interval (trend) of the apparent paleopole wander path. It is established a larger, compared to the present-day, discrepancy between the paleolatitudinal positions for the formation of magnetization in the terrigenous complexes within the BKh orogenic belt for the superimposed Upper Bureya depression (the BU "terrane") relative to NChP during the Mid-, Late Jurassic, reaching $14.9° \pm 7.1°$ with rotation on $55.9° \pm 9.1°$. Relative to the Siberian plate, where magnetization of Mid-, and Late Jurassic sediments (the Chulman area) occurred at 64° paleolatitude, the BU terrane was located southward at 33.4° (as compared to the present-day 5.8°). On these grounds it is suggested that the total width of shallow remanent basins of the Paleoasian Ocean, separating the above geoblocks in the Lower, Middle Jurassic, could still reach the first thousands of kilometers, or the observed discrepancy between the paleolatitudes characterizes the order of displacement along the shears and reduction (heaping) of the crust at accretion. The Argun super terrane paleoposition during the Jurassic differs insignificantly from the present-day one, which, in particular, can be determined by the fact that the region belonged to the passive continental margin of the platform at the end of the Mid-Mesozoic. The time of the "final" closure of the water area of shallow bays of the Paleoasian Ocean is considered not earlier than the Late Jurassic-the beginning of the Cretaceous.

Research of "rapid" variations of geomagnetic field intensity in I thousand BC

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For research of variations of the geomagnetic field intensity in I thousand BC the narrowly dated delivery ceramics were used from the islands of east part of Mediterranean and from Asia Minor which is dated in most cases in limits ±20 years. Laboratory researches were conducted by the variant of method of Thellier, modified authors (with amendments on an anisotropy and chemical changes). On built middling–11–annual curve of change of the geomagnetic field intensity on a time-interval the second half of the V – IV centuries BC it is possible confidently to trace variation of the field intensity characteristic time of which - approximately 110 years. Before "centenary" variation there on time-interval selected was not, that, presumably, it was related to the wide dating of the probed material and rapid lowering of archaeointensity in the second half of I thousand B.C. (more than on the third - from a level higher 80 to – below 60 mkT). Consideration of aggregate of again findings about variations of archaeointensity in the second half of I thousand B.C. with the results of row of previous researches about variations of the field in the last millenniums testifies to continuity of existence of "centenary" variation on an extent at least of the last two with a half millenniums. It was before found out existence of this variation on different time-intervals (in VI – V and the II millenniums BC). Work is executed at sponsorship of RFFI, grant 06-05-65219.

Simulation of different scripts of the main geomagnetic field variations on the base of the forecast of their sources dynamics

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The dynamic model of the main geomagnetic field sources has been developing by authors for several last years. Up to now dipoles of 3 magnitude levels are obtained as such sources. The most part of them exists and continuously develops over last 100 years. The time series of dipole parameters obtained are smooth enough to be extrapolated. But for a long-range forecast some more assumptions are required about a global tendency of the sources variations. Depending on assumptions made the possible scripts of the main geomagnetic field variations are worked out for the 1000 next year. The main development tendency which was obtained for 20 century is that decreasing magnitude of the main dipole is followed by forming and increasing the geomagnetic field non-dipole part. It is shown if such tendency holds the large local anomalies of a geomagnetic field spatial structure can start to dominate at the expense of increase of power of the non-dipole part sources. In this case additional poles and local reversals can originate. This work is supported by grant MK-2618.2007.5.

New paleomagnetic data from Permo-Triassic traps of Siberian platform (Popigai River valley)

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Paleomagnetic data from Siberian traps, which are obtain based on an actual methodological and instrumental level, can be used for more precise determination of Permo-Triassic apparent polar wander path (APWP) of Siberian platform. These data also can be used for reconstruction of its tectonic history and more over for valuation of intensity and duration trap formation, which are directly connected with the catastrophic nature of this process. In this study for the first time were researched effusive and subvolcanic traps objected in the Popigai River valley (Northern part of Siberian platform), which are formed from the basic rocks and their age is apprised as Permo-Triassic. In some cases observed subvolcanic formations overlie on

Permian sediments with the angle discrepancy. Paleomagnetic study of the pilot collection shows that the ancient component of magnetization of the normal and reversal polarity is observed in all of six tested samples. A new paleomagnetic pole for Siberian platform was calculated: plat=49.0; plong=148.8; dp/dm=5.9/6.5; N=39, paleolat=60.8 (6 sites). The average coordinates for the area of sampling are slat=72.3, slong=109.5. Obtained paleomagnetic pole lie close to another P-T Siberian poles and a little displaced aside more ancient part of APWP. This fact can be considered as the indication of the more ancient age for traps of the Popigai River valley, than the age of another studied traps of other regions. This fact can be connected with the earlier period of beginning of volcanic activity in this region, but this assumption should be confirmed by more detailed investigations. Calculated paleomagnetic pole enriches the Siberian traps database and can be used for the development of Permo-Triassic segment of APWP and for paleotectonic reconstructions.

Geomagnetic reversal Matuyama – Brunhes

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Investigation of the reversal transition Matuyama – Brunhes in two independent sections of the outcrop Volodarka in the Priobskoe Plateau (52°41'N, 83°38'E) has been started. This outcrop is located on high left bank of Ob' River about Barnaul and its thickness is about 50 m. The section Volodarka is represented by the Pleistocene deposits consisting of loess loam and paleosoil horizons. Field studies, the analysis of magnetic and paleomagnetic parameters of sediments of all section, and a transition zone have allowed the transition zone, and also prereversal and postreversal intervals of the section to be made. The 490 oriented specimens representing 200 temporal stratigraphic levels taken from two sections of Volodarka were studied. Some of these samples were taken continuously other samples were taken 10, 20, and 40 cm apart. The previous investigations have allowed us to infer that two large magnetic polarity zones Brunhes and Matuyama in the paleomagnetic section of loess-paleosoil sequences have been revealed. The transition zone is found in brownish-yellow dense loams. Reliability of obtained paleomagnetic data is confirmed by determination of magnetic minerals-carriers of magnetization, by the nature of natural remanent magnetization, and by the component analysis of natural remanent magnetization. The magnetic susceptibility of sediments of the section changes within the range from $45 \cdot 10^{-5}$ to $170 \cdot 10^{-5}$ SI. Differentiation in rock types (paleosoils, loesses) by a magnetic susceptibility it is not observed. Loesses also as well as paleosoils can possess both the high and low susceptibility values. First, it has been shown that loesses and paleosoils not differ from each other by the composition of magnetic minerals. Integrated and differential thermomagnetic curves for loesses and paleosoils published by V.A. Bolshakov demonstrate the qualitative similarity. The basic carriers of natural remanent magnetization in paleosoils and loesses are magnetite, maghemite and hematite. The similar composition of magnetic minerals in loesses and paleosoils allows us to infer regarding depositional remanent magnetization. At least, the absence of significant chemical remanent magnetization can be inferred from the intensity of natural remanent magnetization and results of laboratory redeposition of the rocks. Two components of natural remanent magnetization, primary and secondary, are present in loesses and paleosoils by the results of progressively thermal demagnetized. Secondary component of a viscous origin collapses at temperature 200-250-500°C. Primary component is allocated at 250-575-600°C. Reversal transition is revealed in brownish-yellow dense loams and its thick is about 2,5 m. The paleomagnetic section of a transition zone has been constructed. The transition record can be divided into some stages. The initial stages of transition represent R→N→R cycle and the final R→N transition. In some stages the field does not reach full N or R polarity. Studying of behavior of the Earth's magnetic field of and its intensity during transition Matuyama – Brunhes proceeds. Virtual Paleomagnetic Poles paths during transition are constructed. Investigations are carried out at support of the Russian Foundation of Basic Researches (grant 07-05-00582).

Variations of polarity magnetization and geochemistry of flood basalts as a manifestation of the superplumes (on the example of flood basalts Noril'sk and Kivinovan provinces)

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Formation and features platobasalts are connected with activity lower-mantle superplumes, separating from boundary the bottom mantle (layer D") - an external core. Interaction the bottom mantle - an external core at formation mantle superplume influences magnetic field generation, up to its inversion. Variations of a geomagnetic field it is fixed in rocks formed at this time. Correlation between formation lower-mantle superplumes, platobasalts and inversions of a geomagnetic field is considered on an example Siberian platobasalts (Noril'sk area, 250 ml. years) and provinces Kivinovan (N. America, 1100 ml. years) . They are localized on an ancient platforms with Ar-Pr the crystal base with thick (10 km) the sedimentary cover blocked lavas. The lavas early and more later stages are characterized by various magnetization. Early - return, late - a normal magnetization. Within each of laves provinces differ in the geochemical relation. Early, before inversion suites, with return magnetization - magmas of type OIB derivative highly-Ti. Later, post inversion suites, with normal magnetization magmas derivative low-Ti. Thus it is observed asynchronous magnetic and tectonic displays core/mantle interaction - logging of inversion of polarity of magnetization of laves from riftogenesis and the beginnings of volcanic activity. "Logging" inversion of polarity of magnetization of lavas from riftogenesis and the beginnings of volcanic activity gives the basis to believe, that from the moment of start of "machine" core-mantle interaction, time spent for formation, lifting, interaction of plume with lithosphere, riftogenesis and volcanism was less time of course of processes in a core, caused inversion of a geomagnetic field.

Non-uniform rate of sedimentation and wavelet-analysis of paleomagnetic data

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For full representation of the geomagnetic field structure in the past the important value has studying characteristic times of field elements fluctuations which are fixed in continuously accumulated sedimentary rocks of big thicknesses. Received by us at researches Pliocene-Pleistocene sediments in Western Turkmenia results testify to extreme heterogeneity of selected characteristic times. The certain fluctuations are observed on separate intervals of the investigated time series of paleomagnetic data, testify about presence of slowed down and accelerated processes. To establish such picture became possible only when the wavelet-analysis was used. At the same time when we consider that the average rate of sedimentation of all investigated thickness of section was constant we may be mistaken. We can receive the data about the slowed down and accelerated processes if the rate of sedimentation was gradually slowing down or increasing. Wavelet-analysis of the main archeomagnetic time series has completely confirmed possible connection of the similar change of characteristic times with a geomagnetic field (if the magnetization investigated by us really records the field of sedimentation time). Undoubtedly, the received results will depend on time uniformity of investigated sections, from presence in them of breaks in sedimentation and so on. On model time series (4 sinusoids of the different periods and amplitudes) we have checked up influence of deviations of real time series from uniformity, its influence on result of the analysis. Some limits of this heterogeneity and its reflection on wavelet-diagrams have been established. This work is supported by RFBR grant N 06-05-64646.

Magnetism and paleomagnetism of the Russian Arctic marine sediments

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Last years two main types of the Arctic Ocean sediment cores were studied: from sequences of very slow sedimentation area in the deep parts of East Siberian Sea, and from shelf sequences in the Barents Sea. Sea depths in the 7 sites of the core sampling in East Siberian Sea are between 1.5 and 3.3 km, core length is between 2.1 and 3.35 m. The measured magnetic susceptibility κ is alternating in limits (2-6) 10^{-4} SI, the core intervals with outlying κ values (up to 12 10^{-4} SI) are revealed. Natural remanent magnetization Jn alternates in cores in limits (1.7-3.2) nT. Average Jn value of the normal magnetized layers is about 3 nT while the reverse magnetized layers are characterizing by Jn values about 1.5 nT. Magnetic cleaning in alternating magnetic field to 123 E let us to get partly rid of viscous magnetization. Taking in consideration of Bruhnes, Matuyama and Gauss subchron durations (Pospelova, 2004) and according to data of measurements it is reasonable to assume of approximately constant sedimentation rate during last 4 my. So, it is possible to relate peculiarities of the sediment magnetic parameters to the definite age intervals. Boundary Bruhnes-Matuyama (0.73 my BP) and subchron Jaramillo (1.07-0.99 my) are clearly fixed in all seven cores; subchron Olduvai (1.95-1.77 my BP) is marked in two cores, subchron Reunjon (2.13 my BP) – in one core, boundary of subchron Matuyama-Gauss (2.6 my BP) is marked in three cores. The Bruhnes- Matuyama boundary is marked in all cores by especially big values of κ. So, outlying κ value can be used as an additional feature for definition of this boundary. Average sedimentation rate during Bruhnes epoch is, according to our measurement data, 1-1.4 mm/kyr in five cores from Mendeleev Ridge, and 2.6-3.0 mm/kyr – in two cores from Podvodnikov Basin. Studying of the Barents Sea sediments we continued investigations of V.V. Kotchegura (1992) expanding his study to central and northern parts of Barents Sea. Sea depths in 30 sites of the core sampling in Barents Sea are between several tens and 400 m. The fine temporal structure of the geomagnetic field for the past 30 kyr manifests itself in the development of geomagnetic field excursions (sharp geomagnetic pole displacements in latitude and longitude) and in slow variations in the geomagnetic field elements. An analysis of the paleomagnetic characteristics shows the Etrussia-Sterno (2300-3000 years ego) and Solovki (4500-7500 years ego) geomagnetic field excursions, the Gothenburg excursion at the Holocene-Pleistocene boundary (12-13 kyr ago) marking the end of the last glaciation, and the Mono excursion (26-28 kyr ago). A significant increase in the magnetic susceptibility at the Holocene-Pleistocene boundary, observed in many Barents cores, reflects climate changes during this period. The cyclic component of the variation in the geomagnetic field inclination with period about 15 kyr has been revealed.

A quantitative model for the magnetite particles' self reversal

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The quantitative model for the fine magnetite particles have been created on the bases of Neel's representations about the rock magnetization reversal phenomenon. It is proposed that at the initial state upon the geological history scale the particles' temperatures were higher than the critical Curie's one and thus the rocks had no magnetization. The cooling of the particles started from their surface layers as far as they were in closest contact with the cooling medium. Therefore the surface layers have been magnetized first and their magnetization recorded the local Earth magnetic field. The particles' bulk magnetization during the further cooling process turned up to be magnetized both in presence of the local Earth magnetic field and the demagnetization fields from the layers. If surface anisotropy was acting in favor of parallel magnetization in side surface layers then the additional factor appeared for stabilization of magnetization vector along the Earth magnetic field in particles' side surfaces and reversing the magnetization in their bulk parts. Because of difference in thermodynamical environments, in which crystalline structures of surface and bulk parts of particles are forming, two or more different magnetization phases can appear intersecting by macroscopic defects. As a result the strong exchange interactions between oppositely magnetized phases disappear or became sufficiently reduced facilitating particles magnetization's reversal. The ideal cases for the magnetite particles of spheroid shapes of the internal and external phases are under the main consideration. If these phases are homogeneously magnetized then the magnetization factors can be introduced and the magnetization reversal phenomenon became tangibly simple for the investigation. When the temperature descends down to the upper Earth crust the particles' magnetizations turned up to be reversed under the following conditions: - Demagnetization factors of the external, surface particles' crystalline phases are larger than its internal parts; - The magnetic moment of the external phases is less than of internal ones; - Earth magnetic field action on magnetic moment of internal phase is less than the action on external phase; - Exchange interaction between external and internal phases is absent or weak enough for existence of the oppositely magnetized phases; - Surface anisotropy is acting in favor of stabilization of magnetization in side surface layers and reversed magnetization in other surface parts; - The particles are large enough having volumes 103–106 nm3 by order of magnitude to discriminate super paramagnetic instability of the particles' magnetic moments; - The particles are small enough having volumes 106–1012 nm3 for cracking the magnetic phases into more of domains' number and thus diminishing the magnetization reversal effect. The similar factors can also play their role in principal in the particles' magnetization reversal phenomenon in cases, when the magnetic phases are the fractures of the particles' parts, intersecting by the macroscopic defects. These fractures can have other shapes than spheroid. The general conditions for the magnetization self reversal are like the formulated set forth for the ideal spheroid shape phases. Generally speaking the magnetization self reversal of an entire rock sample depends evidently on the reversal percentage of magnetite particles have been reversely magnetized. The mechanism of the rock magnetization reversal described can be implied not only for the magnetite particles but for the titanomagnetite ones, which are well known as having the similar crystalline structure and magnetic properties as magnetite particles. This magnetization self reversal mechanism can also be effective for the hematite particles.

Some investigation results of specific character of magnetic anisotropy of rocks in the Far East

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Magnetic anisotropy of Late Riphean and Phanerozoic sedimentary rock complexes of Primorye, Priamurye and Trans Baikal is studied. The distinctions in the scalar values of individual parameters and similarity in the distribution of the principal axes of tensor ellipsoid of anisotropy on the sphere are revealed for anisotropy of magnetic susceptibility (AMS) and that of isothermal remanent magnetization (AIRM). Convergence of indications and/or distinctions between them can testify to a different (superpositional) contribution of the ferri- and paramagnetic grains of the corresponding class to the observed characteristics and to their variable sensitivity to tectonic stresses. It can be assumed that tensor distribution of the principal axes of ellipsoid of AMS and AIRM on the sphere is determined to a significant extent by the synfold stress, while Am and m scalar ratios characterize to a greater extent a dominating contribution of either assemblage (combination) of the ferro-, ferri-, para- and/or diamagnetic minerals to a tensor ellipsoid shape. The linear type of magnetic anisotropy is mostly manifested in Late Riphean metamorphic complexes, as well as in Phanerozoic terrigenous rocks (to a less degree). The foliated type of AMS is revealed in the subordinate quantity and practically, it does not occur anywhere in its "pure" form. The observed ratios of Am and m parameters for AMS and AIRM are often contrary - foliation (F) and linearity (L) are displayed in different ways for the above anisotropy types in rocks from different areas. Tensor distribution of the principal axes of ellipsoid for AMS and AIRM is practically similar (as for the latter, the same concerns different magnetic fields also). Particularly, meaningful correlation (similarity) of the inclination value for the small axes can reflect as the sedimentary character of anisotropy (during an ordinary geomagnetic field impact when orientation magnetization is formed), so the stereotyped character of response of magnetization carriers referred to different types (paramagnetic, MD- and SD-grains) to the external effects in the case of intense stress impact on rocks during the orogenesis and the formation of synfold ChRM. The study of correlation dependence between the ChRM vector inclination and Am, m anisotropy parameters shows that it is individual enough (up to the contrary – from the direct to inverse one) for different areas under study. Thus, for the Mramorny object, characterized by the linear type of AMS, the best correlation is observed for Am parameter and steeper inclinations of ChRM in the recent coordinate system. As for the Oldoi object, where the mixed AMS type prevails (with a contribution of "foliation component"), it is noted the inverse correlation for m parameter with the inclination in the ancient coordinate system (tgIs). That is, the inclination of ChRM vectors acquires the negative values here with anisotropy increase. On the whole, on the Oldoi object, where, according to fold test, synfold ChRM is distinguished while grouping the sections with differing tectonic elements (foliation), more anisotropic specimens of Devonian rocks have steeper inclinations, that is most probably related to the folding processes. Relationship of S with geometry of the fold structures is studied. As exemplified from the sedimentary rocks which build up the Mesozoic superimposed depressions of Priamurye and Trans Baikal, it is seen that average orientations of the intermediate axes K2 of tensor ellipsoid of S, are directed, as a rule, perpendicularly to the strike of terrigenous strata thus marking the direction of the general trend of rock compression (regional stress). It has been preliminarily estimated a degree of completeness of deformations for Phanerozoic terrigenous complexes of a number of terranes of the Amur plate by the time of formation of synfold remanent magnetization (SFRM). Probably, general orientation of this process is determined as by the general trend of the orogenesis in different geological time intervals (being often laterally oriented in different directions), so by its intensity (rate of completeness). Different (opposite) orientation of the complete deformation trend at the stage of SFRM formation for Cambrian and Jurassic rocks, which, probably, make observable different stages of the orogenesis in space and time, can be considered as an example. It is suggested one of the possible variants of plate kinematics which determines the general character of development of folding of the Far East orogenic belts. The correlation revealed between ChRM vector orientations and the principal axes of tensor ellipsoid of anisotropy, and also, the strike and dip of layered structures allow us to evaluate some possible estimation techniques as to AMS influence on smoothing of ChRM inclination. Different approaches to the introduction correction for anisotropy are considered, which are based as on taking into account the anisotropy contribution of assemblage of individual magnetic grains, so on the estimate of interrelation-ship of the ancient magnetization field and anisotropy, determining the distinguished ChRM. On condition the rocks are anisotropic due to magnetic susceptibility, determination of the ancient magnetization field entails difficulties, because In remanent magnetization vector deviates from the magnetization field. The other factor which complicates paleomagnetic investigations, is dislocation of the initially horizontal rock layers. Therefore, if significant anisotropy exists the fold test should be applied not to magnetization but to magnetization field . To automate the calculations V.N. Zavoiskii elaborated a special program calculating the angle between In and H vectors using the strike and dip of the layer, declination and inclination of the recent and ancient field orientations. Single vectors characterizing the recent and ancient orientations of In and H vectors are averaged. As the study of sedimentary rocks shows, on the whole, the total dAMS correction value varies for the objects under study within some degrees reaching ten and more degrees in rare cases. It is noted the correlation between dAMS and anisotropy parameters of Am, m and m.

Low-temperature rock magnetism: fundamentals and frontiers

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The present talk is aimed to give an overview of the background physics, instrumentation, and experimental procedures as applied to the studies of the magnetic properties of rocks and minerals at low temperatures, particularly in the 77 K range. This field has seen a considerable progress in the last 15 years, prompted by the rapid development in instrumentation. Low-temperature magnetometry can be applied both to a relatively simple and straightforward task of identifying mineral phases that carry NRM in a particular rock, and, on the other hand, to more subtle problems, e.g. assessing the oxidation state of magnetite, estimating the amount of superparamagnetic grains in a rock sample, or identifying the presence of bacterial magnetite. If interpreted correctly, the low-temperature magnetic data may be of great help in solving the problems of palaeomagnetism and environmental magnetism. However, it must be realized that our knowledge of even basic magnetic properties of minerals at cryogenic temperatures is at best incomplete. The most obvious and perhaps the most unfortunate is the paucity of the data on the magnetic hysteresis behaviour as a function of temperature in the 77 K range, even for the most extensively studied mineral, magnetite. Equally insufficiently are known the magnetic properties of minerals that do not carry remanence at room temperature but become magnetic at low temperatures. These deficiencies could in principle seriously hamper the interpretation of both low-temperature SIRM demagnetization and susceptibility data.

In the second part of the talk I discuss three examples of low-temperature magnetic studies of geophysically relevant minerals. These include: (i) multidomain magnetite; (ii) very fine intergrowth of slightly Ti-substituted magnetite with an ulvöspinel-like phase, and (iii) iron carbonate (siderite).

Geomagnetic polarity sequence during miocene and pliocene times: new data from Taman Peninsula section

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The northward plate tectonic motion of the African/Arabian continent during the Neogene (24-0 Myrs ago) has led to the closure of the Tethys Ocean. The Alpine-Himalayan orogenic barrier separated this ocean into the Mediterranean domain and the so-called “Paratethys” domain; a large endemic water mass that extended from Austria to Uzbekistan, with the Black Sea and Caspian Sea as actual remnants. Both domains have experienced dramatic paleoenvironmental (and tectonics) changes during the Neogene, examplified by the desiccation and reflooding of the Mediterranean during the Messinian Salinity Crisis (6-5.3 Myrs ago). The configuration of the Mediterranean region has allowed the construction of very detailed astronomically tuned geomagnetic polarity time scales, which at present underlie most modern paleoclimatic, paleooceanographic and paleogeobiologic research efforts. In contrast, the time scale for the Paratethys domain is highly equivocal and controversial ages exist for many events and geological stage boundaries, although suitable conditions exist to develop astronomically tuned polarity time scales both for the eastern and western parts of this basin. As to the Eastern Paratethis magnetostratigraphic researches have been started here as early as in the middle of the 20th century, however recent works, based on modern paleomagnetic technology focuses on the last million year age rocks. This lead to the necessity of new investigations of more ancient magnetostratigraphy on the classical sections of this domain. In this report, we aim to present some new results of geomagnetic polarity time scale construction for the Eastern Paratethys with special focus on the $\sim$10 to 4 Myr of geological history. Investigation of detaily sampled 475-m standard section Zhelezny Rog on the Taman Peninsula yields a sequence of 8 magnetozones, which cover stratigraphic stages from Upper Sarmatian to Lower Kimmerian. Dual-polarity paleomagnetic directions point on the 20-7 degrees clockwise rotations of sampled area since 10-4 Ma ago. The development of the magnetochronology for the Eastern Paratethys will directly establish high-resolution (micro) paleontological, geochemical (isotopes) and cyclostratigraphic records aiming at detailed reconstructions of the environment and climate history of Eurasia. This work was supported by the NWO / RFBR 047.017.005/ 05-05-89000.

Numerical simulation of process of obtaining of depositional remanent magnetization within the frame of 3-D magnetic-rheological model Schwedoff-Bignham

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At the 6-th International Conference "Problems of Geocosmos", the authors have suggested the 3-D model of post-depositional remanent magnetization.

Differential schemes for calculation of magnetization components with the temporal step of integration $\Delta t = t^{i+1} - t^{i}$ are represented by ratios:

$$I_k^{i+1} = I_k^i + \Delta t \times dI_k^i/dt, \ (1)$$

where

$$\frac{dI_k^i}{dt} = -\frac{1}{\tau_{\rightarrow}^{(k)i}}(\vartheta_k^i - h_k h_j \vartheta_j^i) I_0^{\infty} - \frac{1}{\tau_{\uparrow}^{(k)i}} h_k h_j \vartheta_j^i I_0^{\infty}, \ k = x, y, z. \ (2)$$

In ration (2) for i temporal step of integration values for variations $I_0^{\infty}\vartheta_k^i = I_k^i - I_0^{\infty} L(K^i) h_k^i$ and the component $h_k^i = K_k^i / K^i$ of the single vector $\overrightarrow{h}$ of $\overrightarrow{K}^i$ geomagnetic field were used. Cross

$$\tau_{\rightarrow}^{(k)i} = \frac{L(K^i)}{D_k^i [K^i - L(K^i)]} \ (3)$$

and longitudinal

$$\tau_{\uparrow}^{(k)i} = \frac{K^i dL/dK}{2D_k^i L(K^i)} \ (4)$$

times of relaxation contain the coefficients of rotation diffusion

$$D_k^i = \frac{kT}{\delta 6V} \Bigg/ \left(\eta_i^* + \frac{P_r^{(k)i}}{dI_k^i/dt} \right) \ (5)$$

The number of iteration step $i = h_i / v\Delta t$ is determined by the depth of buried h layer of sediments and the velocity of sedimentation $v(h_i)$. In formula (2–5) values $K_k^i = mHh_k^i/kT$, H — an intensity of magnetic Earth's field, m — magnetic moment, δ — form-factor, and V — particle volume, k — Boltzman constant, T — absolute temperature, $L(K)$ — Langevin function, η_i^* — plastic viscosity of sediments, and $P_r^{(k)i}$ — their strength at the depth h_i were used.

Equations group (2–5) is the combination of self-coordinated equations of the so called "complete magnetic-reological curve". Shorting of equations for each other supposes the use of methods numerical analysis. For weak ($K < 1$), and strong ($K > 1$) geomagnetic fields of rations (3) and (4) are simplified essentially.

Numerical simulation is compiled in the way the marked process of sedimentation was not broken. The Authors have adopted the computer experiment to magnetic and rheology of the core MR0604-07R station. Discrete character of the water content change is $\Delta h = 1$ sm. Column core was divided into 1720 parts. Time of formation of i-layer was determined by the ratio $\Delta t = \Delta h/v$. Dependence of sediments stability $P_r(\varpi^*)$ from the water content was taken from the report on the bottom grounds of the Pacific Ocean and continental water areas. Plastic viscosity $\eta^*(\varpi^*)$ of marine sediments corresponds to the law of Volarovich-Bagrov forclay systems.

Small scaled dynamics of relative paleointensity of the geomagnetic field, climate, and environments changes in Middle Pleistocene-Holocene (central part of the Okhotsk Sea)

Malakhova, G.Yu., Gorbarenko, S.A., Goldberg, E.L. (Interdisciplinary Scientific Research Institute FEB RAS, Magadan, Russia)

During the study of Greenland ice core, it was established that the regional temperature in the past changed for 9 17 C during the several decades, and such the quick oscillations of climate (Dansgaard Oyeschger interstadial warming and stadial of cold events repeated during the glaciation with the periodicity of 2-3 thousand years [Dansgaard et al., Nature, 1993]. The late analogous quick climate changes were found in other regions of North Hemisphere, and in sediments of Northern Atlantic the extreme cold events were recorded. These events are related to the partial decay of cover glaciers and an accumulation of glacial sediments, repeating after 7–9 thousand years (Heinrich cold events (HE) [Heinrich, Quatern. Res., 1988]).

The unique geographic setting of the Okhotsk Sea between the Siberian winter maximum of the atmospheric pressure, and the Aleut minimum with the its seasonal covering with the sea ice, results its high sensitivity to quick changes of the atmospheric circulation and climate.

PC07R, -06R, and -05B columns were sampled by piston corer from the central part of the Okhotsk Sea during the Russian-Japanese cruise MR06 04 in 2006 in the R/V Mirai. The core thickness was 18 m. Density (D) and water content (WC) of sediments was measures every 1 sm. Weight percentage of coarse fraction (CF) of sediments more than 63 mkm and less than 2000 mkm, accumulated on the Okhotsk Sea bottom during the spring sea ice melting, was taken as an indicator of glacial carrying. Chlorine concentrations - as an indicator of paleoproductivity - was measured by Smimadzu UV-1650PC spectrophotometer. The age scheme of sediments was made on the basis of tephrachronology, correlation of magnetic-climatic characteristics (MCC) changes with the marine isotope stages (MIS) [Malakhov et al., Vestnik SVNTs DVO RAN. 2007], and the correlation of relative geomagnetic paleointen-sity variations in sediments of column with SINT 800 curve [Guyodo and Valet, Nature, 1999].

In order to exclude the record of geomagnetic signal from climatic factor, normal characteristics of natural component of ChRM magnetization was done after the anhysteretic remanent magnetization ARM, saturation iso-thermal remanent magnetization Jrs, saturation magnetization Js without paramagnetic component, and the paramagnetic component Jp in the field of 0.5 T.

Obtained records of the Okhotsk Sea demonstrate the changes of climate and sea environments resulted from the orbital changes of isolation,, and the many thousand years of oscillation of significant cold events HE. The increase of MCC, D, CF, and the decrease of sediments moisture during the cold events of MIS 2, 4, and 6 were initiated by cooling of the climate, by strengthening of coarse terrigene material supply, and by decrease of biogene component supply. Chlorine decrease in cold events MIS corresponds to established earlier decrease of the Okhotsk Sea productivity during the glaciation [Gorbarenko and Goldberg, Doklady Earth Sci. 2005]. The analogous character of mentioned indexes of change took place during the cold isotopic poststages 5b, 5d, 6.2, 6.4, and 6.6. Due to this observation, we could suppose that indicators of climate/productivity, used by us, and the environments of the Okhotsk Sea had analogous changes also during the many thousand years of climate oscillation. Found in the Okhotsk Sea sequence of cold events HE with quasi periodicity of 5-8 kyr corresponds to periodicity of destroy of mantle glaciers and variations of salts content in ices of Greenland [Heinrich, Quatern. Res. 1988; Mayewski et al., J. Geophys. Res., 1997]. It is possible that changes of atmospheric circulation intensity that are reflected by the variations of Polar circulation index [Mayewski et al., J. Geophys. Res., 1997], and the displacements of stria flows and monsoon activity, play the determining role in the quick change of North Hemisphere climate.

Dating of the ceramic material of the monument “Maiskaja Gora”

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Estimation of time of manufacturing of ceramic material of archaeological monuments is the very issue of the day in connection with that quite often there are difficulties at dating of these materials. A research object in this case are protomy (ceramic torso images of goddesses) from the temple of monument “Maiskaja gora” (Tamanskiy peninsula). Sequencing making of row of ceramic generations, allows to set relative chronology, however the question to the absolute dates is opened. We compare data about the geomagnetic field intensity, received as a result of research of magnetization of ceramic material of archaeological monument “Maiskaja gora”, with information, got on the exactly dated ceramics of the second half of I thousand B.C. (using 10-annual curve of change of archaeointensity, built by means of sliding smooth 11-annual window). This comparison enabled to conclude that the most credible time of making of this material is a time-interval from the second half c.IV to the first fourth of c. III BC. Work is executed under financial support RFFI, grant 06-05-65219.

Late Riphean Katav formation (South Ural) — unique example of remagnetization or ideal recorder of Late Precambrian geomagnetic field?

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In spite of the positive results of fold and reversal tests [Shipunov, 1991] the ancient magnetization recorded in rocks of the Katav formation has long time been considered as metachronous one [Komissarova, 1970]. This point of view was based on the proximity of the direction of this magnetization to the direction of expected Late Paleozoic remagnetization, which is widespread on the territory of Ural-Mongolian fold belt.

It is obvious, however, that this proximity is certainly a warning but not necessarily a clear indication that the magnetization of the Katav formation is secondary. It is important also to note that, in distinction from the case of the Katav formation, in all or almost all cases when Late Paleozoic remagnetisation was established with certainty, the directions of magnetization were of single reversed polarity, that is natural, taking into account that this epoch was a time of predominance of the geomagnetic field of reversed polarity (Superchron Kiaman). Nevertheless up to recently the question about the time of formation of the characteristic magnetization of the Katav limestone rested to be open. In this study we have obtained some new evidences for primary origin of this magnetization:
1) The direction of magnetization in studied Miniar section does not depend on magnetic mineralogy.
2) High-temperature (HT) components isolated in studied nearby two outcrops of overlying the Inzer and underlying the Zilmerdak formations are clearly different from HT component of the Katav formation.
3) Sub-mean directions successfully computed from 20 samples describe the trend towards lower inclinations (by 10°). This trend is consistent with mean direction of HT component, isolated in overlying Inzer formation and likely indicates the plate motion during the sediment deposition.

Besides, there are some reasons to believe that the possibility of vertical-axis rotations of the Minyar section relative to the East-European platform is highly unlikely. If so then we can compare the paleomagnetic poles, calculated for the Katav and the Inzer formations with presently available Neoproterozoic poles from north-western margin of East-European platform. The pole of the Inzer formation (826 25 Ma) lies very close to 750 Ma mean pole of the East-European platform [Meert & Torsvik, 2003]. Paleomagnetic pole of the Katav formation is located some 15 apart from mean pole 750 Ma, however this angular distance seems to be reasonable taking into account the difference in their ages. Thus, location of the pole of the Katav formation close to the Permian paleomagnetic pole can be easily explained by the proximity of reversed Neoproterozoic and Late Paleozoic segments of the APWP of the East-European platform what lifts the main and sole objection against the early formation of the characteristic component of the Katav formation.

Thus all available data indicate that HT component, isolated in rocks of the Katav formation was formed at the very early stages of existences of the rocks, during the sedimentation or soon after.

High-temperature magnetic storage and sub-single blast-furnace regions in the coarse-grained magnet

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High-temperature magnetic storage (α - memory) is caused by the magnetic moments of the contact particles of those being appearing as a result of the first warming up of the models of magnetite from the zone of hyper-genesis.
In the range of temperatures from 20^0C to till 600^0C occurs heterophase corrosion: maggemit (as the part of the magnetite grain) passes into the lamellar it gematit, which, contacting with the soft-iron matrix of magnet formed contact particles. Spin interaction between the ferrimagnet and the antiferromagnet (higher than the temperature of Morin's by ferromagnetism) specifies existence of certain volumes (zone) to crystal, inside which the vector of spontaneous magnetization $\boldsymbol{J}_s$ can have only one direction. Therefore contact particle, as the zone of crystal, possesses special properties.
In Bork on the installation were obtained straight facts of existence in large crystals of magnetite of contact particles by the method of the scanning electron microscopy.

By the method of the scanning electron microscopy on the installation "Comebax" in Borok were obtained straight facts of existence in large crystals of magnetite of contact particles.

The connection of value $\alpha\ \mathbf{J}_{rs}$ with the degree of the oxidation of magnetite ores was experimentally established; there was obtained the determining role of the contact of magnetite and hematite in the appearance of high-temperature magnetic storage.
Sub-single blast-furnace regions – regions of ultra powerful stresses in the crystal connected with the bolls dislocations. They are the zones of crystal uniaxial in magnetic sense. In the magnetic attitude they are singlaxis zones of a crystal. According to their sizes they

correspond to single blast-furnace particles.
A study of the α - memory and low-temperature magnetic storage (γ - memory) were conducted on the same collections of ferrous quartz, magneto-sulfide ores, and so in some models of lava flows. The effect of the first heating appeared in the most different situations: from exceeding of the value of the thermo-viscous magnetization, obtained as a result of the first heating – $\boldsymbol{J}^{I}{}_{rtv}$, above the analogous value $\boldsymbol{J}^{II}{}_{rtv}$ - after the second heating, to significant decreasing $\boldsymbol{J}_{rs}$ after the first cycle.

Experiments with the transitional thermo-remanent magnetization $\boldsymbol{J}_{rtt}$ the heated and not heated models showed a considerable increase $\boldsymbol{J}_{rtt}$ in that formed in the thoroughly heated models on the comparison with $\boldsymbol{J}_{rtt}$ in the prototypes (without the heating)

All this makes it possible to assume that the lamellar cells can partly or completely manifest the properties of sub-odeexchange regions. Prerequisite to this can be the fact that the lamellar cell - is the closed box with the magnetite, whose wall - hematitic to lameli. A sharp difference in the elastic properties of hematite and magnetite can lead to the appearance of strong stresses inside the cells, and consequently, to the appearance of sub-single blast-furnace regions. Thus a question about the fact that is the source of sub-single blast-furnace regions is opened.
It is shown that one should with the large caution relate to the application of traditional methods of paleomagnetic determinations. Therefore the memory of thermo-residual magnetization, and so and viscous, can prove to be very serious interference in paleo-magnetics, possibly, even more serious, than entire second component $\boldsymbol{J}_{n}$. Before conducting of paleomagnetic determinations it is necessary by laboratory simulation to investigate the separate models of collections to the presence of α - memory - it is best anything for the residual saturization magnetization $\boldsymbol{J}_{rs}$.

Paleomagnetic record of Karadja Late Pleistocene Section reflects both global variations of the geomagnetic field and paleoenvironmental changes

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New detailed rock magnetic and paleomagnetic investigations of the marine-lagoon loess-like loams samples from the Karadja range section equals Khvalynian horizon (ca. 42-18 ka B.P.) are fulfilled. Karadja range is located in Azerbaijan not far from the town Mingechaur (Mingechaur Reservoir, 47 E, 40 N). On the base of the well developed methods of paleomagnetism and high-resolution environmental magnetic study it was necessary to test whether a clear magnetic signature is associated with the geomagnetic field variations or climatic changes. The variability of the scalar magnetic parameters (K, SIRM, ARM, Bcr, S-ratio) have been extensively examined and reflected the rhythmic character of transgression and regression of the Caspian paleobasin. A complex of methods well established in rock magnetism was applied to examine the ferromagnetic composition of loess-like loam deposits from Karadja section. The composition of the magnetic minerals (magnetite, maghemite and hematite) was determined by thermomagnetic analysis and isothermal remanent magnetization experiments. Rock magnetic properties showed that there is not an uniformity in terms of magnetic mineralogy, concentration and grain size of a main carrier of the NRM. Determination of the angle elements of the geomagnetic field (declination and inclination) gave information about the intervals of abnormal behavior of magnetization which can be associated with chemical oxidation processes in the deposits. The paleomagnetic study showed that there are intervals of abnormal behavior of the NRM during about 25-20, 29-28 and 39-38 ka B.P. These diagnostic intervals probably reflect the environmental and climate changes during deposition process. The magnetic characteristics of the Karadja deposits keep the information about not only global changes of the geomagnetic field but also environmental conditions which took place during accumulation and litification of the sediments. This research was supported by RFBR grant no. 08-05-00627-a.

New paleomagnetic data of Riphean-Vendian sediments from Turuhansk region of Siberian platform

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In investigated Riphean-Vendian sediments of Turuhansk region of Siberia platform multicomponent composition of natural remanent magnetization was fixed. In most cases both middle- and high-temperature components are bipolar, but the numbers of normal and reverse polarity components strongly differs and does not allow carrying out the reversal test. Bedding of rocks inside each suit, as a rule, is monocline that hampers carrying out fold test also. This test in many events either indeterminate, or negative, that shows probable postfolding age of magnetization. High-temperature postfolding component in Platonovskaya suite of the upper Vendian gives position of paleomagnetic pole in area of Early Ordovician poles of Siberian platform. The pole of middle-temperature component in this suite is located on the same meridian as Early Ordovician poles. This meridian crosses APWP of Siberian platform close Permo-Triasic segment. Permo-Triasic component of reversal polarity is widely advanced in rocks of the Siberian platform and is connected to processes of trappean magmatism in this region. Thus, occurrence of postfolding components can be connected with remagnetization of rocks in area during two tectonomagmatic events. The first one, probably, has taken place in the beginning of Paleozoic and was reflected in process of Turuhansk block thrusting on the Lower Paleozoic strata of the Siberian platform. The second event was Permo-Triasic trappean magmatism. The paleomagnetic poles calculated from all middle- and high-temperature components directions in stratigraphic coordinates system for Riphean rocks in five suites form rather compact group. This group is located far from Paleozoic segment APWP of Siberia and, hence, is not connected to any processes of Paleozoic remagnetization. Paleomagnetic directions for this group are obtained in various types of rocks, carriers of magnetization are various magnetic minerals. Statistic parameters of these directions, as a rule, is higher in stratigraphic system of coordinates, in some cases the foldtest is positive. At many distributions there are directions both normal, and reversal polarity. All these features allow to assume ancient prefolding age of the obtained directions and poles corresponding.

On effect of precession induced flows in the liquid core for early Earth's history

Shalimov, S. (Institute of Physics of the Earth, Moscow, Russia)

Secondary and tertiary flow patterns seen in experiments simulating flow in the Earth's liquid core induced by luni-solar precession of the solid mantle (Vanyo et al., 1995) hint at the development of non-axisymmetric columnar periodic structures. A simple interpretation of the structure formation is presented in a hydrodynamic approach. It is suggested that if similar flow patterns can occur in the Earth's liquid core enclosed into precessing and rotating mantle then kinematic of the flows may be regarded as a possible geodynamo mechanism for early Earth's history (before the solid core formation).

Paleomagnetism of gabbro-dolerites from Chara river and its tributaries: new Mesozoic pole for Siberian craton

Shatsillo, A.V., Powerman, V.I. (Institute of Physics of the Earth RAS, Moscow, Russia)

The research area is located in the vicinity of Chara river (its middle and lower stream) and its tributaries (rivers: Sen, Sukhoi Kumah-Ulah). It stretches for 250 kilometers from Kodar range to the mouth of Tokko river. In tectonic sense it belongs to southwest part of Aldanian megablock of the Siberian craton. We have studied 14 intrusive bodies (both dykes and sills), all of them featuring basic composition. 180 oriented samples were collected. Dykes from Sen and Sukhoi Kumah-Ulah are localized in Archean and Vendian host rocks. Their age is estimated to be late Proterozoic [Salop, 1976]. Other plutonic bodies (the ones that have intruded into Cambrian host rocks) are thought to be similar in age to mid-Paleozoic traps of Viluy paleorift [Ushakov, 1980].

All samples were subject to detailed temperature cleaning until full loss of magnetization. Measuring routine was performed on 2G Enterprise and JR-5A magnetometers. Paleomagnetic analysis has revealed the following:
1) Dykes of Sen river did not contain any signal that could be easily interpreted.
2) One thin dyke, considered to be Mid-Paleozoic in age (left bank of

Chara, ~20 km downstream from Tokkos mouth), contained clear paleomagnetic signal. However, corresponding calculated pole (PLat= -7,6 (7,6); PLong=242,7 (62,7); 95=5,4; N=6) differs significantly from both mid-Paleozoic pole and younger poles of Siberia.
3) In addition to contemporary magnetic field component, the rest of the objects contained one bipolar component, characterized by steep inclinations and NE (+) SW (-) declinations. This component was isolated either as an "end point" one (if it went directly to the origin of the Zijderveld diagram), or as "intermediate" (if it missed the origin). In several cases there was indirect evidence of the components presence due to remagnetization circles. Comparison of mean directions from these objects (Dg=234,5; Ig=72,2; k=144,8; α95=4,6; n=8) proved that the component formed after folding of rocks (k_s/k_g=0,15). Enkin fold test has given negative result (we used 21 end components, 20 intermediate components, and 43 great circles).

Calculated paleomagnetic pole PLat=62,0; PLong=188,5; A95=7,6) coincides (γ/γ_c=8,7/14,9) with Balticas APWP [Besse, Courtillot, 2002] for the time period of 145-140 and is in accord with Late Jurassic Early Cretaceous poles for Siberia [Pavlov, Karetnikov, 2008]. It differs significantly from known older and younger poles. The presence of Mesozoic after-folding paleomagnetic direction in rocks of different ages proves its metachronous character. Most probably, intrusion of widely spread Aldanian complex during the Mesozoic is responsible for re-magnetization of the studied gabbro-dolerites. A nearby Murun syenite massif was dated in the past (K-Ar, whole rock analysis): 147, 143, and 136Ma [Salop, 1976]. Thus, paleomagnetic age from APWP coincides with geochronological age of Aldanian complex. This proves tight connection between Mesozoic magmatism and regional re-magnetization episode. Based on aforesaid, calculated pole can be confidently dated as late Jurassic early Cretaceous.

This study was funded by RFFR grants 07-05-00750, grant of the President of Russian Federation -139.2007.5, and the program N10 RAS "Geodynamic evolution of lithosphere of Central-Asian mobile belt (from ocean to continent)".

Numerical simulations of DRM formation using a flocculation model

Shcherbakov, V.P., Sycheva, N.K., Zhidkov, G.V.

According to existing theoretical predictions, the sedimentary magnetizations Msed would be fully aligned with the ambient field H, though redeposition experiments show a quasi-linear dependence Msed(H). We present results of numerical modeling of process of DRM formation in the case when it is strongly influenced by collisions of flocs of grains during their deposition. The collisions effectively suppress the alignment of magnetic grains along H, thus strongly decreases M giving rise to quasi-linear Msed(H) dependence. The effectiveness of this scenario crucially depends on the conditions of the deposition. Namely, the size of flocs must be big enough, about a few microns, the volume concentration of the initial material must exceed a critical value C0. The value of C0 is predetermined by the depth of the basin of sedimentation. The coagulation and subsequent collisions are important factors forming the magnetization of suspension at relatively high concentration of the depositing material. The appropriate conditions are normally take place for the lake and shallow sea sedimentation processes. For oceanic sediments, due to small sedimentation rate, the coagulation is negligible. The scheme suggested here gives a basis for explanation of results of experiments concerning magnetic properties of redepostited sediments. The study is supported by the RFBR grant 05-06-64585.

Analysis of results of paleointensity determinations in Cretaceous

Shcherbakova, V.V. (Geophysical Observatory "Borok", Russia)

Knowledge of the basic characteristics of the ancient geomagnetic field provides valuable information about the formation and evolution of the inner solid core, mantle and outer shells of the Earth. In particular, the analysis of average paleontensity variation in the geologic past is a subject of active discussion in the modern literature. However, our current knowledge of the origin of the geomagnetic field and its origin in the Earth's core is seriously limited by the quantity and quality of palaeointensity records. Indeed, in the updated versions of the World Paleointensity Database [Perrin & Shcherbakov, 1997; Perrin et al., 1998; Perrin & Schnepp, 2004; Shcherbakov & Sycheva, 2006], there are less than 3500 records obtained from individual cooling units since the beginning of paleointensity studies in the late 1940s, for the entire geologic time scale (0 - 3500 Ma). About one third of these records have been published by Bol'shakov and Solodovnikov, between 1960 and 2001, mainly from the former Soviet Union bloc. The main advantage of these studies is that they were almost exclusively done using the most reliable Thellier method (Thellier & Thellier, 1959) on volcanic rocks combined with investigation of baked contacts. Modern paleointensity database analysis revealed the necessity of data selection on the basis of commonly accepted criteria of reliability. One of the most commonly used criteria is the result of so-called "pTRM checks", supposed to reveal the occurrence of mineralogical changes in the rocks during Thellier experiments. However, strict fulfillment of this requirement means rejection of the numerous works published by Bol'shakov and Solodovnikov, as was done in most modern compilations [e.g. Tauxe & Staudigel, 2004; Selkin & Tauxe, 2000]. Then a substantial uncertainty in the interpretation of the Phanerozoic paleointensity determinations occurs. Indeed, data published by Bol'shakov and Solodovnikov shows distinctive bimodal distribution of paleointensity for the last 300 Ma [Perrin & Shcherbakov, 1997; Shcherbakov & Sycheva, 2006], which might be related to two different regimes of the geodynamo, with a large number of data showing low Mesozoic Dipole intensities. However, after rejecting Russian data, this is not so clear leading some authors to propose high Mesozoic values [Tauxe & Staudigel, 2004; Tarduno & Cottrell, 2005]. New paleointensity determinations performed on Cretaceous rocks of Armenia and Georgia, complying modern criteria of reliability are reported in this study. Results obtained favor the hypothesis of low Mezozoic Dipole suggested by Perrin et al. (1991). Analyses of palaeointensity dataset for the period 60–150 Ma satisfying criteria of reliability similar to those formulated by Perrin & Shcherbakov [1997] is presented. The critera are only Thellier-type determinations are considered; at least three samples are used for the VDM calculation; an error on the estimate should not exceed 15% (the criterion of internal consistency). 134 Thellier-type palaeointensity determinations were found to pass this selection for the 60-150 Ma period and most of the data lie below the line VDM = 8 1022 A/m2 depicting the modern Earth VDM value. A large majority of the data belongs to the 3-5 1022 A/m2 interval, in perfect agreement with values proposed earlier by Perrin and Shcherbakov (1997). At the same time, quite a large dispersion of the data is clearly indisputable.

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Preliminary results of palaeointensity determinations of Cretaceous Antarctica's rocks

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The complex of palaeomagnetic studies on the collection of Cretaceous rocks from islands and coast of Western Antarctica is carried out. Sampling is executed by a standard technique. Dykes and embracing rocks are investigated. Preliminary results of palaeointensity determinations are reported.

Planetary convection and magnetic stabilities

Starchenko, S.V. (Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation of RAS); Kotelnikova, M.S. (Lavrentev Hydrodynamic Institute SO RAN); Chris Jones (University of Leeds)

The strong influence of the inner rigid core size is found on planetary convection instability. The relative size about half of the modern Earth's inner core size makes compositional convection valuable and able on addition magnetic support as in the past Earth or on magnetic appearance possible in future Venus. The inner core growing up to the about half of the convective shell size supports thermal convection and related magnetism. Further growing of the core suppresses the compositional convection which died out when thickness of the shell becomes too small. The last possibly was in the past Mars when its magnetic dynamo has been stopped.

We found that the principal balance between Magnetic, Archimedean and Coriolis force is in the Earth, Jupiter and Saturn with strong magnetic field in their cores. In Uranus, Neptune and perhaps Ganymede, magneto-convection is supported by the balance between Inertia, Archimedean and Coriolis forces those exceed or are about the magnetic force.

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Analytic convection solution and the Earth's type planetary magnetism

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The planetary convection and magnetic instabilities driven by thermal or/and compositional power had been investigated in their natural limit of very small transport coefficients.

For the Earth's type planets, the marginal convection instabilities were investigated. For the first time in word practice we succeed to find an analytic semi-steady solution for the case with strong instability concentrated near the inner rigid core of a planet. This could effectively be applied to modern Mercury, while to the Earth, Venus and Mars at the correspondent stage in their evolution.

This activity had been supported by Russian Foundation of the Basic Research with grant 06-05-65162.

New paleomagnetic records in late Cenozoic era in key magneto-stratigraphical section of the Russkaya platform

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The first detailed magneto-stratigraphical polarity scale of late Cenozoic era of Eastern part of East European platform (the Russkaya platform) is based on 3 regional key sections: European north of Russia (or Arctic Ocean), Middle Volga region and Southern Urals. The Southern Urals section among them is a benchmark section for inter-regional correlations on the territory in question. The consolidated paleomagnetic section obtained from the 3 regional key sections, formed the basis for The first detailed magneto- stratigraphical polarity scale of late Cenozoic era of the Russkaya platform from the Barents sea to the Caspian sea. The scale (from top to bottom) shows orthochrones: n-Brunes, r-Matuyama, n- Gauss, r-Gilbert, V-epoch (n-"Chebenki") and fragments of r-VI- orthochrone. Orthochrones are complicated by sub-chrones and excursions.

1. Orthochrone n-Brunes contains 10 excursions, which are stratigraphically true attached to the consolidated scale of excursions.

2. Orthochrone r-Matuyama contains all the standard sub-chrones and new records, which are not given on the A.Cox's scale. They acquired local names. Those are: sub-chrone "Vasil" - middle akchagyl, zelim - vasilievskiy horizon; excursions: a) "apsheronik" - late apsheron; b) "yakimki" - top of akkulaevsky horizon of middle akchagyl; c) "zelim" - border of zelim - vasilievskiy and akkulaevsky horizons.

3. Orthochrone n-Gauss. Besides standard sub-chrones there is the "Ufimik" excursion, which was revealed in the middle of karlamansky horizon of early akchagyl.

4. Orthochrone r-Gilbert. 4 sub-chrones of standard scale can be traced and there is one more newly revealed sub-chrone called "Barbari" in the lower half of the III chebenkovsky horizon (Pontian?).

5. Orthochrone n-"Chebenki" (V-epoch). The sub-chrone "Dmitrievsky" is singled out for the first time in the II chebenkovsky horizon (Pontian) in the orthochrone. VI-r- orthochrone – not dissected.

According to the latest documentary data obtained on the territory of the former USSR and abroad the orthochrone r-Matuyama is gaining a more complicated paleomagnetic image than that in the standard A.Cox's scale. This fact "encourages" that the other orthochrones of the quarter are also more complicated as it can be seen in The consolidated paleomagnetic section of the neogene of the Russkaya platform.

The magnetic-elastic effects in magnetite

Tyuremnov, V.A., Neradovsky, Yu.N. (Geological Institute, Kola Science Centre, Russia).

Previously the variations of magnetic characteristics titanomagnetite ores of the Kovdor deposit under influence of static stress were the subject of study. For the same ores we have investigated the magnetic-elastic effects under influence of acoustic waves in the range from 25 kHz to 5 MHz. In addition, magnetic state of the rocks was noted using powdergraphy.

General regularities of magnetic characteristic changes of the rocks with natural and artificial magnetization have been established. Anomalous changes of magnetization what are unique to dynamic (frequency) influence has been found. The relations between the magnetic-elastic effects and degree of initial titanomagnetite variability and appearance products of disintegration in his structure have been noted.

The peculiarities of the magnetic-elastic effects in the anisotropic rocks (Kola Peninsula)

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For studying of magnetic elastic phenomena the modelling of acoustic effect on rocks of pirttiyarvy suite of column section of the Kola Superdeep Well was carried out. The rocks of this suite are schistose, small-grained meta-trachybasalts. The rocks are characterized by hematite-ilmenite mineralization with included magnetite. In the column section of the Kola Superdeep Well these rocks are the most magnetic, the magnetic susceptibility reaches $50{\cdot}10^{-3}$ SI and more.

The acoustic action on cubic samples with 20 mm on an edge has been executed by the piezoelectric detectors with frequency from 25 kHz to 5 MHz on the schema $\omega_1 \rightarrow 0(\mathrm{I}_1)$; $\omega_2 \rightarrow 0(\mathrm{I}_2)$; $\omega_3 \rightarrow 0(\mathrm{I}_3)$; $\ldots \omega_n \rightarrow 0(\mathrm{I}_n)$. As a result of the experiments reduction of natural remanent magnetization under influence of acoustic waves has been established. The same effect has been noted for the rocks after magnetization their in field of 0.8 kA/m. In the demagnetization state increase of the remanent magnetization is noted. An important point is that the magnetic-elastic effect has been desplayed variously depending on direction of the vector of acoustic waves proportion relative to the direction of magnetizing field and depending on anisotropy of the rocks.

Methods of analysis of effects of induced magnetic anisotropy of igneous rocks

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The study of the ability of rocks to store information on the paleotemperature and paleopressure is a way for better understanding of the formation mechanism of minerals and prediction of their position in rocks. The reconstruction of paleopressures and paleotemperatures is of importance in ore geophysics both theoretically and practically (in developing mineralization criteria)and in studies of deep-seated processes. It is known that, when rocks containing ferromagnetic minerals (for example, magnetite, minerals of the titanomagnetite series, pyrrhotite, and so on) cool from various temperatures in a constant magnetic field, they can acquire induced magnetic anisotropy (IMA) of a special type observable as constricted and asymmetric incremental magnetic hysteresis loops. As has been shown in various studies, the IMA of rocks is capable of storing information on the magnetic field, as well as on the temperature and pressure of the IMA acquisition. The cooling of rock in a constant magnetic field HT from a temperature TX TC (where TC is the Curie point of a ferromagnetic mineral) makes the magnetization hysteresis loop constricted in the range of magnetic fields close in intensity to HT. Subsequent heating removes the constriction at the temperature TX. Methods used for the determination of the magnetic field intensity, temperature, and pressure involved in the IMA acquisition by rocks can be briefly characterized as follows. Methods of the determination of the magnetic field intensity HT from the IMA effects have long been developed and include, in particular, the methods of stepwise AF remagnetization and derivatives. These methods are based on the effect of nonlinearity of the dependence Irpi = f(H). The method of stepwise remagnetization is more accurate. The method of derivatives, while being less accurate and more laborious, is simple in realization and more understandable. The magnetic paleogeothermometer method has been developed for the determination of the magnetic field intensity HT. This method is based on the analysis of the temperature dependence of the amplitudes of differential hysteresis loop (DHL) harmonics. Certain DHL harmonics are more sensitive to constriction variations. The temperature TX is determined from local maximums and minimums in the experimental plots An = f(T), where n is the harmonic order. Criteria for the elimination of local distortions in the dependencies An = f(T) unrelated to the temperature TX have been developed. Experiments and mathematical models also show that the IMA of rocks carries information on the pressure PX of the IMA acquisition. The properties of the IMA magnetic memory were studied on samples of rocks ranging in age from a few tens of years (for example, lavas of the latest eruption of the Tolbachik Volcano) to 100–200 Ma (Cretaceous–Jurassic). Samples of lavas and tuffs of Armenia, Scotland, Mongolia, the Far East, Kamchatka, the Kurile Islands, the Yana-Kolyma fold area, and the Mid-Atlantic Ridge were examined. The majority of these rocks contained magnetite and titanomagnetite with Curie points ranging from 170 to 570C. Some pyrrhotitebearing rocks and synthetic samples of magnetite and titanomagnetites with various Ti contents were also examined.

Paleomagnetic investigations of Crimean and Caucasus cimmerides

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Objects of studying in research were volcanoclastic and sedimentary Mesozoic strata, and intrusive bodies of Crimean and Caucasus mountains. In the central part of the Kachinsky uplift of Mountain Crimea sub volcanic bodies, intrusive formations and containing them volkanoklastic strata middle Jurassic age are investigated. Magmatic bodies middle-upper Jurassic age of all Mountain and Foothill Crimea, and also sediments of Cretaceous age from the Second ridge of mountain Crimea are tested. Within the Gagrsko-Dzhavsky folded uplift on a southern slope of the Big Caucasus are selected middle Jurassic-lower Cretaceous breeds of the river Mzymta. Within the New Russian-Lazarevskoj and Chvezhipsinsky folded zones in valleys of the rivers Chuhukt, Tsushvazhd, Kuapse, Tuapses are investigated sediments of upper Cretaceous age. On the average a current of the river of Pshish within the Abino-Gunajsky folded zone are tested upper Cretaceous strata. Paleomagnetic researches of samples were made in paleomagnetic laboratory of the All-Russia oil research prospecting institute St.-Petersburg and in laboratory of a fort of Hoofddijk of geological faculty of university Utrecht (Netherlands). To allocation a component of natural remanent magnetization have been applied step temperature cleaning and demagnetizing by a alternative magnetic field. The component analysis is made by the standard technique with use of software packages of Enkin. According to paleoreconstractions middle Jurassic island arch of Mountain Crimea was the the western continuation of the Malokavkazsky island arch, contacting to the Rodopsky massive in the west. Interaction with the last caused specificity of movement Mountain Crimea terrain, its separation from the Malokavkazsky arch and considerable rotations. However, the majority of objects of researches used for reconstruction are located in regional mélanges on a Taurian series. Because of a chaotic arrangement clastolites these complexes objects have a wide disorder of directions which is interpreted like turns of geological structures of the past. Such rotations have local character and are connected with the movements which have occurred directly with objects, being clastolites in mélanges zones. Clockwise rotations of middle Jurassic volkanites, not entering into mélange zones, shown in previous works, prove to be true in the present research and make from 35 to 165 . These rotations could be a consequence of modern movements on the right-hand normal falts reflected on geological area of researches. Besides, primary directions of a volcanic chain of an island arch, most likely, did not answer modern position of its fragments opened now. Position of a pole of rotation of blocks, proceeding from value of a corner of their turn, were or in their limits, or in immediate proximity from them. The studied objects were sorted by statistical parameters, presence of positive field tests and structural position from mélange zones. For middle Jurassic strata from selected several objects has been calculated paleolatitude of their formations 26–28°. The distance on a meridian, corresponding to size of open oceanic basin, concerning edge of Eurasia (settling down at width 42°) in middle Jurassic time, was 1500–1800 km. Geological data (conglomerates of mountain Demerdzhi with fragments of ofiolites) testify about reduction and the subsequent shortening of this basin with oceanic type of a core. The uplift formed on a place of a collision with central Pontides, were source for accumulation of molasses strata. The subductione zone was on 100–300 km to the south. Thus, subduction of oceanic core under Evrasia was accompanied by the general movement of island arch terrains of Mezotetis ocean to the north. Jurassic paleomagnetic data of Caucasus possess in the majority of sites a low grouping and the most part of samples has been rejected. The remained materials give paleolatitudes 25°. Lower and Upper Cretaceous strata of mountain Crimea and Caucasus pass a series of field tests. Paleomagnetic vectors of lower Cretaceous strata of Caucasus have the opposite directions differing on 180°. It is an argument to primary magnetization of them. Lower Cretaceous sediments of Crimea possess the positive test of a fold and paleolatitudes, equal to position of southern edge of Eurasia. Thus to a late chalk there was a reduction of oceanic basin Mezotetis and a collision of an island arc to southern edge of Eurasia at this time.

The reason for a decrease in the Earth's rotation speed through the Phanerozoic according to paleomagnetic data

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Angular rotation velocity (ARV) is the main characteristic of the rotational motion of a solid body. In plate tectonics, it is estimated not very accurately and is based on the assumption that every continent is a rigid slab. Calculations of the instantaneous ARV of the Eurasian domains, based on GPS-networks, disprove this concept. The method used in physics to estimate the ARV of a rotating body is simple and, as a result, to a second approximation, Eurasia is actually not a rigid plate. Within the continent, the ARV of its domains changes several times, increasing in absolute value from the continental periphery to the central domain of rotation (Zemtsov, 2007). Based on palaeomagnetic data, similar and new patterns of the rotational tectonics of ancient Eurasia can be recognized. A change in the direction of rotation for ancient Europe (Baltica) when it intersected the equator is apparently a general geophysical pattern of the plate motion. During this short Upper Devonian interval in the tectonics of Baltica there were a lot of near-E-W strike slip crust deformations accompanied by ultramafic diamondiferous magmatism in the northern Fennoscandian Shield (in ancient coordinates). Differential rotations, slow for Baltica and fast for Siberia, existed in Lower Devonian time and after their collision in the Upper Carboniferous can be observed presently, showing that average ARV values were "latitude-dependent". It seems that one should distinguish the pattern of wrench deformations at tropical latitudes. According to K.M. Storetvedt (2005), these are dominantly N–S deformations caused by lithospheric compression and linear shearing strain deformations directed along the equator, but wrench deformations at moderate and polar latitudes are chiefly ring-shaped shearing strain deformation and extension deformation, caused by spontaneous continental rotations. From the beginning of Triassic time during 160 Ma average ARV values for Baltica, the Urals and for the Siberian domains were somewhat higher than contemporary ones (Zemtsov et al., 2006). This seems to be connected with the motion of Eurasia southwards and with the known decrease in the Earthś rotation speed, i.e. with the gradual movement of the Moon away from the Earth through geological time (Varga, 1996; Zharkov, 2003). The majority of ancient continental domains of today's Eurasia and the continents of the disintegrated Gondwana probably rotated like Baltica in the Early Paleozoic; in other words, they had a negative ARV vector. The torsional friction that arose thereupon together with the tidal friction in all oceans could gradually dissipated part of the tremendous energy of rotation of the Earth's mantle through last ca. 580 Ma (Zemtsov, 2008).

Separation of the magnetic field into external and internal parts at the surface of moved object

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We have solved a problem of separation of the magnetic field, measured at the surface of a body having the form of a prolate spheroid, onto two parts, one of which is external with respect to this body (Earth's magnetic field) while the other is its own magnetic field. This problem, which is fundamental for magnetic navigation, is considered in an orthogonal coordinate system of a prolate spheroid where this body is one of coordinate surfaces. By presenting the solution of the Laplase equation in this coordinate system in the form of a series of expansion in terms of spheroidal functions, separation of the field onto the external and internal parts is carried out formally, but mathematically correctly, without dwelling in this origin. Similar separation of a field can be made for the compressed spheroid, a cone, a paraboloid and toroidal surface etc. The results may be used for calculation of magnetic deviation of object during movement.

Section S. Seismology

The Fennoscandian Shield crust and upper mantle 3D structure obtained from SVEKALAPKO project data

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We present a 3-D model of absolute values of S-wave velocities and Vp/Vs ratios in the crust and upper mantle beneath the SVEKALAPKO temporary seismic array. A region under consideration covers the transition from Archean to Proterozoic domains in the Precambrian Fennoscandian Shield. The model was obtained by inversion of seismological data of different kinds: P-wave receiver functions waveforms, Rayleigh phase velocity curves and travel times of S waves converted from P waves at the 410- and 660-km discontinuities. We processed data only for broad-band stations of the SVEKALAPKO to get receiver function data. The phase velocities of Rayleigh waves were taken from previous surface wave studies. For each station data sets of different kind were jointly inverted by the simulated annealing method in the 1D P- and S-wave velocities profiles. 3-D S-wave velocity model and distribution of Vp/Vs ratio were obtained from 1-D velocity distributions using kriging technique. The 3-D seismic model demonstrates pronounced lateral variations of values of Vs and Vp/Vs ratio in the crust and upper mantle. The depth to the Moho boundary varies from 51 to 63 km in our model, which agrees with the results of controlled-source seismic studies in the region. The Moho boundary is overlain by a high-velocity lower crust (HVLC) that is non-uniform in composition and origin. Our study revealed no systematic correlation between the lithosphere structure and tectonothermal age of Archean and Proterozoic crustal terrains in the study area.

Kaliningrad earthquake September 21 2004 local and regional displacement fields

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Based on September 21 2004 Kaliningrad earthquakes source solutions obtained previously local stress fields were analyzed. The software Coulomb 3.1 was used. The distributions of Coulomb stress changes for different friction coefficients across the area and in depth were assessed. Regional tectonic features were taking into an account. A trigger character of events occurrence was studied. It was supposed that the second earthquake should be located closer to the first one than it was established earlier. Local and regional horizontal and vertical displacements as well as 3D deformations were counted using total realized seismic moment. The data obtained were compared with the Baltic GPS observations. The GPS data were collected from different international archives (IGS, SOPAC, ESEAS, ASG-PL (Poland)) before and after the earthquake 21 September 2004 have been reduced using Precise Point Positioning (PPP) mode of GIPSY OASIS II software. Stations coordinates Longitude and Latitude were estimated with 1-sigma formal errors plus-or-minus about 1.1-1.2 mm. In the result, GPS regional horizontal displacement distribution was obtained both by means of special analysis of 2004 daily values for stations LAMA, VLAD, ONSA, SPT0, VIS0, VAAS, VLNS, RIGA and on basis of shorter time series study to reveal statistically reliable anomalies in a form of steps or impulses. The map of horizontal displacements was compiled. These results do not contrary to seismic data.

Kaliningrad September 21 2004 earthquake seismotectonic position

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The revision of primary Kaliningrad September 21 2004 intensity data was made using EMS-98 macroseismic scale. A new version of intensity map for the north-eastern part of the Sambian Peninsula

was compiled. Macroseismic and instrumental locations of comparable European and USA last decade's earthquakes were analyzed. The alternate reconcilable seismotectonic model is introduced. The structural and wavelet analysis of gravymagnetic data were used to create the model. According to it the source zones of largest events were connected with fault zone of the NE-SW direction at the western coast of Sambia. Geodynamically, the left-side deformation and destruction of the local crust area occurred between Jantarny and Bakalino.

A dilatant-diffusion model: new prospects

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The crust earthquake dilatant-diffusion model is based on incontestable physical phenomena: dilatancy and diffusion. An essential element of DD-model is filling of newly-formed dilatant fractures by fluids. At the same time considerable dilatant expansion is not actually observed during earthquake preparing.

The present work is devoted to research of influence of elastic impulses generated in stressedly-deformed environment on underground fluids dynamics.

The tendency of underground water level to decrease during earthquake preparing and to be restored directly before an earthquake has been theoretically founded. An equation of non-stationary filtration of fluid in waterbearing layer under elastic acoustic forcing has been derived. It has been established that underground water level decreasing depends mainly on intensification of its filtration properties and less on the water-bearing layer capacity.

A physical mechanism of corresponding increasing of the rock permeability coefficient has been proposed. This mechanism is based on the experimentally established fact that efficiency of elastic acoustic impulses influence on permeability of fluid-saturated rocks decreases with temperature growth. This effect directly shows that increasing of permeability coefficient (filtration) is connected first of all with variations of surface tension in pores (capillaries). It is necessary to note in this connection that surface tension variations appear almost instantaneously. And decreasing of surface tension is equivalent to growth of pore pressure. According to this sudden changes of the pressure in deformed stratum also have impulse character and make additional dynamic load on stratum.

On this basis a phenomenological mechanism of aftershock activity is proposed which allows to explain “long tails in aftershocks distribution (Omori’s law) and thereby to resolve the contradiction between hyperbolic aftershocks distribution and exponential relaxation of mechanical systems.

Thus, represented investigations in a certain sense make clear the role of fluids diffusion in the crust earthquakes mechanism that allows to reduce pessimistic attitude to the dilatant-diffusion model predominated today.

Seismicity of the North Atlantic: comparison activity within a low spreading mid-ocean rift and a passive continental margin

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In the North Atlantic the NW passive margin of Euro-Asian lithosphere plate (Svalbard Archipelago and adjacent part of the Barents Sea shelf) is interacting with a young zone of oceanic crust generation, marked by a low-spreading rift system of the Knipovich Ridge. To compare the seismic activity of two neighboring areas with an alternative tectonic structure we used all recorded data on earthquakes with $M = 2$ for 1999-2008-March. The total numbers of $M2$ seismic events within compared areas occurred in 1999-2007 is approximately: 684 in the ocean and 558 in the shelf vicinity. The cumulative frequency-magnitude curves for both test areas are similar and allow to assess about one earthquakes per year with $M = 4$. Due to make comparison more relevant, the seismic energy release have been taken into consideration In other words it was necessary to set equivalence between say one events with $M = 3$ and 10 events with $M = 2$. One way to do that is recalculate an earthquake magnitude into its energy. But it is not the best way because to do it one should know detailed information on seismic wave prorogation in the Archipelago (an appropriate relation between earthquake energy, attenuation, epicenter distance and seismic wave amplitudes).

Another way is to use information about seismic regimes of the areas given by their frequency-magnitude relations. Let g denotes a slope of the frequency-magnitude relation plot ($LgN = gM + b$). Conditional seismic activity on some area with $1000km^2$ is given by

$$A(M_0, T) = \frac{1000}{S} \sum_{M} 10^{-g(M-M_0)}.$$

Here summation is carried out by magnitudes of the events occurred during the year T; S is an investigated area in km^2; M_0 is a basic magnitude. This relation establishes equivalence between events with different magnitudes, i.e. an event with $M = 3$ is equivalent 10 $M = 2$ events provided that $S = 1000km^2$, $g = -1$ and $M_0 = 2$.

We calculated the conditional seismic activity for the tested areas for period 1999-2008-March, and it became clear that energy release in oceanic area is more stable in compare with the shelf margin, where long chain of weak events irregularly interrupted by local strong earthquakes. For example, the highest energy release was fixed in the shelf area in 4-Jul-2003 (earthquake with $M = 5$ and $E = 34 * 10^5 MJ$) and in 21-Feb-2008 ($M = 6$ and $E = 408 * 10^4 MJ$). Thus, due to the strong earthquakes that occurs from time to time in the passive continental edge of Spitsbergen, this “old” continental block may be more seismic active than the young oceanic crust within low-spreading rift belt.

Integral techniques for seismogram data processing

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In seismogram data processing it is important to select the time of arrival of elastic waves that contain information on source parameters and the coordinates and time of a seismic event. To determine them more accurately, the results obtained are checked thoroughly, using additional evidence, e.g. data from seismic stations. Fast, reliable time-space location of potentially hazardous events is especially important in seismic monitoring. Automation of the procedures that repeat the manual operations of the seismogram interpreter seems to be labour-consuming and inefficient. The instability of the signals recorded and a high noise level create some difficulties in data processing by conventional methods. The goal of the paper is to develop techniques to identify the characteristics of single-component seismograms based on the integral transformations and integral characteristics of signals calculated conventionally. To mark overlapping signal zones, the wavelets of the Wavelet Toolbox of the Matlab computer technical language were used. Being sensitive to changes in the spectral composition and leaps of signal continuity and being capable of filtering noise without smoothening the leaps, they were used to reveal the visually indiscernible boundaries of the superposition domain of signal components. The integral characteristics of the signals, such as entropy, dispersion and the instability factor, considered as the parameter of the window scanning the time sequence of data, have also proved to be sensitive to overlapping of the signals. The above techniques were employed to process the seismograms recorded by the Petrozavodsk seismic station. Comparison of the results obtained with the results of the WSG standard programme, where coming wave phases are arranged manually, has proved that the integral techniques are informative and show a seismic profile in detail. It is reasonable to apply the techniques developed to close seismic events, such as industrial explosions. Based on the results of processing of seismograms with known coordinates and time of explosion, local velocity models of the earth crust can be developed more accurately. The study was supported by the RFBR grant 08-01-98804.

About non-linear dynamics applied to depth fractures, controlling high seismicity areas in Daghestan

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Seismogenerating fractures are revealed in the surface temperature, field by means of anomalies of heat space survey. These anomalies reflect sections of shift, compression or tension of rocks as well as of jointing and higher permeability, which are developed along fractures. Our heat model of subvertical between blocks zone for analysis of seismogene dynamics (A.M. Boykov, 2007) corresponds Pshekish-Tirnaus (in other words, Foothills) fracture, which controls zones of high seismicity. The fracture is traced for 300 km and presents itself a zone of narrow plates, falling under the foulded construction. Fissures along the plates in the depth come close into one vertical fracture. This fracture splits the frontal part of the Daghestan wedge and forms an almond-shaped structure. The focal point of the Daghestan earthquake 1970 is connected with it. Geological characteristics of this fracture correspond in details to a well-known seismodynamic model (I.A. Volodin, 1999). The fracture is interpreted in the model as resonator under conditions of transitional regime of compression-tension of tectonic blocs. The united vertical fracture in the depth forms an intensive eradiating resonator – the source of non-linear diffraction of the wave seismic field. The radiant intensity of fracture-resonator manifests itself in the landscape dynamics by erosion activity of soils, stipulated by background high frequency vibration. That is why diffraction picture can be reflected in the aerospace photos as totality of lineaments, parallel to the fracture direction in the crystal foundation. But the theory of I.A. Volodin flaw for practical use in the purpose of prediction. However, there exists the model, adequately explaining from the point of view of the theory of seismic flap mechanism of seismogeneration by means of deep fractures. I.A. Volodin indicates (1999) that this model "allows interpreting some results, got by remote methods. The traces of the described processes are reflected on day surface, as on the screen, on which formed seismic fields are printed". Quantitative interpretations of the heat cosmos removal along the route of Foothill fracture by means of program Get Data 2.21. The width of the fracture zone is established, it is identified with sharply standing out area of anomaly intensity $\Delta T \approx 2.7°C$ on all its length from north to south. According to digitization of the width of Foothill fracture along anomaly of radiation temperature varies from 8 km in the north part of the fracture to 2 km in the south part. The Foothill fracture as heat cosmic survey has a maximum width in epicenter zone of the earthquake – the zone of permanent seismic activity, and minimum – on removing from this zone southward. This conclusion corresponds to theoretical ideas. The seismic activation, having as the source a break – generator of seismic energy, is complemented by permanent influence of pulses within influence of the focal point zone. The studies are carried out at support of RFFI (grant 06-05-96610, regional contest "South of Russia").

Non-uniqueness of surface waves inversion for determination of shallow earthquake parameters

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It is well known that moment tensor of seismic source cannot be uniquely determined from surface wave records if the wave length is much larger then the source depth. But this ambiguity had never been previously investigated in detail. Considering pure double-couple sources we present a complete description of equivalent sources radiating similar long period surface wave fields. At the same time we present a special kind of shallow double-couples which are uniquely defined by long period surface wave spectra. We show the results of study of Solomon Islands earthquake, 01.04.2007. We reduce the uncertainty under consideration by search for focal mechanism consistent with long period polarities of direct P-waves. The solution we found differs significantly from the Global CMT and GEOSCOPE solutions obtained from long period surface wave analysis, but all of these three double-couples radiate similar long period surface wave fields.

Comparison of large scale average characteristics of the Sumatra-Andaman earthquake models constructed from different observations

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We present the results of comparative analysis of large scale average characteristics of the Sumatra-Andaman earthquake models constructed from different observations including seismological, geodetic, altimetric, tide gauge and tsunami. We did not found strong contradictions between average characteristics of geodetic and altimetric models on the one hand and seismological models retrieved from very long period seismic records (up to 2000–3000 s) on the other hand. We compare these results with estimates of integral source parameters retrieved from observed surface wave spectra in period band from 500 s to 650 s. The results of performed analysis suggest that the northern part of the fault (to the north from 8° N) did not radiate long period seismic waves shorter than 700 s. This conclusion is consistent with existing composite fast and slow slip tsunami model with fast slip at the southern part of the fault and very slow slip at the northern part.

Correlation of the Earth's seismicity (M7) with the cyclical variation parameters of the Sun and the Moon

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The Earth seismicity is influenced by many factors, mainly geological, but also by astronomical. In this report the correlations of some temporal seismicity data to cyclical variations of lunar declination (19 years) and sunspot numbers (11 years) are established. Studies of the character of periodical and cyclical temporal variations of lunar declination (dL) and solar declination (dS) gave the following results: 1) Rates of change of the periodical oscillation the lunar and solar declinations functions and of the cyclical oscillations of lunar declination function vary and depend on the Sun and the Moon positions in relation to the Earth's equatorial plane. The rates of change of a periodical function declinations become maximal during intersections of this plane by the Moon and the Sun; on the contrary, when these bodies are away from the Earth equatorial plane, the rates of change tend to zero; 2) The rates of change of periodical functions remain near zero, they are 0,5°/day for the Moon (the duration is 1,5'3,5 day twice a month); and 0,05°/day for the Sun (the duration is 8 day twice a year). For the period of 1973 to 2005 the correlation of occurrence of the Earth's seismic events (M 7) with the cyclic variations of lunar declination (dL), the periodic variations in solar declination (dS) and their rates of change has been observed. Temporal distribution of strong earthquakes (M7,0) correlates with: -cyclical oscillations of lunar declination, dL= fL(T); -duration of the rates of change of dL = fL(T), where rates tends to zero; -minimums temporal curves of sunspot numbers.

Azimuth and apparent velocity estimation capabilities of Mikhnevo array

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Small aperture seismic array is operating on the territory of the geophysical observatory “Mikhnevo”, Moscow region, since November, 2004. The array consists of 16 short-period seismic sensors SM3-KV with frequency band 0.5-40 Hz. At present more than 4000 seismic events of various origin were recorded by the array. Beside teleseismic events, most recorded signals are quarry blasts from epicentral distances up to 700 km.

We investigated azimuth estimation capabilities of the array. Records of 18 regional events were analyzed, with epicentral distances from 66 to 410 km. Among them are quarry blasts with known coordinates and origin time and an explosion during “Sport” hotel demolition 25.09.2004. FK-analysis was applied to first P arrivals and surface wave phases. Two methods of FK-analysis were used based for estimation. The new FK-analysis method based on correlation between channel pairs provides more accurate backazimtuh estimates for surface waves than conventional one. All analyzed signals have SNR 2.5. For the SNR3 the accuracy of estimates slightly depends on SNR.

Azimuth error as a residual between true azimuth and estimated was determined for each event. Average azimuth error is 5 degrees for P phases and 3 degrees for surface phases.

The apparent velocity estimates made for the phases are accurate enough to identify their type (whether it is P-phase or any secondary Lg or S-phase), but the resolution is not sufficient to separate Pn (7-8 km/s) from Pg (about 6 km/s) or slow (about 3-5 km/s) S-phase from surface wave (2-3 km/s).

Most of analyzed events were recorded at 14-bit A/D convertrer with sampling rate of 100 Hz. The installation of 24-bit A/D converter with 200 Hz sampling rate promises to increase the accuracy of estimates.

Interpretation of lithospheric structure from teleseismic P and S receiver functions

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The P receiver function is obtained by first rotating the two horizontal components of the seismic records into radial and tangential components and then by deconvolving the vertical component from the horizontal components. The receiver function depends only on the structure near the station because the source and path effects have been removed by deconvolution. To suppress noise, receiver functions calculated from events grouped in a small range of back-azimuths and epicentral distances are stacked. The problem with the P receiver function method is that the multiple converted phases mainly from the Moho discontinuity mask the time interval of the possible arrivals from the lithosphere-asthenosphere boundary. Recently, the S receiver function method became a useful tool to image the seismic lithosphere because the primary and multiple conversions are separated in time.

The S receiver functions obtained by deconvolving the radial component from the vertical and tangential components have the advantage of being free of multiple reflections and are suitable for the study of mantle lithosphere. The P and S receiver functions are essentially made of Ps and Sp converted phases, respectively. The Sp phase defines the conversion from S to P at a discontinuity beneath the station while the Ps stands for a conversion from P to S. We calculate synthetic seismograms to demonstrate the power and limitations of the S receiver functions. Combining complementary seismological observations is an important step towards improving the consistency of the estimates of the crust and upper mantle structure. For instance, teleseismic P and S receiver functions combined with surface wave dispersion measurements should be quite beneficial to jointly infer the earth's shear wave velocity structure. This combination should fill the resolution gap of each data set used in the analysis. In addition, we employ the combined data sets (i.e. P and S receiver functions and surface wave data) observed at one of the broadband stations in Turkey for determining the lithospheric structure.

The inverse problem for an acoustic medium

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We consider the dynamic inverse problem for a 2D acoustic medium and use the Gelfand-Levitan-Moses method for the reconstruction of the acoustic parameters.

This method was originally considered for the Schrödinger equation by Gelfand I.M., Levitan B.M. (1951) and Kay I. and Moses N.E. (1956). Blagovestchenskii A.S. (2001) applied the method to the 1D wave equation. Also, the method was extended to the 2D and 3D acoustic wave equation. Other theoretical results and first applications to 3D inhomogeneous acoustic media were presented by Newton R.G. (1981), Blagovestchenskii A.S., Kurylev Y., Zalipaev V. (2005), and Fedorenko D.A. and Blagoveschensky A.S. (2006).

The Gelfand-Levitan-Moses method has the remarkable property that existence and uniqueness of the solution to the inverse problem can be proven in the case of a delta-function source.

Then, the method leads to a Fredholm equation of the second kind. For velocity reconstruction in a 2D medium, we only need to know the Fourier transform of the seismic data in x for a single fixed value of the horizontal wave-number k_x.

In practice, seismic data are band-limited. The absence of high frequencies is not a problem because it only limits the resolution of the model parameters. We can apply wavelet deconvolution to the data in order to mimic a delta-function source and proceed with the Gelfand-Levitan-Moses method to solve the inverse problem for the acoustic parameters.

However, noise and missing low frequencies can lead to non-uniqueness of the result. To study the performance of the Gelfand-Levitan-Moses method under these conditions, we consider synthetic seismic data for a 1D constant-density model with a Ricker wavelet as a temporal source function and add white noise. The resulting velocity model at a single wave-number has large errors. However, if we use several horizontal wave-numbers k_x and average the resulting models, we still obtain an acceptable result.

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Elastic field of Earth's crust of East Cuba according to DSS data

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In the geologically complex areas, the interpretation results of hodographs of refracted waves, based on heavy-laminated model of environment, are quite often not in correspondence to the data of gravitational prospecting and magnetic exploration and to the geological conception about the area's structure. The method of linearized interpretation of heteropolar field t(x,l) of refraction (I. Shelud'ko and others, 1983) provides the distribution of true speed V(x,z). Cuts of true speed (CTS) constitute a field of elastic parameters in vertical plane. The gathered seismic information gives us an opportunity for "direct" common interpretation of three geophysical fields: elastic, magnetic and gravitational fields. And geophysical information becomes more "geological". There are presented materials on two profiles DSS, developed on East Cuba. Cuts received for multi-layer heavy-laminated model of environment are seemed as traditional: the depth of investigation is limited by high-speed boundaries available in these cuts; all boundaries are approximately parallel to each other and are grouped in the upper part of cut; correlation with trace Δg is purely qualitative; boundaries stratification is real only for surface of pre-orogenic folding ground. It is very dangerous and risky to carry out the connection of boundaries beneath of this ground. The cuts of CTS, provided with the same hodographs, are more informational concerning the distribution of heterogeneity inside the earth crust. Fine correlation with gravimetric data confirms the objective reliability of cuts. Solution of direct task of gravimetry according to CTS cuts has achieved the fine convergence to the observed field Δg. On the CTS cuts a separating boundary on contour 6.0–6.2 km/sec is being outlined and it is very close to horizontal. Above this boundary the elastic field is relatively quiet, and not great increase of speed with depth may be observed, and practically speed inversion is not available. Below this boundary in the elastic field some large and small heterogeneities are observed with abnormal high (8.0 km/sec) and abnormal low (5.8 km/sec) speed values. If we use the generally accepted term “consolidated earth crust” for identification of a part of cut where rocks have speed of 5.8 km/sec and more, we can state that consolidated Earth’s crust of East Cuba has a complex texture with high-speed anomalies and broad areas of speed inversion.

The efficiency of the registration of the St. Petersburg seismic network

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To evaluate the efficiency of the St. Petersburg seismic stations registration two samples of 98 events of technogenic origin were compiled. The first of them was formed by events of Institute of Seismology HEL (Helsinki, Finland) seismic network and the second one contained explosions located with addition of stations VAL, VYB GS RAS. All events occurred during the second half of 2006. The event main parameters defined both by HEL, by routine processing program WSG and SEISAN system were compared. Geographically, events formed 4 groups of quarries in the Leningrad oblast. They are careers at Kyznechnoe, Vyborg (“Vozrogenie”), Kamennogorsk and at Gavrilovo. The data analysis showed that always both Finnish event positions and our source locations do not coincide with each other within a radius of 5 km. All events deviate from quarries within a radius of 13 km. The estimated average latitude and longitude standard deviations for the Finnish data were 1.8 km and they were 9.5 km with account of Russian stations. Origin time errors (RMS) seemed to be 0.3 and 2.2 seconds respectively. Identified discrepancy of source parameters and their distributions objectively connected with local and regional velocity and structural inhomogeneities in the earth crust in the way of wave propagation from different distances and in different azimuth sectors. It should also take into account the use of various velocity models and elaboration methods in different seismological centers. Moreover, the discrepancy may be due to the technology of the mining operations particularly short-delay explosives. It can not be excluded as the insufficient number of seismic stations in the St. Petersburg region. The efficiency of seismic recording can be defined by seismic events repeatability with different magnitudes on this territory. Analysis of these data revealed that the St. Petersburg network records all events with a magnitude of 0.8 or more and the Finnish data are representative from the magnitude of 1.1. It should be added that 20% of all processed technogenic events were registered only by station VYB and not localized by Finnish network. Also we had been spent the processing of 16 new events with magnitudes 1.4-1.8 for the period August-September 2007 that belong to 4 groups of quarries mentioned above. Waveform processing and events localization were spent by WSG 5.5.5 and by the Seisan 8.0 programmes using Finnish bulletins data. The events localization RMS error seemed to be 1.99 according to the WSG program elaboration. The averaged RMS error was 1.5 for the program Seisan. So the Seisan location results were more accurate than epicenter positions appointed by the WSG system. The Finnish localization deviated from quarries on 3-20 km on the average to the southeast. The locations of this study had an average error of 5-10 km but there weren't directed deviation.

About reliability of seismic data

Gravirov, V.V., Kislov, K.V. (International of Institute Earthquake Prediction Theory and Mathematical Geophysics, Moscow, Russia)

Complication of present-day geophysical studies requires to improve methods and instruments for receiving, processing and analysis of seismic data. The main goal of seismometry is effective and reliable extracting of friendly signals from records and transformation of them to a form convenient for further use.

The noise in seismic records can be classified as follows: (1) the noise generated due to incorrect processing technique; (2) the A/D converter noise; (3) the noise caused by variation of instrument characteristics, by deviation of the gauge element parameters from nominal values due to component deterioration and influence of external factors; (4) the noise generated due to temperature and pressure variations perceptible by seismometer as ground motion; (5) additional forces acting to pendulum due to variation of environmental parameters; (6) unusable ground motion as tilts; (7) instrumental error due to mishandling, induction electricity in signal circuits, etc. This classification allows us to estimate a portion of noise due to each source, and an essential part of noise can be taken into account in advance and minimized.

One of the most efficient methods for extraction a friendly signal from noise is the suggested algorithm for optimal adaptive filtering, where the total signal is taken from seismometer output, and a record of barometric pressure is used for reference noise signal. In this case the noise components of the signal caused by influence of wind, pressure variation, etc can be reduced, independently of either these factors affect directly on the instrument, or they generate ground motion recorded by seismometer. The algorithm allows the signal-to-noise ratio to be raised essentially, which is important for analysis of long period records.

Wave distribution of anisotropy of elastic properties of rock samples collected along sections from the surface

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Oriented samples of metamorphic rocks collected along the 22 km long section in the Central - Kola megablock were studied for elastic and density characteristics. Parameters of anisotropy of elastic properties of rocks according to P- and S-waves spreading velocities were determined for these samples and spatial position of elements of elastic symmetry was established. Spatial position of elements of elastic symmetry was compared to elements of rock bedding. There is an inverse relationship between values of anisotropy of elastic properties and relative altitudes of sampling points. Distribution of anisotropy of elastic properties of rocks is individual for the geoblock, confirming hypothesis of the author on presence of wave component in complex of forces supervising geodynamic evolution of the lithosphere. It is shown that dynamic influence on rocks on scale of a geoblock, involving change of spatial position of elements of elastic symmetry, is selective and conservative. The reasons of such selectivity and conservatism can be stipulated, apparently, by outlines of geoblock boundaries, laid since the time of origin of geoblocks as independent elements of the lithosphere.

Gas percolation treatment to the earthquake preparation

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Modern seismological concept comes into collision with a number of difficulties, which are not related to the framework of traditional models. Why would there be many occasions of multiple large quakes over a period of a few days to months? Why would the rock not break in all the locations in which it is already stressed to near breaking point, at the time it is violently shaken? Why would the ground shake sometimes for periods longer than a minute? Why would quakes cause tsunamis, the massive ocean waves? Why would deep source earthquakes appear in seismic investigation quite similar to the shallow ones? To answer the questions a new description of the earthquake hypocenter formation was recently developed. This new consideration declared that a large family of the earthquake peculiarities, which are a real challenge to the traditional models, is closely related with degassing process of the Earth. In the presentation we demonstrate some new results of the gas percolation treatment to the earthquake preparation. We developed a cellular automaton degassing model, which represents the lithospheric substratum as a network of structural units whose rate of failure (or reparation) depends on the local conditions. Deep relation between degassing process and earthquake hypocenters upward migration is established. Connection with self-organized criticality is also discussed.

The diffraction tomography and iterative approach to restore the seismic parameters and electrical conductivity

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The results of numerical simulation on restoration of electrical conductivity and seismic parameters of the local inhomogeneities correspondingly with the help of electromagnetic and elastic sounding signals are considered.

The direct problems for the Maxwell and Lame equations are solved by the finite difference method. Restoration of the desired parameters is implemented by the diffraction tomography method in the time domain, using the first-order Born approximation. Restoration of the electrical conductivity is studied in the low frequency case.

We consider restoration of the inhomogeneity parameters with the help of the iterative procedure. Each step of the iterative procedure includes solution of the direct problem and correction of the desired parameters by the diffraction tomography method. For this purpose the algebraic methods with different regularization schemes are used.

The numerical simulation for 2-D SH problem in elastic case and for 2-D TE problem in electromagnetic case is implemented for the local inhomogeneities with a simple and complex geometry and with a contrast about 50 % relatively to the reference medium. Main attention is given to study the convergence and accuracy of the considered algorithms.

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The use of ambient seismic noise for determining the structure of the crust and the upper mantle

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At present surface-wave tomography is the most effective method to get information about the structure of the Earth crust and upper mantle. But the aseismic areas are studied poorly as yet. It results from impossibility to get the data on group velocities along the paths epicenter-to-station crossing the area.

Meanwhile, in recent seismological studies (e.g. Bensen, Shapiro, Campillo, Ritzwoller, etc.) an alternative approach was suggested to determine the structure of the crust and upper mantle. The approach is based on extracting the Green function between two locations from the diffuse field with a simple field-to-field correlation taken over sufficiently long time. As was shown practically the obtained correlation function has the dispersion as expected for surface waves.

In this paper we attempted to apply this approach to determine the group velocity dispersion curves at some profiles and to estimate from them the average structure of the Earth crust and upper mantle at these profiles. Depending on the components used for calculation of the cross-correlation function we could obtain the dispersion curves for Rayleigh and Love wave.

For testing the method we selected three seismic stations in Asia (BJT, BRVK and ULN) for which the group velocity dispersion curves for Rayleigh and Love waves were observed from records of earthquakes. These dispersion curves were compared with those that were obtained from cross-correlation of seismic noise recorded at these stations. In order to decrease the influence of the earthquakes and to deal with sufficiently diffuse field we considered only normalized signal. Two methods of normalization were used — one-bit normalization, whereby the signal is set to +/- 1 depending on the sign of original waveform, and running absolute mean normalization whereby the waveform is normalized by a running average of its absolute value. It was shown that the comparable dispersion curves obtained from seismic noise and from earthquake records are in good agreement.

After making sure that the ambient seismic noise can be used to determine dispersion curves for paths between stations we selected some seismic stations situated on the East European Platform and computed for them cross-correlations. Then we constructed the group velocities dispersion curves for Rayleigh and Love waves and computed the average vertical velocity sections along the profiles between the stations. On the average the results for crustal structure is in good agreement with the model CRUST2 for the East European Platform.

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Study of the Earth's outermost solid core using PKiKP waves and PKiKP coda

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Structure and composition of the Earth's ferrous inner core (IC) are of interest in geodynamo theory, mineralogy and studies of condensed matters, and seismic observations are the only source of direct measurements of IC properties and structural peculiarities. Although IC is believed to be a result of gradual few billion years long crystallization process, it is rather heterogeneous than a single crystal of iron. The IC fabric is possibly radial diverse, and estimates of sizes of anisotropic hexagonal close-packed (hcp) and face-centered cubic (fcc) iron crystals vary from hundreds of meters to few tens kilometers. Reliable constrains on IC heterogeneities can be obtained from reflections off the Earth's inner core boundary (ICB) and the coda waves following the reflections (PKiKP). Such data provide required spatial resolution and are capable of revealing temporal variations due to possible differential rotation of the IC. To study fine structure of the outermost IC and the ICB we analyze PKiKP waveforms and PKiKP coda on array records of underground nuclear explosions recorded in the distance range 6 – 95 degrees. We find lateral variability of the IC surface being composed of patches characterized by presence of a thin partially liquid layer in the transition from solid inner to liquid outer core interspersed with patches containing a sharp transition. Observations of PKiKP coda evidence fine-scale heterogeneities best interpreted in terms of misaligned anisotropic iron crystals up to 10 km in size that constitute the upper IC, cause PKiKP coda through scattering and reflections on their boundaries, and contribute to ICB patchiness.

Numerical investigation of interference wave field effected by sliding contacts in stratified media

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The some results of wave full-field simulation for three models of media are discussed. The following models are considered: an elastic layer adjacent to on elastic half-space, an elastic layer sandwiched between liquid and solid half-space, an elastic or porous layer sandwiched between two elastic half-space. In all these models on the interface between layer and elastic half-space contact with sliding is set. The source and receivers are located inside of a layer. It is shown, that resonance interference wave of type Kr-wave can be propagated inside of a layer in all enumerate models.

Wave's propagation near internal Earth boundaries

Krauklis, P.V., Krauklis, A.P. (Steklov Mathematical Institute)

The study of internal boundaries of the Earth is a complicated seismological problem due to the short pathes of the body waves along these interfaces. The situation improves if diffracted, creeping and whispering gallery waves are used. These waves are influenced significantly by the properties of the studied boundaries. Main factors are the vertical velocity gradients, curvature of the boundary, inhomogeneous structure, anysotropy. There are several sharp discontinious inside the Earth: boundary M, mantle-outer core boundary, outer core-inner solid core. Based on the asymptotic theory of interface waves we present formulae for the velocity, the attenuation and the penetration depth of the boundaries. For the core-mantle boundary and interface M theoretical results are compared with observational data. Seismological and geophysical implications and consequences are discussed.

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Avalanche-like nucleation of cracks through fracture kinetics

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Models of evolution of crack ensembles are wide spread in seismologic theory. But it is still debated whether acoustic emissions should be used as a precursor of seismologic events. In the Griffith's theory of fracture, which is widely exploited in seismologic models, it is generally accepted that acoustic emission accompanying a crack formation has no influence on the subsequent nucleation of other cracks. The main reason of this ignorance is that acoustic stress is insufficient to be taken into account. Thus a continuum approach for fracture of the loaded solid body prohibits crack-acoustic wave-crack interaction. Besides, postulating that microcracks usually preexist in real solids, avalanche-like nucleation of cracks can be explained through coalescence of microcracks.

It is affirmed that the acoustic emission cannot be ignored owing to the S.N. Zhurkov's kinetic theory of strength [S.N. Zhurkov, Int. J. Fract. Mech., 1 (1965) 311]. The key point of kinetic concept of strength is that a fraction of the sample is controlled by rupture of chemical bonds being caused by thermal energy fluctuations. By thermal fluctuations one means anharmonic motions of atoms and molecules: namely, intrinsic localized modes (discrete breathers) those energy much exceeds kT. In monoatomic chains with realistic Lennard-Jones and Morse potentials breathers are not observed in numerical experiments, and, moreover, they are forbidden. However, they arise if time-periodic driving field is applied to the chain. Therefore avalanche-like nucleation of cracks includes several stages. **Zero stage**: it is well-known that adiabatic compression (tensile) force applied to anharmonic lattice decreases energy barrier. **First stage**: moving crack excites high-frequency plane waves [L.I. Slepyan, Models and Phenomena in Fracture Mechanics, Springer (2002)]. **Second stage**: after development of modulation instability of plane waves, energy localizes along the chain in the form of standing "bumps" (chaotic breathers). "Big breathers" absorb "small ones" and grow [I. Daumont, T. Dauxois, M. Peyrard, Nonlinearity 10 (1997) 617]. **Third stage** : several "big breathers" either decay or overcome energy barrier and nucleate new cracks [D. Hennig, et. al., Phys. Rev. E 76 (2007) 041110].

Additional questions are evolution of acoustic wave envelope generated by "avalanche" and possibility of shock wave formation.

On the Rayleigh wave on a free boundary of the porous Biot medium

Molotkov, L.A. (Steklov Math Institute, St.Petersburg, Russia)

Wave propagation in homogeneous isotropic porous Biot medium is considered. This medium is two-phase, and in it two longitudinal waves and one transverse wave propagate. The medium under consideration is restricted by a plane free surface. The full normal and tangential stresses vanish. The third condition is given in different variants.

In the first case, the pressure in the fluid phase is equal to zero. In this case, if the velocity of the second longitudinal wave is greater than the velocity of the transverse wave, then the Rayleigh wave exists always. For inverse relation between these velocities, the Rayleigh wave can exist or be absent. The inequalities, defining existence or absence of the Rayleigh wave, are established.

In the second case, the pores on the boundary are closed and normal displacements in both phases are equal, third boundary condition is that the relative normal displacements vanish. In this case, the Rayleigh wave exists always. Its velocities is less than velocities of the transverse wave and the second longitudinal wave. The conclusion about existence or absence of the Rayleigh wave are drawn on the basis of analytical investigations of the dispersion equations.

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Structure of the Mongolia-Baikal region lithosphere on the data of teleseismic experiment MOBAL-2003

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The structure of the lithosphere of the Mongolia-Baikal region is investigated in the framework of international project PICS No 1251 (France, Russia, Mongolia). The target area is characterized by high topographic contrasts, sporadic Cenozoic volcanism and recent faulting. The study is based on seismic records from the 1000 km long transect that crosses the main tectonic units (Siberian platform, Baikal rift zone, Hangai dome and Gobi-Altai belt) from the north to the south. We have conducted 2D P wave teleseismic travel time tomography, inverted P receiver functions for S velocity models up to a depth of 300 km and evaluated parameters of azimuthal anisotropy from shear-wave splitting in the SKS seismic phase.

The lowest velocities and density are found beneath the Hangay dome. Large low-velocity anomalies in the crust and the upper mantle are found also beneath the Sayan and Khamar-Daban uplifts and Djida blanket-folded zone. In the Gobi-Altay, the velocities are noticeably higher. The fast direction of azimuthal anisotropy is everywhere around 120°. The delay of the slow split wave varies between 1.0 s and 2.5 s. A detailed analysis of the anisotropy parameters at the MOBAL transect together with MOBAL velocity models and previously known data for Siberian Platform and the Altai-Sayan mountains suggests that about half of the anisotropy effect is accumulated in a broad low-velocity zone, the top of which is found at a depth of 150 km. The rest may correspond to the shallow mantle. Our observations suggest that the late Cenozoic uplift of the Mongolian plateau, associated rifting, magmatism, high heat flow, and lithospheric thinning are not externally driven by the India-Asia collision, but result from the interaction of a mantle plume with the overlying lithosphere.

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Velocity analysis with VSP data with use of migration of multiples

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VSP data offers a potential for high-resolution imaging of the subsurface, however the quality of this imaging strongly depends on the velocity model. The goal of this work is to investigate a new method that will combine updating of the velocity model and migration of VSP data. In conventional seismic data processing only primary reflections are considered as a signal and are therefore migrated. The other events including multiples need to be suppressed in the data to prevent distortions of the seismic images. In recent years, several authors have investigated the possibilities of migration of multiple reflections and concluded that multiples can provide some advantages such as wider illumination and better vertical resolution of the subsurface. This is very important for VSP data, when illumination area is very limited. Moreover, the angular coverage of reflection point by multiples is different from that given by the primary reflections. Therefore it is advantageous to use multiples and primary reflections jointly for velocity updates. Here we use multiples that have only one reflection from the free-surface, because full wave field of multiples can be very difficult to handle. We propose to exploit the idea that the migration of primaries and multiples should give similar images of the subsurface when the velocity model is correct. In other case, when velocity is erroneous, the images obtained by primaries and by multiples will not coincide with each other. As a measure of similarity of two images we define the functional, which is based on cross correlation of the images:

$$J(v) = \int I_p(\mathbf{x}) I_m(\mathbf{x}) d\mathbf{x},$$

where $v = v(\mathbf{x})$ is the velocity in the medium, $I_p(\mathbf{x})$, $I_m(\mathbf{x})$ — images, obtained by primary and by multiple reflections respectively.

This functional has maximum when the velocity model is correct and it can be used in optimization procedure to update the velocity model. In order to handle the complex subsurface, we use wave equation migration formalism. The gradient of the cross-correlation functional with respect to the model parameters gives the direction of the needed velocity model update. For gradient computation we use the adjoint-state method, which can be very efficient, especially in the case of many parameters. To find extermum of the functional we use the conjugate-gradient method. For simple layered media we demonstrate that the use of cross-correlation functional will lead to correct velocity estimate. Also, we study the dependence of the functional from acquisition scheme and signal frequency content.

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Nonlinear soil behavior during the 2007 Chuetsu-Oki, Niigata, earthquake

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Acceleration time histories of the Chuetsu-Oki earthquake (Niigata, Japan, M=6.5, July, 2007) recorded by seismic vertical arrays in the territory of the Kashiwazaki Nuclear Power Plant are studied. Stresses and strains induced in the upper 250 meters of soil in the territory of the Power Plant (~10 km from the fault plane) during the main shock and aftershocks are estimated. For the reconstruction of stresses and strains, we apply the method of nonlinear analysis of soil response based on vertical array records, developed by Pavlenko and Irikura and previously used for studying soil response during the 1995 Kobe Japan), 2000 Tottori (Japan), and 1999 Chi-Chi (Taiwan) earthquakes. A good agreement between the recorded and simulated accelerograms testifies for the validity of the obtained distribution of stresses and strains in soil layers.

Solvable model of a thin plate under a pointwise boundary stress

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Seismological observations reveal the statistical spectrum of oscillation of the Earth with periods 0.5-5 hours. The oscillations with periods from this spectrum are most stable and most frequently observed. They were called seismo-gravitational oscillations (SGO) of the Earth, see for instance: L.N. Petrova (*Oscillations of the Earth from observations by spaced vertical pendulum in Eurasia.* Izvestija Physics of solid Earth,**38**, 4 (2002), pp 325-336). These oscillations were observed by seismographs of different types on one continent, or on few continents simultaneously. Based on interpretation of SGO as eigen-oscillations of the plates, we conjecture an explanation of statistical stability of periods and increment or decrement of the frequences of SGO. Based on bi-harmonic model of the thin elastic tectonic plate in form of a compact 2-d domain Ω with a smooth, with boundary $\partial\Omega$ smooth in average with respect to the wavelength of SGO,

$$Au = \Delta^2 u = \lambda u,$$

we derive explicit formulae for perturbed eigenvalues and eigenfunctions on the thin plate under a point-wise boundary stress. Considering the zero-range boundary condition at the boundary point a we add to the domain of A the 3D subspace $N_{\bar\lambda}$ of singular elements spanned by the Green function $G(x,a,\bar\lambda) := g_0(x,\bar\lambda)$ and its tangential derivatives $\frac{\partial G(x,a,\bar\lambda)}{\partial t} := g_1(x,\bar\lambda)$, $\frac{\partial^2 G(x,a,\bar\lambda)}{\partial t^2} := g_2(x,\bar\lambda)$ of the first and second order: $g_0(n,t) \approx (n^2+t^2)\ln(n^2+t^2)$, $g_1(n,t) \approx t\ln(n^2+t^2)$, $g_2(n,t) \approx \ln(n^2+t^2)$. The bi-harmonic operator A_0^+ defined on the extended domain is self-adjoint, if the singular parts of elements from the extended domain $v = v_0 + \frac{A}{A-iI}\vec{\xi}^v_+ - \frac{I}{A-iI}\vec{\xi}^v_-$ satisfy the "boundary condition" with a real 3×3 Hermitian matrix $M : N_i \to N_i : \vec{\xi}_+ = M\vec{\xi}_-$. This zero-range boundary condition defines a self-adjoint operator A_M. The resolvent of A_M is represented, at regular values λ of the spectral parameter, by the Krein formula:

$$(A_M - \lambda I)^{-1} = \frac{I}{A-\lambda I} - \frac{A+iI}{A-\lambda I} PM \frac{I}{I + P\frac{I+\lambda A}{A-\lambda I}PM} P \frac{A-iI}{A-\lambda I}, \tag{1}$$

where P is an orthogonal projection onto N_i. Assuming that there is a single eigenvalue λ_0 of A on the interval Δ_0, with the eigenfunction φ_0, we use the following representations, separating the polar terms, the smooth correcting terms K_i, K_{-1} on Δ_0

$$\frac{A \pm iI}{A-\lambda I} = (\lambda_0 \pm i)\frac{\varphi_0\rangle\langle\varphi_0}{\lambda_0-\lambda} + K_{\pm i},\ P\frac{I+\lambda A}{A-\lambda I}P = (1+\lambda_0^2)\frac{P\varphi_0\rangle\,\langle P\varphi_0}{\lambda_0-\lambda} + K(\lambda), \tag{2}$$

and a smooth Hermitian matrix-function $K = K_0 + o(|\lambda-\lambda_0|)$, with $K_0 = K(\lambda_0)$ and $\| o(|\lambda-\lambda_0|) \| \le C_0\delta$. If the matrix M is relatively small $\| K(\lambda_0)M \|$ 1, then there exist a single eigenvalue λ_M of the perturbed operator A_M on the interval Δ_0:

$$\lambda_M \approx \lambda_0 + (1+\lambda_0^2)\langle P\varphi_0 M[I + K(\lambda_0)M]^{-1}K(\lambda_0)\varphi_0\rangle,$$

and the corresponding eigenfunction:

$$\varphi_M \approx \varphi_0 - (\lambda_0 - i)K_{-i}(\lambda_0)M[I + K(\lambda_0)M]^{-1}P\varphi_0.$$

Comparison of the calculated characteristics of perturbed eigenfunctions and eigenvalues with instrumental observations, in remote zone, permits to fit the model: to localize the stressed point a and to find the real hermitian matrix M. We conjecture that elements of M play a role of Saint-Venant parameters. The analysis proposed above for a plate with a free edge can be extended, after appropriate change of the boundary condition, to the tectonic plates in realistic environment. Comparing the computer simulation based on the fitted solvable model with systematic instrumental observations of the shape and period of SGO in remote zone can help to localize the active zones, to estimate the accumulated elastic energy, and, eventually, to predict powerful earthquakes. Find an extended discussion concerning the spectral interpretation of SGO in: L. Petrova, B. Pavlov *Tectonic plate under a localized boundary stress : fitting of the zero-range solvable model*, Journal of Physics A, **41**(2008)085206 (15 pp).

The 2003 Kumora aftershock sequence (M_w=5.6) as a typical event in the Baikal rift zone

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The Baikal rift system (BRS) consists of several rift basins among which the South and North Baikal depressions are the most prominent. All the basins are characterized by high seismic activity and mainly normal faulting in the earthquake foci at least in the central part of the system. The Kumora earthquake occurred on 16 Sept., 2003 within the Upper Angara basin which is situated NE of the Baikal Lake. The earthquake was the largest in 2003 for the overall

Baikal region. It was accompanying by numerous aftershocks and felt at the significant territory. This aftershock sequence manifests some features typical for the relatively large events of the BRS and hence the results of its study may be useful and indicative.

The epicenter of the mainshock was located at the western part of the basin closer to its northern side. The aftershock epicenter field was in rather favorable registration conditions in spite of the gap in NW azimuths. Due to availability of two stations at the epicentral distance about 20 km it was possible to precise the hypocenter depths. We relocated aftershocks using Hypoinverse method and a layered velocity model based on DSS. The results show that 80% relocated events are in depth range of 10–20 km with maximal concentration between 14–18 km. The depth of the mainshock hypocenter is 17 km.

Before the Kumora earthquake there were no obvious changes of seismic rate. The mainshock was preceded by a foreshock with energy class by Rautian K=7.6 (M=2.0) occurred two minutes prior to it. Epicenters of the first aftershocks stretched in NW direction encompassing partly the northern ridge. In time the epicentral field expanded but its pattern was kept. The total area of aftershocks is 946 km^2 that is 2.4 times more than for the first events.

Aftershock decay rate was obeyed the power law with exponent close to -1 for the first 20 days during which a half of all aftershocks occurred. The seismic rate in 2006 (by now we have the complete catalog no longer than this year) was still higher than the average rate per year before the 2003 earthquake. The largest aftershock occurred on 1 December, 2003 and had K=12.8 (M=4.8).

The mainshock focal mechanism was determined by first motion polarity and the solution is completely coincides with those from waveform modeling. It is normal faulting along a NE striking plane. Such kind of solution is characteristic for the BRS and named as "baikalian" focal mechanism type. Available focal solutions of aftershocks are more diverse. Though 5 from 7 mechanisms show normal faulting, direction (strike) of their nodal planes varies between N-S and W-E. Two solutions are of reverse faulting with minor strike-slip component. Orientation of the P and T axes in the foci of the mainshock and of the majority of aftershocks correspond to the regional stress field, i.e. NW-SE extension and NE-SW compression.

Orientation of the nodal planes is in accordance with the main geological structures but does not match to the geometry of aftershock field. In the BRS there are some situations when two conjugate ruptures are activated after the main shock. As a rule one aftershock branch coincides with the rupture plane and corresponding geological fault while other traces another direction. In the Kumora case we observe only one opposite active branch the fact to be explained by that the mainshock occurred inside the basin and might be not connected with the master border fault of NE-strike.

So, the event considered here revealed such general features of the earthquakes of BRS as hypocentral depth (up to 20 km), kinematics (normal faulting) and style of aftershock activity.

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Temporal variations in geophysical fields as a manifestation of the nonlinear rock properties

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In this study we have conducted research of rock properties changes under explosive action by means of ultrasonic pulse velocity method and apparent resistivity one. The experiments were carried out at iron-ore Severo-Peschanskaya mine in the North Urals. Rock massive, broken by tectonically fractured zones, was composed of diorite and porphyrite. The observational points were located at distance of 700–800 meters apart from the explosions in the depth of 450–500 meters. The measurements were made by means of four probes with ultrasonic transducers working like electrodes for observation of electrical anisotropy parameters. Probes were cemented in the 3 meters long drill holes. Complex monitoring observation (ultrasonic and electrometric) revealed the appearance of waveshaped fluctuation of P-wave velocities and anisotropy of apparent resistivity after the explosions. The time of relaxation was about several hours and probably indicates the transition of medium in new equilibrium state. Two kinds of anisotropy were observed in these experiments: "static", which associated with features of rock massive structure, and "dynamic", associated with temporal variations of geophysical parameters due to structural changes under failure. This allows to consider that nonelastic deformations, spread in rock massive after explosions, present waves of "unloading" Investigation of temporal behaviors geophysical structure medium after explosions has greatly scientific and practical significance for estimates of rock mass stability in mines, reservoir excavating, etc.

Study of focal mechanisms of earthquakes by moment tensor inversion method and seismotectonic deformations in the Northern Tien Shan

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Tien Shan is one of the most active seismic regions in the word. At present time Tien Shan has shortening rate about 20 mm/year and relief, distribution of active faults, and seismicity indicate that deformation has been distributed across the Tien Shan. There are some zones of possible earthquakes with magnitude Mw 7 and more. Most earthquakes are concentrated near the northern and southern boundaries of this mountain system. Moderate-sized events are common within the mount belt, but large earthquakes are infrequent. To advance our understanding seismotectonics of the northern boundary of Tien Shan without waiting strong earthquakes, we use the information contained in smaller-magnitude events recorded by local broadband seismic network KNET. To estimate the moment tensor solution we downloaded broadband seismograms of earthquakes with magnitude Mw over 3.5 from seismic network KNET for time period 1994-2006 through Incorporated Research Institutions for Seismology and modeled three-component waveforms. We can treat source and propagation process as linear operators, and the moment tensor can describe double-couple at any time. Thus, it is possible to construct observed waveform by summing the moment tensor weighted displacements for each moment tensor (convolution Green's function and source time function). To neglect the effect of source time function we used long period waveform. The moment-tensor elements are estimated by minimizing the least-squares misfit between the observed and the predict waveforms. Faulting geometry, seismic moment and depth of 70 earthquakes in the Northern Tien Shan were estimated by matching observed and synthetic seismogram records. We took events for a distance up to 1–2°. This application expands the available focal mechanism database for this area to include earthquakes that are too small for teleseismic modeling. Prior to inversion, we removed the instrument response from each waveform and matched data in one of two period ranges: 17-9 s or 100-20 s, and the selected range depended on the amount of observed energy. Usually, larger events (Mw>4.5) had sufficient long-period signal to be modeled in the 100-20 s range, while smaller events had to be modeled in the 20-10 s range. For moment tensor inversion we used software by Yagi. Moment tensor solutions obtained in this study were used to calculate seismotectonic deformation (STD). Dominance of reverse faulting in the Northern Tien Shan is clear. At the same time some events have significant strike-slip components. The P-axes of the fault plane solution of earthquakes are sub-horizontal, for the most part plunges < 30 and trend approximately north-south (azimuth about 354°). This is indicative of north-south horizontal contraction in the Northern Tien Shan, according to the India-Eurasia convergence direction and consistent with the tectonics of the Tien Shan in earlier studies Depths of events are mostly in the range 5-20 km that conforms to seismicity distribution Also the represented results show variation of the STD field and that the main part of the studied region could be characterized by compression regime of straining and agree with strain filed by GPS. We can notice three mode-groups of the STD here: trust, trust-vertical and transpressional. However one single event is oblique. Thus Northern Tien Shan is under compression in north-north-west direction, at the same time some small zones with strike-slip shifting components exist. Whereas large events are infrequent, the earthquake distribution and mechanism of moderated-sized events provided important information about seismic strain that are growing evidence on the orientation and distribution of active deformation in the Northern Tien Shan.

Reconstructing head waves with Virtual source method

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The original applications of the Virtual Source Method (VSM) concentrate on imaging and monitoring through complex and changing overburden. This can be accomplished by correlating the wavefields recorded by downhole geophones. There are a number of reasons to expect even better results compared to reflected waves when this concept is extended to using head waves for reservoir imaging and monitoring purposes.

The method is based on using the surface shots and downhole receivers placed below the most complex part of the heterogeneous overburden. The time reversal technique, combined with downhole recording allows to eliminate the transmission effects of the near surface and to obtain reflections from deeper targets. The VSM can be derived directly from the Kirchhoff-Helmhotz integral (KHI) using reciprocity. Although the presence of a full aperture for applying the KHI is never attainable in practice, the scattering due to the heterogeneous overburden helps restore the correct travel times by summing over a limited number of surface sources.The body wave total field can be well represented as the integral over the Fresnel zone around the stationary points, which give the best locations for surface shot placement. Up to date, the VSM has demonstrated effectiveness in seismic applications based on reflected P- and S- waves. We consider an application of VSM for head waves propagating in high velocity half-space in simple 2D model, theoretically and numerically, in order to assess its feasibility for reservoir monitoring.

Head waves created using VSM can lead to improved reservoir imaging and monitoring due to several reasons. Being compared with a reflection survey, head waves have less strict requirement for surface source placement, demonstrated high sensitivity to changes in the reservoir and therefore look promising for monitoring applications.

The simplest approach to generate VS gather is to correlate total wavefield recorded at virtual source with total wavefield recorded at receivers. The resultant VS gather, obtained by summation over all sources, includes all the responses between virtual source and receiver. We have performed a wavefield separation at virtual source and receivers for a simple model and demonstrate the result of correlating head waves with different types of waves.

We have demonstrated that correlation of gated direct wave at virtual source with head waves at receivers in the vicinity of stationary point restores original head wave between the virtual source and the receivers. Correlation of gated head waves at virtual source position with head waves at receivers produces satellite waves, which propagate ahead of head waves at first arrivals. These waves are result of application of Virtual source method for limited apertures and do not exist on real data. Satellite waves could be useful to build tomographic monitoring images of introduced anomaly in the reservoir since they propagate along reservoir interface.

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Active seismic tomography inversion with the self-adaptive wavelet parametrization: algorithm and its application for the Vesuvius volcano structure

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A self-adaptive automated parametrization approach is suggested for the inversion of controlled-source seismic tomography data. The velocities and interfaces are parametrized by their Haar wavelet expansion coefficients. Only those coefficients that are well constrained by the data, as measured by the number of rays that cross the corresponding wavelet function support area and their angular coverage, are inverted for, others are set to zero.

This technique allows to develop an efficient and practical algorithm for the active seismic tomography studies. It reduces the number of unknowns considerably (up to 97%) keeping only well-resolved ones. Therefore only the rough pattern is reconstructed in the less sampled model areas and no features unsupported by data will appear there. At the same time fine details can be reconstructed in the model parts that are densely sampled by seismic rays. From the computational point of view this gives more stability during the inversion and at the same time saves memory and computation time. An estimation of the resolution on the base of ray's hit counts and angular coverage is fast and sufficient to select well-resolved unknowns.

The synthetic examples demonstrate the ability of the algorithm to recover the three-dimensional structure in the case of a relatively sparse network of seismic sources and low ray density in the upper layer due to the zero vertical velocity gradient and poor *a priori* information.

Algorithm is applied for the inversion of the TOMOVES experiment data. The key features of the obtained model of the Vesuvius volcano area are: high-velocity body at depth's -1.2 - 1.0 km under the volcano edifice and a low-velocity volcano root in the carbonate basement, low-velocity basins at the volcano flanks and the position of the carbonate basement top at 1-2 km depth. Our results well agree with the previous studies considering the structure of upper volcano-sedimentary layer but do provide the additional information about the fine structure of the velocity anomalies, particularly under the volcano edifice where the resolution power of the data is maximal.

Special features of seismic waves propagation near Spitsbergen archipelago

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The archipelago Spitsbergen is part of Barents sea shelf plate. It represents the northwest passive surburb Vostochno-Evropejskoj of east-European platform shipped under a sea level. At this area ancient platform structures contact with the youngest on the Earth areas of ocean formation. Various types of tectonic faults are widely presented in area of archipelago. Cola regional seismological center carry out monitoring of seismicity on archipelago since 1982. The stations network in different years changed from 3 up to 6. For this period the numerous database is made. It including seismic events with magnitude from-1.0 up to 6.2. The analysis of seismogramms allows divide them on two not equivalent groups. The first group includes signals with the "typical" form, where arrivals of spatial P and S-waves are contrast and arrival of P-wave more intensively than S-wave. More than 80% of events relate to this group. The second group includes signals with various anomaly form. The anomalies were discovered in the fragments of some seismic records corresponding to body waves. As revealed, about 20% records contain the first onset of P-wave with very small amplitude, which scarcely exceeds a noise background, meanwhile the amplitudes of Pg-wave onsets are usually in 5-10 times higher. 90% anomalies locate within North-Eastern Land and southern part of West Spitsbergen Island, and only 3 cases were registered in the middle-ocean spreading zone at Knipovitch Ridge. The strongest earthquake at this region happened at 21 February, 2008. The some of numerous aftershocks also have anomalous forms. In this report we try to make a comparison of those anomalies and explain plausible reason anomalies origin.

New method for surface wave tomography using the data from distant earthquakes

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Standard procedure of surface wave tomography uses the data on group and/or phase velocity dispersion curves along paths crossing a region under study in different directions, the paths being located within the region. For group velocity tomography this requirement means that sources and stations should be located within this region. But if the data are obtained at a local seismic network it is possible to get group velocity dispersion curved from local earthquakes only for rather short periods, which provide information on shallow structure. Dispersion curves for long periods can be obtained from distant earthquakes, but the paths from such earthquakes cannot cover the region that contains sources and stations uniformly. Though the paths cross the region of the network in sufficiently different azimuths, outside the region their configuration is insufficient for tomography. Application of the tomography technique for such data results in much smoothed solution, in which it is impossible to reveal velocity anomalies in the region of the network.

In case of distant earthquakes the parts of paths from one source are sufficiently close up to some distance, so an average velocity correction along such parts may be assumed the same for all paths. These velocity corrections for each epicenter are to be estimated jointly with lateral velocity variation within the region where the stations are located. In this case a priori assumptions imposed to the two kinds of unknown should be different: the lateral velocity variations should be submitted to the criterion of smoothness, while the velocity corrections at common parts of the paths should fit the condition of minimum norm. Thus the solution should be determined from the combined condition and the constraints on the travel times along all paths.

The method is tested on some numerical examples which showed its efficiency. Also it was applied for estimation of Rayleigh wave group velocity variation in Tibet using a sample of the paths from distant earthquakes recorded at the stations in Tibet extracted from the total data set used previously (Yanovskaya, Kozhevnikov, 2003, 2006). The result is in a good agreement with that obtained earlier for Asian region from the extensive data set by the use of the standard tomography technique. Application of the standard technique to this sample yields a much smoothed solution.

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Main features of deep structure of West- and East-Black Sea Basins and its tectonic implications

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The Black Sea Basin, located between two orogenic systems – Crimea-Caucasus in the north and Pontides in the south, consists of two deep subbasins – West-Black Sea (WBS) and East-Black Sea (EBS) basins filled with thick Cenozoic sediments (up to 12-14 km). They are separated by Mid-Black Sea Ridge (MBSR) – a NW-oriented structure with the basement uplift. It is widely accepted that Black Sea basin has been formed at the end of Cretaceous in a back-arc setting due to closure of Mesozoic Neotethys Ocean. However, a lot of problems concerning the origin of the Black Sea basin and structure of the crust and upper mantle are still under question. In order to get new information from existed data bases, the following studies have been undertaken: 3D gravity back-stripping analysis, reinterpretation of a number of seismic refraction profiles using the ray-tracing method as well as seismic tomography study for the uppermost mantle of the Black Sea. Reinterpretation of previously acquired data of deep seismic refraction study (DSS) shows the presence of thin (5-7 km) high-velocity (6.5-7.2 km/s) oceanic crust below the deep-water part in both western and eastern parts of the Black Sea. Areal distribution of thin crust of oceanic and transition (from continental to transition) type is seen in sediment-free gravity anomalies, obtained by subtraction of gravity effect of sediments from observed field. In the Black Sea area these residual gravity anomalies are caused mainly by strong Moho uplift (up to 19-20 km). 3D velocity model for the uppermost mantle has been constructed for the depths of 40-60 km by local seismic tomography using the data on arrival of P-waves from earthquakes within the Black Sea recorded by seismic stations around the sea. Against the background of low velocity values (Vp=7.5=7.8 km/s) within the onshore areas, one can see high-velocity domains (Vp=7.9-8.1 km/s) below the WBS and EBS characterizing the upper mantle below the Black Sea. These two domains are separated by low velocity area beneath the central part of the sea, just to the south from Crimea. Its south-eastern limitation in the form of NW-oriented gradient zone corresponds with Odessa-Sinop fault, confirming in such a way its deep origin. These new data, together with available data from other geophysical methods, clearly indicate that two sedimentary basins – WBS and EBS – differ in basin architecture, orientation of main tectonic units and structure of the lithosphere. Revealed distinctions are determined, first of all, by different affinity of the microplates, on which they were originated, and also by the peculiarities of their rift and postrift history.

Section SEMP. Seismic-ElectroMagnetic Phenomena

TEC anomalies: local TEC changes prior to earthquakes or TEC response to solar and geomagnetic activity changes?

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A number of papers have reported about deviations of daily values of the maximum total electron content (TEC) in the vicinity of an earthquake's epicenter within some days prior to the main shock. Owing to the importance of this problem, a question of a "locality" of those effects is arising. It is necessary to obtain stronger evidences for the statistical significance of the observed precursors; besides, an analysis of such anomalies not related to the earthquakes' preparation processes is important. On the other hand, any methods used for such purposes, must be based on reliable physical mechanisms. It is known that geomagnetic activity variations raise not only global changes, but also well pronounced local perturbations of the ionosphere parameters that can mask processes of earthquake preparation. Therefore, our chances to reveal ionosphere precursors of earthquakes are very few, under moderate and, especially, high geomagnetic activity. Thus, it is very important to take into account variations of solar activity that are of pure global character. To study this issue we have developed a method based on calculation of global electron content, GEC, and of local electron content in "check-region" with low seismic activity. This method allows us to test whether TEC daily variations before earthquakes are of local character; the method takes into account possible influence of 27-days variations of the ionosphere parameters, caused by the rotation of the Sun as well as other global TEC variations. The maximal deviations of relative amplitude of 27-day GEC variations can exceed 20–30%. For the absolute TEC values of 20 TECU this amounts to TEC changes within 10 TECU (or more) that is of comparable amplitude with TEC "anomalies" reported before. At that, the duration of the phase of 27-day GEC variations with maximum derivative value is of the same order (about 7 days) as the duration of TEC "anomalies". Apart from that, GEC changes can be caused not only by

27-day variations but also by the dynamics of the UV radiation from different active regions in the Sun. The contribution of such regions to the total UV flux may be comparable with changes due to solar rotation. Especially it became apparent during the period of high solar activity in autumn-winter of 2003 and in autumn of 2004. The comparison of local and global TEC values for following earthquakes: the Tokachi-oki, 25 September 2005, a magnitude M=8.3; the Chi-Chi, 21 September 1999, M=7.3; the San Simeon, 22 December 2003, M=6.6 and the Parkfield, 29 September 2004, M=6.0, showed that TEC anomalies recorded in a series of publications, could be caused not as much by the enhanced seismic activity before earthquakes as by changes of the global ionization due to dynamics of the UV solar radiation. The delay of analogous changes in the "check-region" is caused by the difference in local time and by latitudinal distinctions. In order to separate the relative contribution of these processes to TEC changes, supplementary investigations are necessary, as well as development of special methods for realizing such distinction, based on a model of seismo-ionosphere coupling. As a result of such correction, the seismo-ionosphere effect of earthquakes preparation may become either more pronounced, or impaired. In any case, the reliability of conclusions concerning the connection of observed TEC changes with earthquake preparation processes will become higher.

GPS-monitoring of ionospheric disturbances caused by rocket launch, at a long distance

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One of mechanisms of rocket energetic influence on the Earth atmosphere is the wave modification of environment caused by generation of acoustic-gravity waves (AGW) during a supersonic flight of rocket with operating engine. The main data on the atmospheric wave phenomena, accompanying the rocket launches, have been obtained from observation of traveling ionospheric disturbance (TID). The TID represents the ionospheric manifestation of AGW. An acoustic wave propagates to heights of the ionosphere and transforms to the wave disturbance of electron concentration due to interaction of neutral and charged atmospheric gas components. Despite the fact that there is the number of works devoted to influence of rocket launches on the Earth atmosphere, the majority of experiments have been carried out either in the immediate vicinity from the rocket flight trajectory or at the distance that does not exceed 1000 km. Only some works are devoted to researches of ionospheric disturbances at long distances from rocket launch sites. Wave disturbances, caused by launches of rockets "Soyuz" and "Proton" from the cosmodrome Baikonur, are investigated in this report using our algorithm of coherent spatiotemporal accumulation of total electron content (TEC) variations in the ionosphere. TEC responses of the ionosphere observed by four GPS-arrays at about 4000 km from the launch site represent the quasi-periodic fluctuations with the period of 15–20 min, duration of 30–40 min and amplitude of 0.1 TECU. The propagation velocity value of wave disturbances is 300–1400 m/s. Wave disturbances of the ionospheric TEC are caused by the AGW, which propagate in the Earth atmosphere at considerable distances from the source. The area of rocket launch and also active sites of the rocket flight trajectory are found to be responsible for the AGW generation. The response amplitude in separate TEC series is comparable to the average amplitude of background-noise TEC fluctuations. Therefore, we can identify response only with the use of spatiotemporal data processing. The developed algorithm of coherent spatiotemporal accumulation of TEC measurements provides an increase in the signal-to-noise ratio in the accumulated GPS-array output signal. It also provides a reliable registration of the ionospheric disturbance at considerable distances from the rocket launch site. The results of the investigation do not contradict the data of earlier researches on ionospheric disturbances caused by rocket launches. They also agree with observation results of the ionospheric disturbance on the Kharkov incoherent scattering radar.

Tsunami precursor physics (seismo-hydro-EM) and monitoring

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It is not possible to apply modern observation methods for monitoring and prognosis of seaquakes and tsunamis without understanding physical particularities and quantitative characteristics of processes caused by a weak precursory seismic excitation in the lithosphere under a seafloor. Magnetic signals before a seismic wave arrival (from an underwater source) were observed more then once in near sea Pacific regions. But what is the physics of transformation of seismic energy from under the Ocean into EM signals in atmosphere? In accordance with main physical principles and geophysical data, we formulated a nonlinear mathematical model of seismo-hydro-electromagnetic (EM) geophysical field interaction and calculated generation and propagation of elastic, EM, temperature and hydrodynamic seismically generated disturbances (i.e. signals or waves of corresponding physical nature) in the basin of a marginal sea including: transfer of seismic and EM energy from the upper mantle beneath the sea into its depths and EM emission from the sea surface into the atmosphere up to low boundary of the ionosphere. Basing on the calculated characteristics of the signals of different physical nature (all of them correspond to observations, e.g., EM and tsunami waves) the authors develop the project of a Lithosphere-Ocean-Atmosphere Monitoring System (LOAMS) including: a bottom complex, a moored ocean surface buoy complex, and an observation balloon complex. The underwater stations of the bottom complex of the LOAMS will record the first measurable signal of seismic activation beneath the seafloor (namely, ULF EM one, according to the above calculations) and localize the seafloor epicentre of an expected seaquake. These stations will be equipped, in particular, with: magnetometers (to record the first seismic magnetic signal and to determine its polarization), the lines for the electric field measurements, and sounding blocks (magnetotellurics etc) to discover dynamics of physical parameters beneath a sea floor as signs of a seaquake and/or tsunami preparation process. The buoy and balloon complexes of the LOAMS will record the meteorological and oceanographic parametersv́ariations including changes of reflection from a sea surface caused by a tsunami wave propagation. Cables of the balloon and moored buoy will be used as receiving antennas and for multidisciplinary measurements (including gradients of the fields). Also, the project includes radio-tomography (with satellite instrumentation) and sounding of the ionosphere from the buoy and balloon complexes. The balloon and buoy complexes will transmit data to a shore station over satellite link. The frequency ranges and sensitivity thresholds of all of the sensors of the LOAMS will be adapted to the characteristics of expected seismic signals according to the numerical research above. Computational methods and statistical analysis of the recorded multidimensional (because of different physical nature of signals and different heights of observation points) time series will be used for a prognostic interpretation. The multilevel recordings will provide a stable noise (e.g. ionosphere Pc pulsations, hard sea, industry) and seismic event detection. An intensive heat flow typical for tectonically active lithosphere zones may be considered as an energy source for advanced modifications of the LOAMS. The latter may be used as a monitoring and warning system for continental infrastructures and marine technology, e.g. a sea bottom geothermal energy production (taking account, along with ecology and energy problems, that our postglacial period is going to an end). On the other hand, the LOAMS may be considered as a scientific observatory for development of physics of large scale geodynamic and ionosphere events, e.g., tsunami physics, i.e. investigation of all of the phenomena in the lithosphere-hydrosphere-atmosphere-ionosphere medium and above caused by a seismic activation of the oceanic lithosphere.

Comparative analysis of ionospheric variations before strong earthquakes

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The anomalies of electronic concentration at ionosphere, connected with seismic activity, are usually less than ionospheric disturbances, observed during global geomagnetic storms, therefore the seismic effects on middle latitudes are quite often difficult for identifying.

It is known, that characteristics of F2 layer, both in quiet conditions and during geomagnetic storms, are qualitatively identical at stations of radiosounding if they are located from each other at distance no more, than 500–700 kms. However at such distances one of the stations can be in zone of seismic activity, and another - outside of it, so the seismo-ionospheric disturbances should be marked at the first station and to be absent or be less intense at the other. At two such stations Petropavlovsk and Magadan the series of deviations of critical frequencies from their moving average values have been considered. The received irregular variations are compared with each other to exclude the identical changes, connected with geomagnetic disturbances, and to reveal seismo-ionospheric features.

The calculations show, that 10–12 days before earthquakes the positive values of variations are predominated at station Petropavlovsk as compared with station Magadan. The ratio of number of positive deviations to negative increases from values 0.8-1.2 till 1.7-2.2 with growth of magnitudes from M=5.4-5.8 up to M=6.8-7.5. The more magnitude of earthquake is, the better positive disturbances are expressed. It confirms that effect is just connected with seismic activity.

About the relationship of global seismicity with geomagnetic activity

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The intercoupling of strong earthquakes (SE) with magnetic storms (MS) was marked a long ago. However the heterogeneity of geomagnetic disturbances strongly hampers the exposure of signs to the display of which seismic activity (SA) is related. Many researchers try to get dependencies between geomagnetic activity (GA) and basic characteristics of the SE (probability, magnitude and depth) with the purpose of their possible prediction. In literature there are polar opinions of researchers about possibility of prediction of the SE on the basis of geomagnetic data — from the denial of principle possibility of prediction to possibility of operative prognoses. In the present work, on the basis of analysis of the Catalogue of SE of National Center of information about the earthquakes of Geological service of the USA (NEIS USGS) [http://neic.usgs.gov] the results of research of dependence of SA from GA in periods of 43 strong magnetic storms for two cycles of Solar activity from an interval 1974–2006 are given. To investigate the dependence of SA from GA for the indicated temporal interval the search of correlation between the average monthly values of index of geomagnetic activity Ap and monthly number of SE, NQ, was made. Moreover, for data for this period from Catalogue the everyday distributing of number of the SE was calculated. The correlation of the everyday values of number of SE, NQ1, of different intensity and Solar activity indexes, Ap, was analyzed. The analysis was made for three selections: the rows of NQ1 -data were separately examined, including all registered of SE (N2), and also for SE with magnitude of 5 (N1) and 7. On the basis of these data the analysis of correlation of seismicity with the periods of MS was also executed. For this purpose in the examined temporal interval 43 periods of 20–50 days duration were selected (in a few cases the strong MS took place in 15–25 days after as, for example, in November 2001 , August-September 2005 and etc). These periods included strong MS. It was examined MS with the value of Ap 100. There was analyzed data of N1 and N2 during a few days before MS and during 15–30 days after MB. It was set, in particular, that with the probability of P = 0,2–0,6 in all considered cases there was the increase of total number of SE in 1,5–3 times (sometimes and anymore) and amounts of SE with 5 in 1,5–4 times on 2–3, 4–5, 6–7, 8–9, 12–14, 16–18 and 24–25 days after MS.

Some features of global seismicity in periods after the strongest solar flares

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It is known that the large solar protons flares, what is going on approximately one times for three suns cycle, initiate the transition of the power processes into Earth in the boundary states, which are saved to the next strong flares and is determined the size of the power flux at the earthquakes for this period. Noticed also, that seismic activity in the Solar activity cycle has the largest level in the period of minimum of 11-years solar cycle and during the strong solar flares what is going on in the period of the increased solar activity. However the detailed investigations, evidently, was not conducted. In this work on the basis of analysis of Catalogue of earthquakes of National Center of information about the earthquakes of Geological service of the USA (NEIS USGS) [http://neic.usgs.gov] the results of research of possible changes of global seismic activity of the Earth in periods after 17 strong solar flares for two cycles of solar activity from an interval 1974–2006 are discussed. Among them the most strong and geoeffective Solar flares: 06.03.1989 15.0/3b; 14.07.2000 5.7/3b; 01, 04, 06, 09, 11 and 15.06.2001 12.0/3b-4b; 28.10.2003 17.2/4b; 04.11.2003 17.4/3b (peak value of 28.0); 07.11.2004 2.0; 11.11.2004 2.5/3b; 07.09.2005 17.0. To investigate such changes for these periods from the Catalogue the everyday distributing number of earthquakes, NQ, is calculated in the temporal interval of 10 days before and 30 days after every Solar flares. There were analysed the sequences of data of NQ, including all registered earthquakes and separately also for the earthquakes with magnitude of 5, 6 and 7. It was determined that in all considered cases with probability 0,2–0,8 there was the increase of general number of earthquakes in 1,5–3,5 time (sometimes anymore) approximately during days and number of earthquakes with 5 in 1,5–4,5 time on 2, 5–6, 7–11 and 17 days after the Solar flares. It is important, that after the strong flares the strong earthquakes with 6 in 5–6, 10–13, 16–19 days and in 5, 17–19 and 21 days – with 7 were registered. The possible mechanisms (the chainlets of due to the strong mutual coupling between the geophysical processes in the system Earth-Space) of transmission of power disturbances after the strong solar flares, which can cause the set of changes of seismic activity of the Earth, are discussed.

About the origin of the daily periodicities in the local geomagnetic field variations' spectra

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There are diverse periodicities observable in geomagnetic field spectra, for instance 12 hours daily, 14, 28 days, annual, 11 and 22 years etc. In searching different kinds of geophysical anomalies one takes them into account to found out their origin, which obviously can be very diverse. The problem became complicated in particular due to overlapping of different sources. In the present researches an attention is drawing on the shallow underground waters electro conductivity variations as a possible origin of the daily variations in the geomagnetic field spectra. The observations on the hydro geochemical parameters such as radon, H index and electrical conductivity on thermal water of Khoja-Obigarm, Yavroz, Shaambary in the Tajikistan seismic active areas have been carried out. The depths of bore holes are respectively about 50, 100 and 1300 meters with hydro- carbonate-sulfate-chloride-potassium-silicon, chloride-sulfate-potassium and sulfate-chloride-potassium waters and average debits equal to 1.50, 0.35 and 0.90 liter/s. The periodical variations in H of about 14 days have been detected in particular at Shaambary site, caused evidently due to the crust lunar tides deformational processes, and failure of this periodicity about one week before the Dushanbe earthquake 18 August 2006, M = 4.5, hypocenter depth 2.5-5.0 km at the 20 km epicenter's distance. Large fault zones where all these sites located on are known as anomaly porous and water saturated lines and thus are very preamble to underground waters flows. The long lasting through decades direct crust deformation observations, carried out in the Tajikistan's geophysical testing grounds in seismic areas, indicated, that in a regular state the geoblocks are oscillating under the regular periodical tidal impact. Therefore the fluids can propagate through the porous faults medium with the same periodicities. Waters conductivity daily variations demonstrated a sounding effect. The periodical anomalies of about 12 hours varied in amplitudes up to 20 mSm/m at Khoja-Obigarm, 60 mSm/m at Yavroz and 160 mSm/m at Shaambary, which compose about 10% of their full electro conductivity. The deeper is bore hole the larger is electro conductivity, reflecting perhaps the fact that deeper waters contain much ion concentrated electrolytes. The following model based on electro conductivity variations data obtained is under the present investigation. The horizontal layer with the thickness 1 km by order of magnitude has electro conductivity 100-1000 mSm/m by order of magnitude. An external periodical homogeneous geomagnetic filed with own periodicity induces electric currents in that layer spreading on the effective skin-depth. This secondary, induced, electric currents generate own geomagnetic field on the Earth surface space in turn. Following general electromagnetic theory one can specify that the secondary geomagnetic field is directed oppositely to the original filed, turned out thus compensated. The question whether 10% conductivity variations are capable to generate measurable variations in local geomagnetic field spectra? The estimations have been done for the electromagnetic induction effect in the layer and calculations for the reflected geomagnetic field on the Earth surface. It was found out that 10% conductivity variations can provide from 1% up to 10% by order of magnitude reduction in common geomagnetic filed at least at the frequencies from 10Hz up to 100Hz, proving in principle the possibility of daily periodicities' presence in local geomagnetic field spectra.

The results of the analysis of satellite geomagnetic data and ground radon diffusion data in seismic active zone of Pacific region

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The results of the interpretation of MAGSAT satellite geomagnetic measurements, which are indicative of a capability of extraction of radon diffusion field in seismic active zones, are presented. The results of the geophysical analysis of temporary changes of the radon diffusion field obtained in seismic active zone of Pacific region, and their connection with the earthquake epicenters are considered, too. It is shown, that the similar radon diffusion areas, observed within the limits of seismic active zones of Pacific region and migration of temporary variations of the radon diffusion field is one from developments of difficult processes connected to radon emissions and migration of the front of elastic pressure. It is shown, that the control behind the intense radon diffusion processes from tectonosphere in seismic regions can be executed with the help of satellite geomagnetic measurements. Study of results of the interpretation of repeated radon diffusion measurements allows to make a conclusion that in seismic active regions there are observed periodic changing zones with high and low radon diffusion from the earth's crust, connected with seismic processes around earthquake epicenter. The activity is executed at support of Russian Foundation of the Basic Research by grant 07-05-90006.

Local anomalies of ULF magnetic disturbances before strong earthquakes and magnetic fields induced by tsunami

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The problem of forecasting of strong earthquakes (EQ) is still far from its solution in spite of the numerous observations and surveys been conducted in seismic active zones for many years in order to follow the crust movements, seismic, and geomagnetic variations, ground waters, geochemical changes and so on. During the last 15–20 years, observations of ULF electromagnetic waves (f=0.001–10 Hz) in seismic active zones had been conducted owing to the high-sensitive magnetometers. Now the most part of researchers have a good reason to believe that lithosphere sources of anomaly ULF electromagnetic emissions appear in vicinity of the forthcoming EQ heart. An anomaly region with increasing pressure and temperature arises usually in the EQ heart. That leads to increasing of the reflected electromagnetic waves intensity recorded at the Earth's surface.

On the other side strong seismic events in the ocean such as submarine earthquakes, landslides or volcanic eruptions can produce tsunami wave. Tsunami is a series of travelling waves with length much more than the depth of the ocean. These waves can reach large dimensions and travel across the ocean with small lost of energy. The large scale wave propagating in a conducting sea medium in the presence of the Earth's magnetic field can produce electromagnetic signals in the sea and at the ground surface.

In this work we consider an anomalous behavior of gradients and phase velocities of ULF geomagnetic disturbances (frequency range f=0.001–1 Hz) at the distance ≤100 km from a forthcoming strong EQ epicenter. We have found that 1–2 months before the EQ in statistical distributions of directions of the gradients and phase velocities vectors a new direction arises just to the future EQ epicenter. Possible effects in magnetic field variations registered at the marine and the coast magnetic stations being connected with extended tsunami are considered.

Fine structure of electric pulsed field observed above the bent stroke of lightning

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We demonstrate the fine structure of the electric field in neutral atmosphere over a lightning stroke with the bent channel. The report is related to the red sprite phenomena. The most effective and successful model of sprite development exploits the quasi-electrostatic field, which persists in the atmosphere after a lightning stroke occurs. A specific feature of transient luminous events (TLE) in mesosphere is their fine structure possibly associated with the horizontal section of lightning channel. The latter was inferred from the radar echo. The latest records of sprite images with the high time resolution demonstrated that a typical luminous event is a result of video accumulation of many bright, fast moving, and compact points. These objects might be formed by the preceding structured transient electric fields originated from the powerful lightning stroke of complex geometry. We do not model the sprite development in the present paper. Instead, we concentrate on the property overlooked in literature: the transient electric fields in neutral atmosphere above a bent stroke of lightning have a complicated spatial distribution. We use the simplest 'engineering model' of a return stroke in computations. The model was modified in two respects: the sign of its current was changed (to describe a positive stroke) and increased in amplitude by the factor of 20. The length of lightning channel was also increased from 4 to 20 km. The stroke channel is bent (broken) in the middle, so that current wave initially moves upward to the 10 km altitude and turns horizontally afterwards. We demonstrate that modification readily provides multiple pulses intense enough for launching both the positive and negative streamers in the mesosphere. The first pulse in the succession originates from the vertical section of lightning channel and its reflection in the ground. Radiation from the horizontal section (the second pulse) appears after the current wave turns horizontally. Finally, the wave reflected from the ground provides the third pulse. An interference of these pulses in atmosphere provides a sophisticated structure of the field distribution. The characteristic size of elements in the transient electric field is about 1 km along the horizontal direction, and a few tens of kilometers on the height. The time scale of variations is a few tens of microseconds. The driving forces associated with electric field may induce the complicated bunching of charged particles, which later turns into the filaments of a transient luminous event. A conclusion is made that transient electric field should be included into advanced models of sprite formation.

Stresses in rock samples and electromagnetic relaxation times

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The results of laboratory studies are given in the work made on rock samples models. The samples are undertaken of mechanical stresses with press. The method of free relaxation of absorbtion current has been applied. Curves of the dependence of the absorbtion current decrement versus time have been obtained for different values of mechanical stress. The curves are characterized by not only one but by a number of relaxation times — short and long.

The short time changes are not pronounced at the increase of stresses, whereas the long relaxation times increase greatly. It is evident that the increase of the relaxation times is connected with the formation of microcracks in the sample. The formation of the main crack leads to the streak decrease of long relaxation time. Thus electrophysical properties characterize the change in the system of cracks. The authors try to find the explanation of different relaxation times from the view of fractals theory.

The results of the investigations can be applied for the development of new methods of natural studies in seismology.

Earthquake lights

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During a number of earthquakes the luminous phenomena were observed named as "earthquake lights". The most significant event was observed in 1995 during Kobe earthquake. The action of electric field is assumed as the source of these lights. The most difficult problem is to explain the rather high localization of charges and their existence for seconds and tens of seconds in the highly conducting soil. We suggest that the magnetic diffusion from source region is a dominant process (due to the skin-effect). For short duration of current generation pulse the increasing conductivity decreases the skin-layer. In our model we assume electrokinetic mechanism of current generation in the fault under consideration as well as triboelectric one.

We have developed the 3D numerical code which includes the arbitrary distribution of currents, conductivity in the ground and at the surface, the sea water above the epicentre or (and) near the ruptured segments of the fault. Simulations for the 1995 Kobe earthquake (for the realistic geometry of the shores), are fulfilled for different current configurations, namely: 1) the current flows horizontally only in one direction; 2) the current flows from the two opposite edges of the ruptured segment into its centre in horizontal direction; 3) the current flows from the two opposite edges of the ruptured segment into its centre in vertical direction. The epicentre of the Kobe earthquake is located under the strait, so the ground in some place is covered by high conductivity (3 S/m) sea water (constant 100 m depth is accepted), which reduces magnetic diffusion. The results correlate well with scarce measurements of the electric and magnetic fields at large distances from the epicentre (70–100 km). Under the vertical triboelectric current hypothesis and under the output of the rupture on the surface at Awaji Island we got electric fields sufficient for the excitation of optical emissions in the atmospheric bands.

Observations of the low-frequency electric field fluctuations in the ionosphere over the crust faults

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Based on the results of the satellite Dynamic Explorer-2 measurements it is established that the Earth's crust large geological structure peculiarities influence on the ionosphere parameters outside of auroral zone. Such an influence is observed as sharp increasing of the low-frequency (1 Hz – 512 kHz) electric field magnitude. The spectral density of the plasma fluctuations of the decameter scale is significantly enhanced over background and superthermal electron fluxes are observed simultaneously. These effects do not depend on the seismic activity, local time, seasons and the level of the geomagnetic activity. Another intriguing fact is that such a combination of unusual ionosphere plasma processes can be observed even when the fault is covered by water.

We present detailed analysis of satellite data for the Talasso-Ferganskij fault system supported by seismo-tomographic results. Cumulative data with global coverage are given too.

Some hypotheses about the possible mechanisms of the lithosphere-ionosphere coupling, which are responsible for the aforementioned effects, are discussed, together with proposed techniques of their verification.

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Behavior of total electron content over earthquake epicenter regions

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The total electron content (TEC) is widely used to study peculiarities of ionospheric behavior before and after the onset of earthquakes. These peculiarities are investigated in the region about 1000 km from the epicenter at least with 3–4 stations inside this region and 1–2 stations outside for comparison. Methods of TEC estimations include some combination of the phase and group delay measurements. As a result systematic decreases of TEC are observed 2–3 days before and until ∼3 days after the earthquake main shock. More dense set of stations is able to distinguish clear precursors at 1–3 days and even 4–6 days prior to the earthquake. Sometimes a wavelike structure is visible in spatial distribution of the TEC values. Methods of restoration of N(h)-profiles from GPS–TEC data allow to investigate what part of the ionosphere higher hmF2 can be captured by disturbances. In this paper a case of the earthquake 31.03.2006 (33.5°N, 48.78°E, 01.17 UT, magnitude 6.6) is considered by means of TEC-RAL database (3 stations inside epicenter region, 2 – outside). All of March was very quiet and earthquake peculiarities must be displayed clearly. Correction of the IRI model by foF2 and TEC values for one station allows to build diurnal dependencies foF2 (UT) for the other stations. It is shown that decrease of TEC and foF2 can be seen in this period of investigation (in particular, on 2 days before). However similar behavior can be seen 10–14 days before without connection to earthquake. Results depend on hardness of set of stations and their locations regarding epicenter as well as on the method of processing.

General model of Lithosphere-Atmosphere-Ionosphere coupling due to seismicity

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The model includes three basic processes: upward motion of the stress perturbation below lithosphere (deformation wave) leading to upward migration of the fluids inside the crust; origin of the Atmosphere Gravity Waves just above the ground surface due to gas/water release and following energy transportation through atmosphere; induction of the currents in lower ionosphere and development of the ionosphere turbulence modification. Supporting observational facts will be discussed together with theoretical consideration.

Electromagnetic phenomena related to tsunami waves

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Various electromagnetic phenomena accompanying the propagation of long waves in the open ocean are studied. These phenomena include secondary EM fields induced by the movement of seawater in the geomagnetic field and ionospheric effects connected with tsunami waves.

Opportunities of using of electromagnetic signal of lightning discharges for remote sensing of seismic activity

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By the example of earthquake events in the Kamchatka region the opportunity of using of electromagnetic signals of lightning discharges (atmospherics) for the remote sensing of seismic activity is considered. Variations of the amplitude of atmospherics, propagating in subionospheric waveguide above areas of earthquake epicentres reflect changes in the structure of electron concentration in the lower ionosphere occurring under the influence of lithospheric processes. The characteristic attributes of variations preceding strong seismic events with no deep focus (electromagnetic precursors of earthquakes) are revealed. The application of algorithm to the extended set of observational data for the winter periods of 2001, 2002 has shown that the possibility of the short-term prediction of such earthquake events can account for 60%. The reasons of “false alarms” (probability of 25%) are not yet revealed.

Evidence of eight interconnected forces existence in the earth depths and perspective of earthquake prediction

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It was shown earlier that under the influence of permanently existing in the Earth pressure and temperature gradients, the appearing flows can be connected by the equations of the thermal conduction type, with coefficients of the forward and crossed conductivity and permittivity for pressure (P), temperature (T), electric potential (φ), and concentration of the substances dissolved in the fluids (C). The solution of this equation by Fourier method allowing for only four forces (P,T,C,φ) results in an asymmetrical expression, connecting two time dependent coordinates in the left and the right-hand sides. To get a symmetric relation, two more equivalent forces must be considered. These may be magnetic and thermo magnetic forces. Then two dependent coordinates can be connected with each other by the second-order differential equation. Considering the right-hand side of the relation as a disturbing force, we can get the conditions of oscillation excitation for another coordinate. Inasmuch as only electrical and temperature quantities can be correctly measured, the author, taking into account these theoretical considerations, assembled in 1980 a borehole plant (BHP) designed mainly for earthquake forecast. Sensor systems were upgraded to register time information. At present BHP can segregate and register both Earth’s Natural and Atmospheric- Ionospheric (AI) Electric Disturbances, and also the natural signal of the rock surrounding the sensor, and make synchronous with them recordings of temperature fluctuations at high sensibility. On the basis of the long-continued work of BHP, a general earthquake preparation mechanism has been revealed and a lot of effects proceeding and accompanying earthquakes have been observed.

Long before the seismic movement (a year before the Spitack Earthquake) low-amplitude fluctuations with periods about one minute or less have been registered. Then they turn into long - period fluctuations (LPF) with larger amplitude and 10-30 minutes period. Near the epicenter they are inseparable, and when the epicenter is remote but the earthquake is strong enough, LPF are divided into several types of wave packets, which propagate with their own speeds. When the distance is 400-700 km and the magnitude is close to 7, they are recorded by the sensor sensible to underground disturbances, and when the distance is over 1000 km and the magnitude is over 7 - by the sensor, which is sensible to AI disturbances. The records of Rudbar, Java, Sumatra, Taiwan and some local earthquakes will be presented Analysis of the wide practical materials, obtained by BHP, shows that there are eight interconnected degrees of freedom. That is LPF, which appear in the earthquake source, are divided into eight types of waves when spreading. The division is well recognized on the records of the temperature sensor. Demonstration material, which supports the existence of the eight interconnected forces, will be presented.

Matched oscillations of meteorological, actinometrical and electrical values

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Investigations of interconnections between the atmospheric electrical and meteorological values have shown that these connections have a complex nonlinear structure.

In this report the events of matched oscillations of meteorological, actinometrical and electrical values reaching correlation levels at 0,75-0,95 are analyzed based on the high time resolution observations performed at the observatory (56.48°N, 85.05°E) of IMCES SB RAS in Tomsk in 2006–2008.

In our analysis the sliding scale values were defined from several hours to 120 hours and more, the shift values – from decades of minutes to several hours. As a result we obtained that oscillations of the atmospheric electric intensity and the air electrical conduction from units of minutes to units of hours are simultaneously observed with analogous oscillations of main meteorological values. A characteristic feature was cyclic variation of sign of the normalized correlation function for null shift between series of realizations. The variations of sign occurred during several hours, but values of the correlation function were stable during several days.

The spectral analysis of oscillations of the atmospheric electric intensity obtained during the April–August of 2006 has shown the availability of sections in the average spectrum structure which are well approximated by the linear functions. The sections coincide the oscillation periods at 2–5, 5–20, 20–100, 100–420, and 420–5000 min. It was defined that a trend has got negative values from the period at 100–420 min, a spectral density has decreased with spreading the period.

Comparison of experimental and model Q–bursts in time domain

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We compare the records of natural extremely low frequency (ELF) transient signals (Q-bursts) with computations based on the analytical time domain solution. Natural low frequency electromagnetic radio signal is a random combination of individual pulses arriving to an observer from independent lightning discharges that occur all over the globe. The ordinary electromagnetic pulses occurring at the rate of 100 events per second form a continuous background signal in the ELF band. This background should be accounted for when searching for seismogenic modifications of artificial radio emissions or for the direct radiations from seismic activity. Waveforms were modelled pertinent to individual ELF radio pulses arriving from lightning strokes. We used the recently developed direct time domain solution with accelerated convergence. Unfortunately, a straightforward comparison was impossible of the model data with experiment until recently, as the experimental detection was always performed at relatively noisy sites. Traditional measurements applied the filtering of industrial interference at the frequency of power supply lines and its harmonics. In the present report we use the data recorded at an exceptionally quiet observatory. The notch filters were unnecessary that reduce industrial interference, and the wide band receiver could be used with the upper cut-off frequency well above 1 kHz. The ball antenna allowed for ELF-VLF records of the vertical electric field in the fair weather conditions nearby Kochi (33.3° N and 33.4° E) with a unique time resolution of the 16 kHz sampling frequency. The present report compares experiment with the model data. Computations were made for the uniform Earth – ionosphere cavity model with the linear frequency dependence of propagation constant $\nu(f)$. Similarity of computed and observed data allows for the following conclusions. (i) It confirms the correctness of the direct time domain solution, (ii) it proves the validity of the linear model $\nu(f)$ suggested for the ELF propagation parameter, (iii) it supports the uniform Earth – ionosphere cavity model, and (iv) it validates the source – observer distance found from the wide band waveforms directly in the time domain.

Atmospheric electric and electromagnetic field anomalies as possible precursors of earthquakes

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Although the search and study of precursors of electrodynamic character is made in different directions - atmospheric electric field (AEF), electromagnetic emission (EME), earth electric potential (EEP), magnetic field, seismo-ionospheric couplings, etc - the results obtained so far do not satisfy the basic requirements, concerning reliability, plausibility, reproduction. Besides, the main problem which arises at the data interpretation about mechanisms of occurrence of this type of precursors as well as about source location, which generates them, still remains open. Therefore, it still remains an urgent task to accumulate evidence on these anomalies in different geological and geophysical conditions and to refine models of electromagnetic earthquake precursors. We have been analyzed and juxtaposed the anomalies in the behaviour of AEF at the Polish observatory Swider and EME, EEP and also anomalous impulse radionoises recorded at the Bulgarian observatory Vitosha before the strong Carpathien earthquake on 30.08.1986 with M=6.9-7.0 (origin time 21.28 UT). Zone preparation radius of such earthquakes is more than 1000 km, according I.P. Dobrovolsky. The observatory Swider is situated at distance about 700 km and the observatory Vitosha – at distance above 400 km from the epicenter of this earthquake. Noticeable AEF anomaly was observed from 03 to 12 UT of 30.08.1986 at the observatory Swider. Its amplitude was about 1000 V/m (from -250 V/m to +750 V/m), which is much higher than AEF variations during quiet conditions. Anomalous EEP, EME and impulse radionoises effects were recorded for several hours before this earthquake at the observatory Vitosha. The retrospective analyses of one case of a great earthquake in connection with the earth electromagnetic activity shows the possibility to use the observed effects as immediate precursors of earthquakes.

ULF/ELF electromagnetic phenomena related to huge earthquakes

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We have carried out the observation network of ULF/ELF electromagnetic waves below 50 Hz at Nakatsugawa (in Gifu Prefecture in Japan) with three component induction coil antennas (the permalloy of 1.2 m length with 100,000 turns of the copper wire) since 1998. We have observed the excitation of anomalous resonances possibly associated with earthquakes at Nakatasugawa station. In this report, we analyzed the anomalous strong Schumann resonance and another anomalous resonance observed before the 2004 Mid-Niigata Prefecture earthquake and the 2007 Noto Hantou earthquake. The intensity of a particular mode of the Schumann resonance increased before the large earthquake near the observation station, and decreased after the occurrence of earthquake. An excitation of another anomalous resonance was also observed at the frequency shifted by about 2 Hz from the typical frequency of the Schumann resonance. Since the temporal change of the intensity of the anomalous Schumann resonance and excited another anomalous resonance was almost same, there is a possibility that another anomalous resonance was made by the Schumann resonance. However we need to consider more convincible generation mechanism of anomalous resonances and consider about the some factor unique to Nakatsugawa station.

Dynamics of the Earth's oscillations with periods more 1 hour and their particularities before some strong earthquakes

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Continuous observations over Earth's surface oscillations have been analyzed with the purpose to define the dynamic characteristics of seismogravitational oscillations with periods 1–5 hours. The seismographs used in the investigations had different constructions and they were located in Eurasia. The main results and their interpretation have been presented in the report. It was revealed that in the points which are located at great distances from each other, the variation of oscillation intensity can be the same during 1–1.5 months. At the same time the great intensity of oscillations has been simultaneously observed at different stations during 1–2 days before great earthquakes. Some oscillations with short-lived increase of intensity have been observed, which are travelled with nearly constant velocity at the distances greater than 2600 km.

From time to time on the Earth's surface the long-lived compressional and dilatational deformations are observed. They have been observed during 1.5, 2.5, 3, 6 and 12 days and have been registered in 1998, 1999 and 2004. The increase of seismogravitational oscillations takes place in the maximum stage of deformation. After that the great earthquakes with magnitude 7.0 and less are appeared. The frequencies of stable seismogravitational oscillations during 1–2 days before some great earthquakes are increasing. The rate of increasing is different but comparable.

It has been concluded that the Earth's surface oscillations with periods greater than 1 hour and the long-lived deformations have the common reasons. The increasing of frequencies of stable seismogravitational oscillations is connected with the growing of stress and accumulated energy. This energy is concentrated in the domain of these oscillations. In general the peculiarities of dynamics of seismogravitational oscillations of the Earth revealed from long observations can be used in the tasks of short-term forecast of earthquakes.

Variation of ionospheric parameters recorded by the satellite DEMETER during seismic activity

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DEMETER is an ionospheric micro-satellite launched on a polar orbit at an altitude of 710 km. Its main scientific objective is to study the ionospheric perturbations in relation with seismic activity, and then, its scientific payload allows to measure electromagnetic waves and plasma parameters all around the Earth except in the auroral zones. Two parameters are considered in this paper: the electric field and the electron temperature. First specific events will be shown where the electric field and/or the electron temperature are perturbed prior to large earthquakes above the future epicentre. Although, these examples have been carefully selected (close in time and space to the earthquakes, abnormal variations relative to the background level for the same location, the same local time and the same magnetic activity) it is always possible that the perturbations are due to the other natural mechanisms because the ionosphere is highly variable and mainly under the control of the sun. Only a statistical analysis of the data is able to remove this ambiguity. The statistic is done as functions of the geographic position, the local time, and the magnetic activity. Geographical maps with average data are obtained to be used as background levels, and the superposed epoch method is applied to merge the data recorded during seismic activity. In relation to previous presentations the data set has been increased because we have now more than three years of data and a comparison is done when we remove the aftershocks from the statistics because pre- and post-seismic effects can be mixed.

Temporal variations of ionosphere F2-layer critical frequency over Vrancea seismic zone

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It is evident now that different regions of geocosmos (lithosphere-atmosphere-plasmasphere) are in close interaction. Thus, there is large number of experimental facts which shows the presence of earthquake effects at the heights of ionosphere. The aim of the presented work is to study temporal variations of ionosphere F2-layer peak density over the area of powerful (with magnitudes greater than 5.5) earthquakes preparation. For this purpose the procedure of wavelet analysis was applied to standard vertical sounding data at Sofia station (42.7 N, 23.4 E). Hourly values of F2-layer critical frequency (foF2) for years 1964–1974 and 1981–1999 were used. Regular (daily, seasonal, solar cycle etc.) foF2 variations were ascertained, but emphasis was made on establishing of irregular electron density behavior before seismic events.

Variations of VLF signals received on DEMETER satellite in association with seismicity

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We present two methods of the global ionosphere diagnostics using VLF signals received on the board of DEMETER satellite in association with two cases of strong seismic activation. The method of reception zone changes reveals an evident effect before and during the great Sumatra earthquake with long-time duration of the order of one month. The result leads to the conclusion on the size of perturbation area of the order of several thousands kilometers. Disadvantage of this method is in its difficulty to separate preseismic and postseismic effects. In contrast, the difference method allows us to overcome this difficulty and it shows the appearance of preseismic effect for several days for seismic activation near Japan. However, we need such an analysis for reliability in regular satellite data to be checked by ground reception of subionospheric VLF signals. It is not so obvious that both of these satellite and ground effects are excited by the same generation mechanism on the ground. So, these look as complementary.

ULF/ELF electromagnetic radiation and seismicity. A technique of source azimuth detection and the results of analysis

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It is shown in our previous paper [Schekotov et al., Radio Sci., doi:10.1029/2005RS003441, 2007] that additional ULF/ELF electromagnetic emission is generated several days prior and after strong earthquakes (EQ). Polarization parameters of this emission indicate indirectly the existence of a source in the EQ preparation zone. In the present paper a technique of detection the source azimuth is developed and applied to the data of 3 year measurements at geophysical observatories Karimshino (Kamchatka, Russia) and Moshiri (Japan). The azimuths of ULF/ELF sources are compared with those of earthquakes. The source azimuth is equal to the angle between the small axis of the polarization ellipse and N-S direction. The frequency range 2–6 Hz is taken for analysis to minimize the influence of distant atmospheric sources dominating at higher frequencies and global geomagnetic activity, prevailing at lower frequencies. Source azimuth is calculated for time intervals with signal amplitude exceeding a threshold value and averaged over frequency band. The analysis shows that the agreement exists between ULF/ELF source and EQ azimuths that can hardly be explained by random coincidence.

Dynamics of magnetic disturbances per 2003–2005 and realization of seismic energy

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Abnormal events on the Sun in October-November 2003 and 2004 have caused non-standard processes in a geomagnetic field and in a number of the geophysical phenomena. Earlier it was shown by us that by searches of connection of earthquakes with geomagnetic storms it was necessary to consider not only amplitudes of irregular fluctuations but also their frequency spectrum. Generally between amplitude and duration of fluctuation (Caraway seeds, hour) linear ratios were kept. Cases when these ratios were broken were considered as abnormal. On supervision of a magnetic observatory in Kiev (50.6°N; 30.3°E) geomagnetic conditions in connection with strong earthquakes 2004-2005 are considered including catastrophic seismic events. On a background of average distributions of geomagnetic parameters abnormal effects in solar-daily variations and in substorms are shown by us. Abnormal displays in the geomagnetic field connected with extreme behaviour of activity of the Sun in November 2004 are considered and their possible influence on realization of seismic energy in the area around Sumatra. As an estimation of a degree disturbance fields characteristics of "capacity" and the "speeds" introduced earlier for irregular variations were used by us. Activization of seismic processes in central zones begins with strong differences in a geomagnetic field. Differences in a geomagnetic field, in particular in - component are that "trigger" when preparation for a discharge of seismic energy becomes more active. Introduced characteristics can be used as the comparative characteristic that pushes of a various power class. Connection of earthquakes magnitude with "capacity" of night substorms is shown. Apparently, abnormal values of this characteristics can play a role of the "trigger" mechanism in realization of seismic energy.

Seismic travelling ionospheric disturbances at F2-region in time of heliogeophysical disturbances

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The properties of travelling ionospheric disturbances of electron concentration (their horizontal sizes are 1–4 thousand kms, excesses of a background are 15–30%), formed in F2 layer as a result of pulsing actions at preparation of earthquakes in time of heliogeophysical perturbations were explored. The inhomogeneities arise 10–15 h before earthquakes and move horizontally with a transonic speed on distances of a few thousand kms up to round-the-world trajectories focused approximately along the arc of a major circle, transiting above epicenter region. Information of spent examination was caused by spatial – time differences of the dynamics of F2-layer of the ionosphere in the time of heliogeophysical disturbances from the dynamics of quasi-causative macroscale ionospheric inhomogeneities. In conditions of ionospheric storms and substorms there can be perturbations of electron concentration, commensurable in characteristic sizes and contrast range with seismic TID, but completely different in character of temporal and spatial changes. The complex analysis of the arrays of critical frequencies of F2 - layer of the ionosphere (foF2) of a world network of automatic ground ionospheric stations of vertical sondage was carried out. The analysis was carried out on the basis of statistical methods with use of representations about Poison stream of events, as well as on the basis of the causal approach to separate inhomogeneities. As a result of these examinations, the geophysical patterns of ionospheric effects incipient at superimposition of seismic travelling ionospheric disturbances of electron concentration and ionospheric disturbances of solar and magnetospheric origin were synthesized.

Electromagnetic manifestations of earthquakes in the high-latitude lower ionosphere

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The ionosphere is the environment which is subjected to influence of different disturbances. The disturbances are mainly caused by processes on the Sun and also by processes in the lithosphere of the Earth. Variations in parameters of the ionosphere depend on the features occurring in the Earth's crust: earthquake magnitude size, depth and location of epicenters, types of rocks, etc. Lithosphere-ionosphere processes are also of interest in prediction of earthquakes.

To find effects in the ionosphere, caused by lithosphere processes, proceeding on the final phase of preparation of earthquakes, we chose earthquakes, which occurred at the quiet geomagnetic field. We have analyzed experimental data of partial reflections MF radar (Tumanny, 69.0°N; 35.7°E) and of vertical sounding of the ionosphere (Sodankylä, Finland, 67.37°N; 26.63°E) during two strong earthquakes on 17 July 2006 and on 26 May 2006. The earthquakes took place in the same region (Indonesia) at the quiet geomagnetic field and at small A-class solar flares. From the analysis of the data we have found similarity in changes of lower ionosphere parameters. Before the beginning of the earthquakes and just after them the sinusoidal amplitude variations of the ordinary component of partial reflected signals with the periods of 2 to 6 hours are observed. In the days of the earthquakes the spectra with a well-expressed maximum are observed. The next days after the earthquakes several maxima in spectra of amplitudes are observed. The periods of fluctuations in the days of the earthquakes increase in comparison with the days preceding and following the days of the earthquakes. According to vertical sounding data the periods of fmin amplitudes fluctuations during the days of earthquakes are also of the order of several hours. We have found similarity in forms of spectra of ordinary component amplitudes of partial reflected signals at heights from 85 till 105 km. At the same time the periods of ordinary component amplitude variations of signals did not change. It means that internal gravity waves have penetrated on these heights of the lower ionosphere. Daily electric field variations at the height of 101 km have shown that just before the earthquake the electric field appear to be stronger than at the same time but in the day before the earthquake. In the considered days the speeds of ionosphere plasma movements above the Kola Peninsula, received from patterns of SuperDARN convection and corrected for the lower ionosphere, are adjusted with the drift speeds measured in Tumanny.

Analysis of the experimental data has shown that at the quiet geomagnetic field and at small A-class solar flares the reaction of the high-latitude lower ionosphere to strong earthquakes both on 17 July 2006 and on 26 May 2006 has been manifested. In the spectra of the ordinary component amplitudes of partial reflected signals, the internal gravity waves with the periods of some hours are observed, which are connected with earthquakes.

Testing of the method for the conversion from the MT apparent resistivity

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The method was proposed for the separation of contributions of various structural elements to the time changes in the apparent resistivity

ρ_a and for the estimation of relative variations in rock resistivity ρ_i that is responsible for variations in the ρ_a observed at the surface of a geoelectric structure that is studied well enough to perform numerical modeling. This method reduces to the construction and solution of the system of linear equations. The matrix A consists of the $[\rho_{i_1},\rho_{i_2}]$ -averaged values of apparent resistivity sensitivities to the variations in electrical resistivity of highly conducting elements of the structure at the electromagnetic field period T_j: $a_{i_j} = \varepsilon_{ij_a v}$ THe elements of the column of the free terms B of system are $b_j = lg(\rho_{a_2}/\rho_{a_1})$ at the period T_j, the unknowns $x_i = lg(\rho_{i_2}/\rho_{i_1})$. The main problem in the realisation of this method is a correct determination of the $a_{i_j} = \varepsilon_{i_a v}(T_j)$ using numerical modeling of a well-studied geoelectric structure. The results of testing of this method on a 1-D model structure was published in journal "Physics of the Solid Earth", 2006, vol.42, No4.

Testing of the proposed method was conducted using 2-D model of Petropavlovsk geodynamical polygon (Kamchatka). The geoelectric model of this polygon includes three highly conducting elements. The frequency responses and the spatial dependences of ρ_a sensitivity to variations in the resistivity of these elements were studied. Thanks to that the optimal frequency values and the best places for MT monitoring were determined. For several favorable points the matrixes of the above-mentioned systems of the linear equations are calculated. Solving such systems at various values ρ_{a_1} and ρ_{a_2}, preliminary calculated on preset values ρ_{i_1} and ρ_{i_2}, constructed for one point or set of several points, it is possible to estimate accuracy of definition of the ρ_{i_2}/ρ_{i_1}. Carried out researches have shown, that application of the proposed method in optimal points of observation allows to define values ρ_{i_2}/ρ_{i_1} with accuracy sufficient for monitoring of relative changes in the electrical conductivity of rocks.

Thermal neutrons' flux response to the earthquakes depending on the epicenters' location based on Kamchatka observations

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Long-term observations of thermal neutrons' flux near the Earth's crust have shown that its variations reflect both the processes in the near-Earth space and the geodynamic processes. This fact is explained by the dual nature of thermal neutrons' flux near the Earth's crust: its first source is bound up with the high-energy particles of cosmic rays penetrating into the Earth's atmosphere and interacting with its elements, and the second source originates from the radioactive gases contained in the Earth's crust. At the same time it is known that thermal neutrons are very sensitive regarding different local effects, including climatic and atmospheric conditions, therefore one of the most important problems is to separate the variations of geodynamic nature from the rest.

The recent observations in the seismic-active area of Kamchatka have shown that most likely the thermal neutrons' flux response to the geodynamic processes (in particular, to the preparation processes before the earthquakes) depends not only on the magnitude of the following earthquake, remoteness of its epicenter from the experimental unit, but also on the epicenter's location, in particular, its direction from the unit. That is there are some preferable directions, for which the response of the thermal neutrons' flux is the most clear and striking.

The present report is based on the results of the statistic and comparative analysis of Kamchatka experimental data on thermal neutrons' flux variations during the period 2004–2007 for the time intervals with and without strong earthquakes taking into consideration the directions to the earthquakes' epicenters from the experimental unit.

Tsunami monitoring and warning system

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From the space tsunami is seen as a wave propagating from the epicenter of the quake. The cause of tsunami is often an earthquake event in the ocean floor. If the bottom moves a couple of meters vertically in a few seconds, the whole water column above is forced to follow. Kilometers or more of water column is quickly lifted. The area of the earthquake and of the lifted water can be many hundreds or thousands of square kilometers. Enormous kinetic energy is transferred to the water and the result is tsunami formation. When reaching the shallow coastal waters the tsunami amplitude rises. A big tsunami will run up on the shore with enormous destroying power, as a wave front or wall of water for a minute or more. It exerts huge force equivalent to or exceeding that influenced by the air during a severe tropical cyclone.

Much effort is being put into detecting tsunami once they have occurred. First of all it is made an attempt here to consider tsunami as a soliton, its propagation in the ocean medium and transformations near the cost. It is proposed physical and mathematical model of tsunami, considered Bussinesca and Cortovega-de-Frith equations and discussed examples of obtained solutions. Some results of middle tsunami power calculations are given.

Tsunami wave in a conducting sea medium crossing the Earth's magnetic field induces quasiconstant (static) electric and magnetic fields, as well as propagating alternate electromagnetic fields generated by MHD instability that one can register as a signals of tsunami. Besides it generates pressure waves – another additional form of signal. The main task is to measure, to register these signals and then consequent information have to be transferred by the radio channel to a coastal station where there is made a decision on notification of the coastal population.

Configuration of warning system bases on bottom stations (BS) in the ocean at some distances from the shore and coastal ground stations (CGS) of the "Tsunami alarm system" are discussed here. The basic warning system module includes three orthogonal axes magnetic and electric sensors as well as piezoelectric pressure and acoustic sensors. An optimization of the local centers (LC), CGS'es, BS clusters (BSC), regional coastal chain (RCC) and RCC center structure schemes to raise tsunami detection effectiveness and avoid false signals are considered too. The chief task and purpose is to warn before the tsunami reaches a coast. This system solves problem of timely warning about tsunami approaching the coast.

Manifestation of the fractal properties of earthquakes and geomagnetic disturbances in scaling characteristics of ULF emissions

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Fractal properties of earthquakes are reported by many researches. Such fractal behaviour manifests itself in the earthquake statistics (the Guttenberg-Richter law, the Omori law etc.); in the hierarchical (fractal) organization of the tectonic fault systems and so on. Fractal properties of seismic noise has been recently predicted on the basis of simulation of the coda waves scattering on the fractal crack networks (Kiyashchenko et al., Phys. Chem. Earth, 2004). Since the earthquake sources produce not only seismic noise, but also electromagnetic one, the scaling characteristics of the latter can carry information on the fractal dynamics of the earthquake preparation processes. In this presentation we summarize our experience in fractal analysis of ULF emissions registered in seismic-active areas. The peculiarities revealed are presented. Since the seismogenic ULF emissions are always mixed with those ones of magnetospheric origin, we have fulfilled the similar fractal analysis of the data obtained in seismic quite regions (210 GM stations and the high-latitude drifting station North Pole-30). We have revealed nearly the same dynamics of the fractal characteristics before the earthquakes in seismic-active regions and before geomagnetic disturbances in the seismic-quite region. Namely such similar dynamics manifests itself in appearance of the intervals with flicker-noise in the ULF frequency range (f=0.001–1 Hz) prior to the earthquakes and geomagnetic disturbances with corresponding increase of the ULF time series fractal dimensions. The results obtained are discussed on the basis of the SOC (self-organized criticality) concept. As a conclusion we have outlined a possibility of using the scaling characteristics of ULF emissions for monitoring the preparation phase of strong seismic and magnetospheric events and extraction of their precursory signatures.

Fractal characteristics of ULF emissions registered in the high latitude seismic-quiet region of Spitsbergen Island

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In the last years, the interest to fractal properties of ULF emissions has been arisen in relation to study the earthquake preparation processes. On the basis of observations in seismic-active regions, the characteristic peculiarity in variations of the ULF emission scaling (fractal) parameters before some strong earthquakes has been revealed. But the seismogenic ULF emissions are always masked by the emissions of space origin. To distinguish lithospheric effects from magnetospheric ones, it is necessary to study the fractal properties of ULF emissions not only in seismic-active regions, but also in seismic-quiet areas. The high-latitude region is one of such seismic-quiet areas, where magnetospheric effects are especially pronounced.

Here we analyze the magnetic data of the Barenzburg, Spitsbergen station (Φ_m=76°N, Λ_m=115°) obtained with high resolution of 10 Hz (materials of Polar Geophysical Institute). Such a high resolution allows us to investigate appropriately the fractal properties of ULF emissions in the frequency range from f=0.001 Hz up to f=1-2 Hz. We have applied the Higuchi method of data processing to obtain more stable values of scaling exponents and fractal dimensions of the ULF emission time series. The first results of such analysis, which have been fulfilled separately for the noon, dusk, night and dawn sectors, are presented. The obtained fractal characteristics are compared with corresponding characteristics reported earlier for the low-latitude seismic-active region of Guam Island. The efficiency of using high-latitude stations as reference locations for seismic-active areas is discussed.

SOC-based simulations of seismic-electromagnetic dynamics in fractal tectonic fault systems

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Over the last decade, we have developed a novel cross-disciplinary approach to study the earthquake preparation process and search for new earthquake precursory signatures (see Troyan et al., in: M. Hayakawa (ed.), Atmospheric and Ionospheric electromagnetic phenomena associated with Earthquakes, TerraPUB, 1999). The principal component of this approach is modeling of the dynamics of tectonic fault systems based on self-organized criticality (SOC) framework (Uritsky et al., Physics and Chemistry of the Earth, 2004; Smirnova et al., WSEAS Transactions on Advances in Engineering Education, 2005). In this talk, we summarize our experience in SOC-based modeling of multiscale emergent phenomena in such systems, and study its potential seismic-electromagnetic implications. We discuss several progressive steps in the field of numerical SOC simulations, starting with the first BTW (Bak, Tang and Wiesenfeld) model and finishing with more advanced models such as the non-Abelian sandpile by Hughes and Paczuski (HP models).

The developed approach allows us to explain some essential statistical parameters of fractal organization of the tectonic fault systems, and make an educated guess regarding its underlying thermodynamic state. The approach proves to be a useful tool for studying time-evolving spatial distribution of electrical conductivity along the fault zone, and it provides a basis for explaining electromagnetic precursors of major earthquakes in the low-frequency band. We demonstrate that the relationship between seismic and ULF electromagnetic geophysical processes can be adequately represented by certain classes of SOC models. The results obtained lay a foundation for a new methodological framework for forecasting catastrophic earthquakes based on transient anomalous signatures in fractal geophysical fields.

Peculiarities of the ULF emission fractal characteristics obtained at the stations of 210 GM

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In the series of papers by Smirnova and Hayakawa, the definite dynamics of fractal characteristics of ULF emissions registered at the Guam observatory in relation to the strong earthquake has been reported. It is also revealed that scaling parameters (spectral exponents β and fractal dimensions D) of the ULF time series are influenced by geomagnetic activity. So the local seismo-electromagnetic phenomena are screened by magnetospheric effects, which are of more global character. To distinguish both effects the data from reference stations are necessary in addition to the Guam data. Here we consider coordinated magnetic records (1 Hz sampling rate) of the 5 stations located approximately at the same geomagnetic meridian (210 GM). Now the profile is extended from the low latitude to the auroral zone. This chain of stations includes the Guam, Moshiri, Paratunka, Magadan and Chokurdakh locations. One year period (1993) that embodies the date of the strong Guam earthquake of 8 April 1993 is analyzed. We have used the Higuchi method to get the stable values of fractal characteristics. Comparison of the ULF emission scaling parameters obtained at different latitudes has been fulfilled. Dependence of β and D versus Kp index of geomagnetic activity has been separately analyzed for all 24 local time intervals. Seasonal variation of the correlation between ULF emission scaling characteristics and Kp index is examined. The results obtained are considered on the basis of the SOC (Self-organized criticality) theory. A possibility of using the data of the 210 GM stations as reference materials for the Guam seismic active area is discussed.

Does the secondary cosmic rays neutrons' flux increase during the tidal or seismic wave passing across the region?

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The present study is based on the results of the measurements of thermal neutrons' flux in Pamir region – one of the most seismic regions of the Earth – during the period of 1986-1997. Remarkable increases of the thermal neutrons' flux near the Earth's surface were observed during the tidal wave passing across this region. At the same time the seismologists observe about twenty earthquakes of different magnitude in this region every day. During the period of the thermal neutrons' observations from 1986 to 1997 there were about 2500 earthquakes with magnitude over three, and none of them was accompanied by the thermal neutrons' increase. What's the reason for so different response in thermal neutrons' flux for tidal wave and seismic wave passing? It's supposed that mechanical influence on the Earth's crust must result in the same effect, no matter what processes caused this influence. The reasons of this difference and possible conditions which would provide an opportunity for the thermal neutrons' flux increases during the seismic wave passing across this region are analyzed in the report.

Analysis of low-latitudinal ionosphere modification prior to Peru 2005 seismic event

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This paper investigates the features of spatial-temporal modification of equatorial ionosphere for American longitudinal region prior to the strong Peru earthquake (M=7.5) of 25 September 2005 that was registered at 01.55 UT (LT=UT-5h). Geographical coordinates of the epicenter was (5.67°S, 76.41°W), geomagnetic - (4.55°N, 355.33°).

The possible influence of the earthquake preparation processes on the main low-latitude ionosphere peculiarity – the equatorial anomaly – is discussed. To estimate spatial sizes and temporal dynamics of seismo-ionospheric anomaly the global TEC maps (Global Ionospheric Map) were used. The Latitude-Time TEC plots and meridian sections (λ=75°W) of TEC spatial structure were constructed. Analysis of the LTT maps has shown that modification of the equatorial anomaly occurred a few days before the earthquake. In previous days, during the evening and night hours (local time), a specific transformation of the TEC distribution had taken place. This modification took the shape of a double-crest structure with a trough near the epicenter; it means the intensification of equatorial anomaly and extension of the anomaly "tail" part into the evening time. The difference of TEC values in crests and trough reached the value of 16–18 TECU. Analysis of GIM TEC for 3 months has revealed that it is rather atypical situation for the given region and season, usually in this time the restored normal latitudinal distribution with a maximum near the magnetic equator is observed. Calculations LTT made by use of IRI-2001 model have also demonstrated that during evening hours latitudinal distributions of TEC have the "restored" normal structure with a single maximum. In addition to the ground-based GPS receivers network the measurements provided by space-based GPS receiver of CHAMP satellite were analyzed. TEC variations derived on the base of CHAMP measurements along satellite passes filtered in the longitudinal diapason of 90°W-60°W during 02–03 UT (21–22 LT). The presence of the double-crest structure with trough near the magnetic equator was found out. For more detailed study of features of the ionosphere diurnal behavior we consider the regional TEC maps, created with spatial resolution of 1° and temporal interval of 1 h on the base of LPIM (La Plata Ionospheric Model). Measurements of more than 50 GPS stations located in this region were used to create TEC maps. Analysis of LPIM maps confirmed the presence of modification of TEC distribution and enabled to do more accurate estimation of numerical characteristics of the effects observed.

Features of the ionosphere behavior prior to the Kythira 2006 earthquake

Zakharenkova, I.E., Shagimuratov, I.I., Tepenitsyna, N.Yu. (West Department of IZMIRAN, Kaliningrad, Russia)

In this report the specific features of TEC (total electron content of the ionosphere) behavior as possible precursors of Southern Greece earthquake of January 8, 2006 (M6.8). For this purpose we used both the TEC data of nearest to the epicenter GPS-IGS stations and TEC maps over Europe. The favorable circumstance for this analysis was the quiet geomagnetic situation during the period previous to the earthquake (the sum of Kp didn't exceed 15). One day prior to earthquake the typical anomaly was found out as the day-time significant increase of TEC at the nearest stations up to the value of 50% relative to the background condition. To estimate the spatial dimensions of seismo-ionospheric anomaly the differential mapping method was used. Anomalous TEC enhancement was registered since 10 UT and reached the maximal value of 55% at 18–20 UT. So, the seismo-ionospheric anomaly was found out as the cloud-shaped increase of total electron content of the ionosphere, it had a well-defined local character and it was situated in the immediate vicinity of the earthquake epicenter area. The zone of the anomaly maximum manifestation (TEC enhancement more than 35%) had spatial scale of about 4000 km in longitude and 1500 km in latitude. To verify the locality of the observed anomaly we used index of global electron content (GEC) proposed by Prof. E.L. Afraimovich. We calculated the variation of mean GEC and series of mean TEC variations I(t) over regions with different square. We find out that anomalous TEC enhancement doesn't have global character and with increase of the region square the tendency of the anomaly smearing appears. This fact confirms that this effect was local and was observed only over epicentral region.

Simulations of the equatorial ionosphere response to the seismic electric field sources

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The results of the computer simulations of the equatorial ionosphere response to the additional electric fields of the presumably seismic origin have been presented and discussed. These model experiments are further development of the series of simulations for the mid-latitude ionosphere: we consider similar geometric configurations and types of additional electric field sources but for the low-latitude conditions. We imitate these sources by placing additional electric potential sources at the corresponding nodes of the numerical grid and turning it on in constant regime for 24 hours. The computer simulations have been held by means of the first principle Upper Atmosphere Model (UAM).

The obtained results have been compared with GPS (Global Positioning System) data for the Peru earthquake of 26 September 2005 that detected anomalous perturbations in the TEC (and NmF2) near the earthquake epicenter area for a few days before and after the main shock. The effects are the reduction (or increase in some cases) of the equatorial anomaly with trough deepening and symmetric shifting of the double-peak TEC (and NmF2) maxima from the earthquake epicenter. Computer simulations reproduced well those features of the equatorial ionosphere behaviour.

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