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(3) your paper size shouldn't exceed six pages.

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Plenary Talks

Global warming of the last centuries and natural factors of climate changes

Dergachev, V.A. (Ioffe Physical-Technical Institute, St.Petersburg, Russia)

Climate has varied on all time scales from decades to millions of years. It is generally accepted that the Earth's climate in the past was substantially warmer or cooler than today. It is also known that temperature and the level of CO_2 rise and fall roughly together. Climate change during the last 100 years or so has been intensively discussed over the last few decades.

The key variables we usually consider when talking about climate are temperature (main control on climate) and precipitation (much more complex than temperature). Instrumental records show that the temperature is increased from the latter half of the nineteenth century. Certainly, both the temperature and the amount of CO_2 in the air have increased during this time.

The popular media and the supposed scientific "consensus" believes the average warming observed since the beginning of the industrial era is due exclusively to the increase in anthropogenic greenhouse gas concentrations in the Earth's atmosphere. A closer look at the science, however, reveals that the data do not support these claims. There are a wide range of natural events and processes, which could potentially be impacted by global warming. It is necessary to make every effort to present the true science of climate change.

This report will present the results of the analysis of climatic characteristics and the change of climate mainly as a result of natural processes on time scale covering the last some hundred and thousand years. To estimate confidently the climate change now and to predict its changes in the future, it is necessary to rely on a long-term picture of such changes in the past received from the proxy data. However, it is necessary to take into account that the proxy data are not a direct measure of climatic variability. In addition, the proxy data frequently have poor time and space resolution. Wide use of models of a climate frequently become useless because of uncertainty of estimated from the proxy data processes which are included. The Earth's climatic

system is far too complex, with too many unknown drivers and feedbacks, to enable use of models. There is no established theory of climate.

Polar world of Russia: Problems and perspectives

Troyan, V.N. (St. Petersburg University, St. Petersburg, Russia)

Global warming is a real tendency for XXI Century or it is only temporary climate changing. This problem was discussed last decades by many scientists, politicians and journalists. We shall consider some examples of the global temperature behavior during last 1000, 100, 20 years; the tendency of climate variability and change in high Northern latitude. We shall present global multi-model averages and assessed ranges for surface warming and spatial distribution of the multi-model averages for surface warming (2020–2029 and 2090–2099). It will be given observed changes of the Arctic Sea ice during last years and September sea ice 2002–2007.

The essential decreasing of the ice sea opens wide possibilities for geophysical investigation and geophysical prospecting in the Arctic Region. We shall show some results of geophysical measurements: seismic, magnetic, gravity and results of the interpretation.

Exploiting fossil deposits in the northern seas will require an infrastructure that functions perfectly and economically — even under extreme geological and climatic conditions that prevail in those area. Russia is rich in natural resources and it's still sitting on a large number undeveloped petroleum and gas deposits. We know, for example, that there are huge reserves in places like Eastern Siberia, the Barents Sea and the Northern Arctic Ocean. Extraction under Arctic conditions will be very difficult and expensive, however, and will also require new technologies, international partners and possibly Global Warming. And that is exactly what is happened now with Total and Statoil company involvement at the Stockman gas deposit in the Barents Sea.

The exploitation of natural resources always leads to major landscape changes. The increasing new technologies is now benefiting because they make raw material extraction more efficient and reliable. In Russia we need to treat nature and natural resources with solicitude especially in the Arctic Region where the nature is very fragile.

Section C. Conductivity of the Earth

Geoelectric model of the geothermal perspective area near the town Palana (Kamchatka Peninsula) according to AMT data

Antaschuk, K.M., Pertel, M.I., Saraev, A.K. (Saint-Petersburg State University, Saint-Petersburg, 199034 Russia)

Audiomagnetotelluric (AMT) investigations have been carried out in the area near the town Palana (NW part of the Kamchatka Peninsula). The main elements of geothermal deposits are a heat source (intrusion) and a drainage system for thermal water circulation (faults and fractured zones). Thus the purposes of the works were study of geologic structure of the territory, localization and contouring of conductive anomalies connected with faults and also allocation of deep conductive zones, potentially connected with deposits of thermal water, for the choice of prospecting drilling sites. AMT investigations have been carried out using the ACF-4M tensor equipment with the frequency range of 0.1–800 Hz. For reduction of the noise influence the remote reference technology has been applied.

At the first stage of investigations an area with the square about 36 km^2 has been studied. Geolectric sections up to 1500 m depth have been derived according to the 2D inversion. Three anomalous conductive zones have been delineated. Taking into account these results and economical reasons an area with the square about 9 km^2 in the vicinity of the town Palana has been selected and detail AMT investigations have been carried out here. The quite detail survey (the distance between profiles and sounding stations were 250 m) allowed us to fulfill the reliable data interpretation.

Geolectric sections have been studied up to 2000 m depth and two layers geoelectric structure has been obtained. The first (upper) layer of high resistivity is connected with the volcanic and volcano-siliceous rocks. The second layer of low resistivity is connected with sedimentary rocks. A broad conductive anomaly has been delineated in the SE part of the area. It is located between two faults of the NE direction. The geological interpretation has been carried out using AMT data and results of the pervious magnetic and gravimetric airborne surveys. As a result a geoelectric model of the geothermal perspective area has been created. The place of supposed intrusion body has

been localized and two main faults systems of NW and NE direction have been delineated. A site for prospecting drilling has been chosen at the most conductive part of the area.

This work was supported by the grant No. NK-606(3) of Federal Target Program "Scientific and scientific-educational personnel of innovative Russia" in 2009–2013.

Anomalies of the lithosphere conductivity and tectonics of the East European Platform

Astapenko, V.N. (Belarusian Research Geological Exploration Institute, Minsk, Belarus)

Several known crustal anomalies of the electrical conductivity of the Baltic and Ukrainian Shields are confined to the contact zones of different-age Earth's crustal blocks. The origination of the conductivity anomalies is associated with the processes of formation of old platforms and subsequent tectonic processes. The Volga-Central Russian system of troughs extending across the Platform from the Teisseyre-Tornquist zone on the southwest to the Pre-Timan trough on the northwest is one of the largest structures of the East European Platform (EEP). There is an idea that the Volyn-Orsha system of troughs and the Central Russian aulacogen serve as boundaries between three large EEP crustal segments — Fennoscandia, Volga-Uralia and Sarmatia, and the Pachelma aulacogen — as a boundary between Volga-Uralia and Sarmatia. The process of joining of all three crustal segments into the single EEP had taken place in the Paleoproterozoic (2.0-1.8 Ga) and had been accompanied by the subduction and collision of paleoplates. It is suggested that a wide range of aulacogens, troughs and grabens infilled at present with the 5 km thick cataplatform sedimentary cover had been developed in the plate contact zone during the lithosphere activation at the Early-Baikalian stage of the EEP evolution (900–600 Ma). Magnetotelluric soundings performed in these regions have determined rather high values of the electrical conductivity of the upper crust from the basement surface to a depth of the order of 20 km as interpreted by a gradient models, or zones of electrical conductivity in a depth range from 2 to 20 km — in a layered model. The total conductance of an anomalous layer is as high as 4,500 S. The space correlation of anomalous zones showing different geophysical parameters in the upper crust suggests a high

porosity and shattering of crustal rocks. Two conductivity anomalies with similar parameters (Orsha and Volyn ones) were distinguished in the western part of the Volyn — Central Russian system of troughs, though their total conductance is no more than 1,000 S. The Orsha — Ilmen, Valdai, Lubim, Moscow — Tambov magnetic variation anomalies correspond to areas of high electrical conductivity. The known mantle conductivity anomalies are confined to areas of plate paleosubduction and collision within EEP. In the case of low heat flow values an increase of the mantle electrical conductivity can be due to a special composition of the mantle material, where unstable amphiboles occur in a depth range from 80 to 120 km.

Xenolith constraints on conductivity of the Tien Shan Earth crust and upper mantle

Batalev, V.Yu., Bataleva, E.A., Rybin, A.K. (Research Station RAN, Bishkek 720049, Kyrgyzstan)

The present work deals with the petrological interpretation of the MT inversion data on the base of chemical analysis and laboratory measurements of electrical conductivity of xenoliths collected from the basaltic outcrops in the South Tien Shan. The Kyrgyz Tien Shan mountains are located between the active structures of the Tarim Plate (on the South), and the stable Kazakh Platform (on the North). The geodynamic history of the Tien Shan formation may be divided in four main periods. The late Cenozoic tectonic activity was a result of the ongoing indentation of the Indian subcontinent into the Eurasian plate which has been started about 55–56 Ma ago. The collision caused the propagation of the crustal shortenings and undertrusting into the interior of the Eurasian continent, resulting in further crustal thickening and intracontinental mountain building. The lithosphere structure beneath Tien Shan has been addressed recently in the magnetotelluric (MT) study along 76°E profile 450 km long across Tien Shan. Electrical conductivity of Tien Shan rocks, samples of eclogite, mafic granulite and spinel lherzolite, have been measured in laboratory at high T and P by the use of electrical impedance method. The agreement between the laboratory conductivity of spinel lherzolites at temperatures corresponding to paleogeotherm and the conductivity of layers at similar temperatures obtained from MT-inversion demonstrate a difference, which can be only explained by a vertical down

shift of the geotherm for about 25 km. The laboratory conductivity of mafic granulites is compared with the conductivity of layers near the Moho boundary in MT-inversion model. Comparison of the specific resistance of mafic granulite, spinel lherzolites and the resistance derived from MT-inversion indicate a good agreement for the layers of granulites and lherzolites beneath Ak-Say valley and Kok-Shaal ridge in compliance with present temperature distribution. The laboratory estimated conductivity at temperatures 700–1000°C corresponds to the conductivity of a spinel lherzolites layer at the depth 60–80 km from MT-inversion.

Location of the asthenosperic layer beneath the Fennoscandian Shield territory

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

One of main goals of the experiment BEAR was to confirm the existence of the well conducting asthenospheric layer beneath the Fennoscandian Shield. Earlyer this problem was considered by I. Lahty, T. Korja and L. Pedersen (2007). In previous works of our team (2002, 2005, 2007, 2008) we also paid attention to this problem. In our work (2008) we performed analysis of deep mantle conductivity distribution beneath the Fennoscandian Shield obtained by interpretation of "longitudinal" and maximal impedance phase curves of experiment BEAR MT data. In order to obtain more stabile results we used the combine interpretation of MTS curves together with the global MVS curve. It was shown that for the depths lower then 100 km conductivity distributions for different sites practically coincide which allowed to build the common mean curve of conductivity distribution for Fennoscandian Shield. The gradient of obtained conductivity is minimal at the depths 250–350 km which may indicate the transition of the mantle substance into plastic condition typical to the asthenosphere. In order to confirm this assumption we undertake the new approach to data interpretation. We decided to decline using the global MV data within the Sq variation range and to use instead of them only BEAR data. For this purpose there were taken the average values of amplitude and phase of those BEAR curves which are in good accordance with the global MVS curve. With this substitution the further combined interpretation of "longitudinal" and phase

BEAR curves allowed to build depths resistivity distribution within the interval 100–1000 km for 34 BEAR sites. For 24 sites there can be distinctly seen the layer with the resistivity 25–30 Ohm.m at the depth 200–350 km. This result confirms our assumption on the presence of the asthenosphere beneath the most part of the Fennoscandian Shield territory.

Using MT method for defining the geometry of mobile-permeable zones of the crust within the Eastern part of the Baltic Shield

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

By the example of two-dimensional modeling of the fracture zone there is shown the possibility of studying the conductive fracture geometry using quasi-twodimensional interpretation. This approach has been applied to the analysis of experimental magnetotelluric sounding data obtained in the Eastern part of the Baltic Shield in order to define the geometry of the fracture zones connected with the deep faults. There was built the model of the deep section along the profile crossing the region with high conductivity of the crust within the joint zone between the Karelian and Belomorsky plates which gives the approximate location of the region with the decreased resistivity in crust at the depth 20–40 km. The level of the upper boundary of the conductive region approximately corresponds to the level of the upper boundary of the mobile-permeable zone formed by the volcanogenic and tufa-like rocks during the early-proterozoic period of subduction of the the Karelian and Belomorsky plates defined by seismic data. The performed express-analysis of magnetotelluric data shows the promising of such investigations with a view to solve the problems of geotektonic and geological prospecting in insufficiently explored regions.

Cluster directional analysis of the magnetic field structure and impedance estimation

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

The basic physical and mathematical model used in the mathematical analysis of time series of electromagnetic field magnitotelluric sounding, the model of the flat wave vertically falling on half-space is. Sometimes the task is considered in more common production for a under a corner falling wave (A.A. Kovtun). Essential circumstance at calculation impedance tenzor is the hypothesis that variations of magnetic and electric fields are stochastic functions.

We developed a method cluster analysis of directional structures of vector geophysical fields in tasks of monitoring. The method was applied to processing three-component measurements of a magnetic field at two stations located on peninsula Boso. General duration of time supervision made 10 months. Essential distinctions direction portraits in the quiet and indignant day of supervision were found out. The indignant days are characterized by significant asymmetry of clusters of directions.

Existence of priority directions of excitation of a geoelectric cut should result in change systems of secondary currents. Impedance ratings executed on full set of realizations at asymmetrical excitation not an one-dimension blocks structure of the Earth will be deformed.

The practical decision may be or artificial symmetry of a file of realizations - withdrawal of the most powerful clusters, or research of system of decisions on set of priority directions, that is realization cluster ratings of an impedance.

The inversion of the controled source magnetotelluric (CSMT) and natural (AMT–MT) data

Shevtsov, A.N. (Geological Institute KSC RAS, Apatity, Russia)

In 2007, 2009 carried out CSMT measurements in area of the North and Central Karelia and of the North-West part of the Kola Peninsula. The controlled sources data were obtained by two crossly orthogonal power industry lines with length about 110 km allocated in East and Central part of the Kola Peninsula. Data were obtained at

the distances up to 700 km in frequency range from 0.1 to 200 Hz. In points of the CSMT were fulfilled both AMT-MT measurements and direct current (DC) measurements with potentials and dipole-dipole arrays at distances up to 10 km.

The inversion of this data include a number problems - most often the reason of different interpretations between data from natural and controlled sources are sharp distinctions on a level of apparent resistance (up to one–two orders) between maximum and minimal curves AMT-MTS and absence of a uniform procedure of the registration of the discrepancies caused by different polarization of a primary field of a source. Secondly, data of the frequencies dependences of the components of the EM field — (3-magnetics H_x (South-North), H_y (East-West), H_z(top-bottom), and 2-electrics - E_x (South-North), E_y (East-West)) at the distances more them 100 km includes information about parameters (conductivity and height up to bottom boundary) of the ionosphere, that must be taken into account. The phases shift between components EM field and estimations for the impedance tensor components must be taken into account also at interpretation of the measured data. Moreover DC data for upper part of the geoelectrical cross-section must be compounded with CSMT and AMT-MT data.

For points of the 2007, 2009 experiments data inversion was carried out for the CSMT, AMT-MT and DC measurements. Obtained model includes “normal” cross-sections for 3 different regions (of the North and Central Karelia and of the North-West part of the Kola Peninsula). The research is done under support from Russian Fund of Basic Research grants No 07-08-00181-a and No 10-05-98809-_a and of the Project Department of the Earths Sciences of RAS - 6 “Geodynamics and gears of deforming of rock sphere”.

Using the transversal component of the MT apparent resistivity for geodynamic monitoring

Sholpo, M.E. (SPbF IZMIRAN, Russian Academy of Sciences, St.Petersburg, Russia)

Sensitivity of the transversal component of the apparent resistivity to changes in resistivity of ith element of the 2D geoelectric structure — function $\varepsilon_{i\,xy}(x, \sqrt{T}) = d \log \rho_{xy}$ (i is the element number) — is studied using 2D geoelectric model of the Petropavlovsk geodynamic

research area (Kamchatka). It is shown that the earlier proposed formula connecting the relative changes in the MT apparent resistivity with the relative changes in the resistivity of 1D structure elements can be with good accuracy apply for the transversal component of ρ_a. It allows to solve the inversion problem using the method which has already been tested for the longitudinal component of ρ_a.

There were revealed some interesting features of behaviour of function $\varepsilon_{i\,xy}(x, \sqrt{T})$.

1. The plots of function $\varepsilon_{i\,xy}(x, \sqrt{T})$ vary in form depending on observation sites; with increase of period they approach the constant levels which values depend on the site location.

2. In the observation sites located outside the limits of some sedimentary element of structure, sensitivity of transversal apparent resistivity to the change in the resistivity of this element is negative.

3. On the boundaries of the structure elements with different electric resistivities there is observed a sharp overfall of function $\varepsilon_{i\,xy}(x)$ values- transition from a small positive extremum from the inside of i-th element to the negative one from the outside.

With the regard for these peculiarities the monitoring of the transversal apparent resistivity can be a useful addition to the monitoring of the longitudinal component ρ_a for studying the dynamics of the resistivities of sedimentary and upper crust elements of the geoelectric structure, as well as for defining the source of variations in the apparent resistivity.

Mobile and controlled source modifications of the radiomagnetotelluric method, prospects of application in near-surface geophysics

Simakov, A., Saraev, A., Antonov, N., Shlykov, A. (St. Petersburg State University, St. Petersburg, Russia)

Development of new instruments and technologies of the near-surface geophysics is a very important problem. Data of shallow investigations are used for the solution of engineering, hydro geological and environmental problems as well as for the geological mapping and mineral exploration. The radiomagnetotelluric (RMT) method is a very promising facility for the solution of wide range of near-surface

geophysical tasks. Last years the RMT method has been rapidly developed and extensively used in several actual areas. In the method are measured electromagnetic fields of the remote radio transmitters in the frequency band 10–1000 kHz. In the far-field zone of a radio transmitter its electromagnetic field can be considered as a plane wave. Using data of measurements the surface impedance Z can be estimated. The impedance is usually converted to apparent resistivity ρ_a and phase φ_z at each measurement site. This transformation allows the measurements to be related more easily to the subsurface geology. The depth of investigations is from first meters to first dozens of meters.

Realization of fast RMT surveys of vast territories using mobile RMT system is very important for environmental control and contamination threats early warning. The developed mobile RMT-M system measures the horizontal electric field component by ungrounded electric antenna and two horizontal magnetic field components by induction coils allows us to fulfill fast surveys of vast areas. It allows us to make measurements along 2040 km of profiles per day and they are cheaper than standard methods like SEV and TEM. 5–7 km/h speed of a car provides the separation between sounding stations about 30–40 m. 2D inversion results of mobile survey data have good correlation with ones obtained during foot measurements.

A controlled source modification of RMT equipment consists of four-channel recorder with electric and magnetic antennae and portable electromagnetic field source (CS generator). This modification operates in 1–1000 kHz frequency band making wider the investigation depth compare to standard RMT method. The CSgenerator connects to the 200–700 m length grounded cable. Due to generator's rectangular pulse we obtain up to 10–12 odd harmonics of main frequency, thus using 3–4 main frequencies from the frequency range 1–100 kHz one can fill all frequency band from 1 to 1000 kHz. CSRMT method allows us to investigate an area from 500 m to first kilometers from the source (satisfying the far-field zone conditions). Application of such technique does not require the emitting of a big number of frequencies and measurements at one station will take little time. The CSRMT equipment allows us to work in remote areas where there are not enough radio transmitters.

MT array data processing in the EMMA project

Smirnov, M.Yu. (St.Petersburg State University, St.Petersburg, Russia), Korja, T., Egbert, G. (University of Oulu, Finland)

In magnetotelluric (MT) method reliable estimation of transfer functions is an important step towards the final interpretation model. Several important aspects of magnetotelluric data processing are considered. Application of robust estimator proved to be very efficient in improving the accuracy of MT transfer functions estimation. Multivariate analysis (Egbert, 1987) opens nature of magnetotelluric array observations and provides some hints on source field structure as well as noise behavior.

Two electromagnetic array were measured in EMMA project to study conductivity structure of the Archaean lithosphere in Fennoscandian Shield. The first array was operated during almost one year, while the second one was running only during the summer time. Twelve 5-components magnetotelluric instruments with fluxgate magnetometers record simultaneously time variations of Earth's natural electromagnetic field at the sites separated by c. 30 km. The quality and duration of the first EMMA array provides an excellent possibility to test different approaches to data analysis. The results of EMMA array data processing are presented.

Section M. Solar-Terrestrial Physics

Peculiarities of fractal characteristics of the ULF emissions along the profile of the 210 MM stations

Abramova, T.V., Smirnova, N.A. (St. Petersburg State University, St. Petersburg, Russia)

Coordinated magnetic records (1Hz sampling rate) of 5 stations situated along the 210 magnetic meridian (210 MM) are considered. This chain of stations is lasted from low latitudes to the auroral zone, and it includes Guam ($\Phi_m = 4.6°$N), Moshiri ($\Phi_m = 37.6°$N), Paratunka ($\Phi_m = 46.3°$N), Magadan ($\Phi_m = 53.6°$N) and Chokurdakh ($\Phi_m = 64.7°$N). One year period (1993) that embodies the date of the strong Guam earthquake of 8 August 1993 is analyzed. Fractal analysis of the ULF emissions (variations of the components H, D, Z in the ultra-low-frequency range of 0.002 – 0.5 Hz) has been fulfilled. The Higuchi method has been used to get the stable values of fractal characteristics – spectral indexes β and fractal dimensions D. Comparison of the ULF emission scaling parameters obtained at different latitudes has been drawn. Dependence of β and D versus Kp index has been analyzed for different sectors of local time. Seasonal variations of β and D as well as seasonal dependence of their correlation with Kp index are examined. The results obtained are discussed from the nonlinear dynamics point of view on the basis of the SOC (Self-Organized Criticality) concept.

Influence of the IMF B_x component on the position and geometry of the tail neutral sheet. Global MHD modeling results

Amosova, M.V., Sergeev, V.A., Gordeev, E.I. (St.Petersburg State University, St.Petersburg, Russia)

We use the global MHD magnetospheric modeling to investigate how the interplanetary magnetic field (IMF) B_x-component influence on the geometry and location of the neutral sheet (NS). We show results from two simulations (using BATSRUS code) with different

B_x-component ($B_x = -6$ nT, $B_x = 6$ nT) in which all other solar wind parameters were fixed, but only IMF B_z varied. We show large Z-displacements of the tail neutral sheet caused by IMF B_x, whose direction depends on B_x sign. The magnitude of NS shift also depends on radial distance and increase in tailward direction. The most interesting and unexpected result is that amount of NS shift strongly depends on IMF B_z, increasing a few times during time intervals of southward B_z. Also we have detected the time delay in response of cross-tail neutral sheet geometry to changes of IMF B_z. It turns out that the center of neutral sheet (at $Y \sim 0$) responds faster that the flanks to these changes, with propagation velocity of $\sim$ 250 km/sec. To understand a physical origin of the NS vertical motion we compared the values of the total pressure between the northern and southern tail lobes $P_{tot} = P_m + P_p$, where P_m — magnetic and P_p — plasma pressure. This pressure balance changes after the IMF B_z turning. The present results have important implications for the data-based modeling, prediction of neutral sheet position in analysis of spacecraft observations as well as for the basic magnetospheric physics.

Topological features of high latitude magnetospheric processes and the possibility of the formation of local particle traps

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Results of the observations CORONAS satellites demonstrate the existence of quasistable (during 4.5–6 h) increases of energetic electron fluxes to the poles from the external electron radiation belt. One of the possible interpretations of such observations is the appearance of comparatively long-lived particle traps at large geocentric distances. Such traps can appear due to formation of not surrounding the Earth isolines B_{min} =const, where B_{min} is the minimal value of the magnetic field at the magnetic field line. The configuration B_{min} =const

in the high latitude magnetosphere is analyzed using Tsyganenko-96, -01 and -04 models for the selected number of events. It is shown, that discussed feature of B_{min} =const distribution appears in these models. The existence of real not surrounding the Earth B_{min} =const contours can be also connected with the development of local current system which were not included in the existed models of magnetospheric current systems. The high latitude continuation of the ordinary ring current from ∼7 Re till magnetopause at daytime and till ∼10–13 Re at nighttime is selected as one of the major of such current systems.

Cosmic ray variation influence on the duration of elementary synoptic periods

Artamonova, I.V. (St.Petersburg State University, St.Petersburg, Russia); Veretenenko, S.V. (Ioffe Physico-Technical Institute RAS, St.Petersburg, Russia)

Investigation of the duration of elementary synoptic periods (ESP) according to the classification by Vangengeim and Girs was carried out depending on solar (SCR) and galactic (GCR) cosmic ray variations. An increase in the ESP duration for the zonal (W) and meridional (C) circulation forms and a reduction in the ESP duration for the eastern circulation form (E) were revealed on the days following the onsets of solar proton events with energy of particles Ep 90 MeV. During Forbush decreases of GCR an increase in the ESP duration for the meridional form C and a reduction in the ESP duration for the circulation forms W and E were detected. It was assumed that the detected changes in the ESP duration are caused by the influence of the variations of cosmic rays under study on the processes of regeneration of North Atlantic cyclones and anticyclones resulting to the formation of stationary blocking baric systems over the North Atlantic and Europe.

Kinetic structure and stability of the thin current sheet

Artemyev, A.V., Zelenyi, L.M., Petrukovich, A.A. (Space Research Institute, RAS, Moscow); Malova, H.V. (Skobeltsyn Institute of Nuclear Physics, MSU, Moscow), Popov, V.Yu. (Physics Faculty of MSU, Moscow)

Thin current sheets (TCS) with a typical scale of about 1000 km are a remarkable feature of the Earth's magnetotail. TCSs are often detected owing to the large-scale motions (flapping) of the sheet or of the entire magnetotail. In this report we study the ion kinetic structure of current sheet using the Cluster observations. We carry out a comparison between the observed velocity distribution of current carrying protons and the theoretic predictions based on the concept of transient trajectories. The influence of kinetic structure of thin current sheets on their dynamics is discussed.

The ionospheric possible mechanism of warming and its influence today

Avakyan, S.V., Voronin, N.A. (All-Russian Scientific Center "S.I. Vavilov State Optical Institute", St. Petersburg)

Numerous researches into correlation of weather and climate characteristics with solar and geomagnetic activity confirm that such correlation does exist.

By now mainly the research on galactic cosmic rays (GSR) and solar cosmic rays (SCR) influences on atmosphere transparency characteristics and further on climate-weather characteristics have been carried out. These fluxes increase causes the growth of low (usually optically thick) cloudness (GSR), cause the reduction of stratosphere-troposphere transparency (SCR) and therefore produces in generally cooling effect on the mean surface air temperature.

However these events are rare. At the same time such strong and frequent manifestations of solar activity as flares and magnetic storms are not so far taken into account since it is not known what physical mechanisms could be responsible for energy transfer from solar flares and magnetic storms to the lower atmosphere.

The paper describes a novel radio-optical mechanism responsible for the solar-terrestrial links which is based on taking into account the

excitation of Rydberg states of atoms and molecules in generation of the ionospheric microwave radiation and in realization of the dissociative recombination of cluster ions in troposphere. The mechanism enables agents of solar and geomagnetic activities affect atmospheric processes. This first agent under consideration is variation of fluxes of solar EUV/X -ray radiation during flares. The second agent is fluxes of electrons and protons which precipitate from radiation belts as a result of geomagnetic storms and under the anthropogenic influences. The latter (the work of powerful navigation radio stations), determines the locality of precipitations (which correlate with magnetic storms) and accordingly the local action of the microwave radiation of the ionosphere on the weather characteristics. The mechanism explains why the reduction of solar-geomagnetic activities might result in slowing down of global warming today.

Optical observations of the eveningside undulations during the 23rd solar activity cycle

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The statistical analysis of observations of large-scale waves of diffuse luminosity (undulations) during the 23rd cycle of solar activity is carried out. We used the optical data obtained by the all-sky TV camera at Tixie (71.6 N, 128.9 E) and Zhigansk (66.8 N, 123.4 E). In total 54 events (43 events at Tixie and 11 events at Zhigansk) were registered. The tendency is found out that the occurrence frequency of undulations in the evening sector (17-23 LT) is registered more often during the descending phase of solar activity. It is shown that undulations can be generated both on the equatorward boundary of diffuse auroral zone and inside the diffuse zone, and not only during the development of magnetic storms.

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Complex observations of ionospheric disturbances in the North-Eastern region of ASIA

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Variations of ionospheric parameters during two successive magnetic storms on 6–9 December 2006 and 14-17 December 2006, and HILDCAA event (19-23 December 2006) are presented. We used the data of vertical sounding stations located at different latitudes along 190 deg magnetic meridian, oblique-incidence sounding on the radio paths Magadan–Irkutsk and Norilsk–Irkutsk, riometers and magnetometers and OmniWeb database. During the main phase of the first magnetic storm at night hours an increase of the F2 layer critical frequency and an occurrence of the sporadic E layer (Esr) were observed at Zhigansk (corrected geomagnetic coordinates: 61.5 deg, 194.7 deg) and Yakutsk (CGM coord.: 56.4 deg, 201.3 deg). During the main phase of the second magnetic storm, the reflections from the F2 layer at Zhigansk and Yakutsk were absent due to the total absorption and blanketing Es. It should be noted that the critical frequency of Esr reflections at Zhigansk in the evening-midnight hours smoothly decreased from 6 MHz to 2 MHz on 6-9 December 2006 (the first magnetic storm) while during a strong second magnetic storm these reflections with foEs$\sim$6 MHz were registered predominantly on 14 and 15 December 2006. In the night hours on 14 December 2006 the anomalous echoes of F2 layer (F2s) with frequencies up to 5 MHz were registered at Yakutsk. It testifies an intensification of auroral fluxes near Yakutsk. Large bays in the cosmic noise absorption (more than 4 dB) at Kystatyam (CGM coord.: 61.9 deg, 194.4 deg) and magnetic variations at Zyryanka (CGM coord.: 60.0 deg, 217.7 deg) were observed on 6-8 December and 14-15 December 2006. During the HILDCAA event the critical frequency of F2 layer remained constant ($\sim$5 MHz) except the day hours on 23 December 2006 when the foF2 decreased up to $\sim$4 MHz. The Esr with foEs 3 MHz at Zhigansk were also registered. The enhancements of the auroral activity (AL index) were accompanied by

bursts in the level of cosmic noise absorption and magnetic field variations.

This work was supported by the SB RAS integration project No.15, Russian Foundation for Basic Research (project no. 09-05-98546-r_vostok_a) and partially by the Presidium of the Russian Academy of Sciences (Program 16, part 3).

Influence of the negative solar wind pressure pulse on the morning auroras and cosmic noise absorption

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It is well established that sudden magnetosphere compression is accompanied with particle precipitation that leads to aurora intensification and enhancement of cosmic noise absorption (CNA) in the dayside ionosphere. The influence of sudden magnetosphere expansion on particle precipitation is rather weak investigated problem. In the present study we used Scandinavian array of riometers and PGI optical instruments in Spitsbergen to monitor the precipitation following the sharp decrease in solar wind dynamic pressure within the wide latitude range in the morning sector. We used the data of Geotail satellite probing the interplanetary medium in the morning sector that reduce the uncertainty in the event timing. Location of the instruments in the morning sector (i.e. away from the noon meridian) allowed us to distinguish two stages in the event development. At the first stage, the negative SI at Geotail was accompanied with short-time decrease of CNA in auroral zone. During this CNA variation the pre-existing rayed arc observed near zenith of TV-camera in Barentsburg fell down. Ten minutes later (second stage) two new arcs appeared on the south-east horizon of TV-camera just poleward the existing auroras and looked as arising from the dayside. No noticeable change in CNA was detected. We associate the auroral and CNA features at the first stage with the front of fast propagating MHD disturbance lunched by negative SI. The auroral activity at the second stage may be related with rather slow process – large-scale reconfiguration (expansion) of the dayside magnetosphere.

Ultrarelativistic electron precipitations as a main cause of the most powerful disturbances in the middle polar atmosphere

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To-day we know the following sporadic geophysical disturbances, changing significantly the electric properties of the Earth atmosphere: the X ray flares on Sun, the solar proton precipitations (SPP), the auroral electron precipitations, the energetic relativistic electron precipitations and the ultrarelativistic electron precipitations (O(100 MeV)). The last type of precipitation is important due to the fact that their electron energy is sufficient for the X ray and gamma ray generations with intensities, which creates a sporadic D layer of ionization at the altitudes 10 – 40 km. The electric conductivity of a sporadic layer is of the same magnitude as the conductivity of the regular D layer of the ionosphere. Due to this an effective altitude for the reflection of very low frequencies f (VLF, f = 10 – 16 kHz) is falling from 58 – 63 at day time and 70 – 75 km at night time to 50, 40 and even 30 km.

All knowledge about the precipitations of UREP phenomena were gotten due to the indirect measurements, i. e. due to the on ground synchronous measurements of the abnormal amplitude and phase variations of VLF signals at a short auroral radio pass and at a long pass in their mutual receiving point in Apatity, Kola peninsula. The second radio pass was on 2/3 of its length – middle latitude pass (GBR station, f = 16 kHz). The self adjusted method of an inverse VLF problem solving permitted to find the absolute values of the ionized layer parameters at all moments of disturbance time, including an initial moment.

An electron with energy near 100 MeV, penetrates into the atmosphere at the depth, for which the atmosphere pressure is near 50 g/cm^2. At the same time such electrons transform 50% of their energy in the X and gamma rays. So a sporadic D layer of ionization appears, which is capable to reflect the VLF waves. This point is a crucial item in a qualitative difference of the UREP from the SPP and the auroral electron precipitations.

Having synchronous data for two radio passes, it is possible to solve a new inverse problem in which an object of finding is the equatorial latitude boundary of a precipitation. From a fact that in some cases

the phase variations for both radio passes were near it ensues that the boundary was near 62° latitude. From the experimental fact that the maximum phase variation for the long radio pass never was more than the maximum phase variation between three work frequencies for the short radio pass it follows that an equatorial boundary of precipitation never lowed below the 62° latitude vicinity while 6 years of continuous registration.

The last 4 months data (January – April 1988), after which the GBR station signal registration was stopped, are represented. For the pointed period there were 3 powerful disturbances and 3 strong disturbances. Between these disturbances only 2 (on 27 March and 1 April) began and achieved their maximums at daytime for both radio passes. At the disturbance maximum the amplitude of the one mode, long pass signal diminished in 5 and 3 times correspondingly and its phase diminished at 1/6 part of the signal period. This decreasing was less then the maximum diminishing of signals for the short radio pass. Consequently the long pass in the discussing cases was disturbed partly. So, this item with the same results of the previous 6 years prove that the effect of magnetic field cut off in the class of VLF anomalous disturbances exists.

Returning to the effect of amplitude diminishing in 10 and more times for the short radio pass and powerful disturbances, we state that such drastic diminishing of the signal was possible only due to the interference compensation of the Watson – Fock diffraction wave, which does not anyhow depend on the ionized atmosphere layer, by first ray having singular reflection from the layer. This compensation is a result of interference phenomenon of zero order.

Joint study of the equatorward-moving auroral traces and energetic particle injections at the geostationary orbit

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Transient equatorward-moving auroral traces were studied together with sharp energetic particles increase observed by LANL spacecrafts in nearby MLT sectors. We analyze TV observations of 17 auroral substorm events (each of them showing a number of equatorward traces). Time dependent geographic location was defined for each

trace. Based on this data all distinct auroral traces as well as the auroral bulge equatorward boundary were mapped to the magnetosphere using T96 model. Comparison of these projections with energetic particle observations by LANL spacecrafts showed clear enhancement in the electron (proton) fluxes dawnward (duskward) of the mapping region. Simultaneous dispersionless electron and proton enhancement was observed close to the mapping region. We also calculated drift trajectories for the particles of different energies and defined assumed azimuthal boundaries of dispersionless injection. The auroral trace mapping region was found within the boundaries for all cases. We conclude that transient equatorward-moving auroral traces represent the ionospheric manifestation of the accelerated plasma injection at geostationary orbit.

Effects of the protonosphere fluxes of the hot oxygen and heat on the global thermosphere-ionosphere parameters

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The existence of a hot oxygen (Oh) in the upper thermosphere is mainly provided by optical observations of the high-altitude airglow. In these experiments a peak of hot O population was found at an altitude approximately 550 km with a temperature of about 4000 K. Although it was shown that hot O concentration reached a value of 1–2% with respect to ambient (cold) O, realistic concentration profile and temperature global distribution of a hot O have not been established. The presence of non-thermal atoms in the thermosphere leads to variations of the thermodynamical regime in the upper atmosphere. Major chemical processes of the hot O production were taken into account in the time-dependent, Global Self-consistent Model of Thermosphere, Ionosphere and Protonosphere of the Earth (GCM TIP) in order to simulate global distribution of hot O concentration and temperature (Th). Calculations were executed for moderate solar, quiet geomagnetic conditions and winter season. It was shown that the maximum (Oh) is located at -60° latitude, 300° longitude and located at 24 UT. The Th maximum is about 2050 K. Such temperature and concentration Oh cause increase in neutral gas temperature at high thermosphere by ∼100 K at a daytime and by ∼70 K at night time. Variations of the neutral gas velocity circulation were

calculated. Maximum increase in neutral velocity is about 36 m/s and corresponds to 50°N, 180° long. in the northern and 50°S, 270° long. in the southern hemisphere and in the geomagnetic coordinate system. Calculation results have shown that reactions with vibrationally exited N2 are very important for the hot O production. Plasma population and energy in the protonosphere may be sufficient support for the altitude profiles of hot O and its temperature. It is possible because thermal electrons from protonosphere are capable exciting O to O(1D), which through energy transfer processes gave rise a hot O concentration. These processes are simulated by the flux of hot O at the upper boundary in the model GSM TIP.

Analysis of ionosondes, OIS and satellite data during a geomagnetic storm

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Magnetospheric storms cause drastic variation of the ionosphere structure. As a result, there are some difficulties in operation of different radio systems. The goal of this study is (1) to compare data on the HF radio path of oblique ionospheric sounding (OIS) Heiss Island – St. Petersburg and ionospheric data from the ionosonde chain with magnetospheric data as well as particle precipitation data of the DMSP satellite during the intense magnetic storm of 14-16 May, 1997, (2) to examine some peculiarities of variations of the OIS frequency range as a tool for diagnosis of the high-latitude ionosphere during the storm period. A similar examination gives a possibility to estimate the degree of ionospheric variation during disturbances for solving some Space Weather problem. The study results are the following. Measurements on the OIS radio path are more valuable than ionosonde data for analysis of the high-latitude ionosphere dynamics during storms and substorms. It was shown that the frequency range MOF – LOF provides information about the ionospheric dynamics. For an intense disturbance with the sharp onset, there is a growth of MOF values both some hours before the time To (the beginning of sharp increase of AE-index) and after the disturbance end for some hours. A growth of MOF before the time To can serve as the forerunner of disturbance. The analysis of the satellite DMSP data has showed that a magnetospheric disturbance caused precipitation dis-

placement equatorward, and some growth of its width and energy. It was found that under moderate conditions (substorms), electron precipitation at high latitudes before the time To caused a growth of the electron density Ne at the F2-layer maximum.

Effect of IMF B_y on indices of geomagnetic activity

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According to satellite and ground observations during the period 1985–2009 the dependence of the zonal geomagnetic indices (AE, Kp and Dst) from the azimuthal component of IMF (B_y) during weak and moderate magnetic storms are studied. It is shown that during the main phase of magnetic storms and the minimum Dst, the value of AE and Kp indices increases with increasing of IMF B_y values. In contrast of Kp and AE indices, the such relationship between Dst index and IMF B_y is not observed.

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Heliospheric current sheet topology based on spacecraft data

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Using a combination of spacecraft data: Ulysses and ACE (year 1995–2007), STEREO and ACE (2007–2009), and a kinematic model we have reconstructed the evolution of the heliospheric current sheet. The data set of the first two sources allowed us to perform a 3D analysis of the topology of the current sheet. The second data set was used to analyze large scale variations of the interplanetary magnetic field and estimate lifetime of the objects in the ecliptic plane. The kinematic model was used to perform a mapping back projection from spacecraft to the source surface. As a source surface data we used ground based observation derived data — Wilcox Solar Observatory synoptic charts. The spacecraft data are: velocity, three components

of magnetic field, proton and electron density. With data analysis and mapping back procedure we improved our empiric-based kinematic model, and performed a large scale reconstruction of the HCS.

Thunderstorms of Kamchatka during 23 cycle of the solar activity

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Thunderstorms, which were taking place through item supervision "Paratunka" on Kamchatka, are considered. Thunderstorms were observed visually and with application VLF direction finder recording thunderstorms on distance up to 4000 km. The azimuth distribution and intensity of thunderstorms discharges received with the help VLF direction finder, were compared to the data of world network of stations by definition of a site of thunder-storms WWLLN. The good conformity of the observable data is shown. The comparative analysis of direction finder data and visual (on the data of Kamchatka Hydrometeocenter) observations of thunderstorms activity is carried out during 23 11-year solar cycle. The analysis has shown the absence of the correlation between quantity of days with a thunderstorm (on the visual observations data) with average quantity of accepted signals from thunderstorm discharges, that is explained by distinction in methods of observations and connected with its observable distances up to thunder-storms. It is received, that on a phase of recession of solar activity, during 2001–2009 the fall of average quantity of the accepted signals from thunderstorm discharges (on the direction finder data) was observed also.

The ionospheric response on the May 2010 geomagnetic disturbances observed using multi-site ionospheric sounding measurements

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At the beginning of the new 24th solar cycle several geomagnetic storms were occurred. One of the most essential storms took place

on May 2–3, 2010 and another one, the first geomagnetic storm with Dst index lower then −90 nT after extended solar minimum, was observed on May 29, 2010. The ionosphere response on these events was analyzed by using the ionospheric sounding data. Three ionosondes formed a triangle in the mid-latitudes of the central European region were selected for the given analysis. There are the "Parus" ionosonde in observatory of the West Department of IZMIRAN, Kaliningrad and two digisondes located in Pruhonice (Czech Republic) and Juliusruh (Germany). The digisonde data were provided by the DIAS network. The ionograms derived from all ionosondes were scaled manually in order to exclude errors related with autoscaling. The peak electron density (foF2) variations and shape of the electron density profiles were analyzed. The main characteristics of the ionosphere modification were revealed.

The effects of the August 1, 2008 partial solar eclipse in the atmosphere and geospace over Kharkiv (Ukraine)

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This report is concerned with the effects due to a partial (magnitude of 0.42) eclipse detected with multi-instrument observations at the air-Earth boundary, in the ionosphere and the geomagnetic field. The techniques employed include optical instruments, the MF radar, the HF Doppler, the ionosonde, and other techniques.

Associated with the eclipse are a decrease of 2 K in the temperature at the air-Earth boundary and a decrease of 1.3" to 1.0" in the r.m.s. value of the angle of arrival of solar optical emissions. These effect onsets lag behind the main phase of the eclipse by approximately 5 and 15 min, respectively.

Over a 2–2.5 hr time interval, the signal in the 25 kHz Arkhangelsk–Kharkiv radio circuit showed increases of about 30% in amplitude and of 2 /mus in phase lag relative to quiet-time reference values measured on other days.

The wave activity in the ionospheric D region during the solar eclipse showed an increase in the 10–20-min period interval. The HF Doppler radar observations revealed decreases of 17% and 31% in the E- and lower F-region electron density, N, respectively, and an increase in wave disturbances in the 5, 10, 20, 50–100-min period intervals. The

ionosonde technique revealed a decrease of 31% in N and a wave disturbance with the ∼75-min period at the F2 peak. The onset of the wave disturbance production shows an approximately 30–35 min lag behind the solar eclipse onset. The solar eclipse effects lasted for not less than 3 hr.

The main physical and chemical processes occurring during the solar eclipse were simulated, and an agreement was found to exist between physical models and observations. The data have been used to determine a few atmospheric and geospace parameters that are difficult to measure. They include the parameters characterizing turbulence, the structure function of the temperature and of the index of refraction at the air-Earth boundary, linear recombination rates, the relative molecular ion contribution to the total recombination, the eddy and ambipolar diffusion coefficients in the ionosphere, and others.

Effects in geospace during the 1 August 2008 solar eclipse over Kharkov

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Solar eclipses (SEs) are one of high-energy sources in geospace. During SEs takes place appreciable reconstruction of environment to night conditions. The SE effects are shown in change of a dynamic and thermal mode of geospace plasma.

Observation results of effects in the geospace plasma during August 1, 2008 partial solar eclipse were presented. The experimental data were obtained using the Kharkov incoherent scatter radar (near Kharkov city).

The SE caused a decrease of F2 layer maximum density by 32%, a decrease of the critical frequency foF2 by 17.5%, and an increase in the maximum F2 layer height by 3 km.

During SE a decrease in the electron and ion temperatures by 70–180 and 0–140 K, respectively, within the height range 190–490 km was obtained. At the height range 290–680 km electron density decreased by about 25%. Near the main SE phase vertical component of the plasma movement velocity decreased by 10–55 m s–1, respectively in the height range 200–530 km. In the height range 500–900 km the

relative density of the hydrogen ions in the moment of the main SE phase decreased by 15–20%.

Theoretical calculation results of dynamic processes parameters in geospace plasma during 1 August 2008 solar eclipse were presented. The SE caused a decrease of neutral atmosphere temperature by 17–40 K in the height range 250–350 km. During SE period an increase of the total plasma flux and flux due to ambipolal diffusion densities in the height range 210–580 km was obtained. The SE caused a decrease of energy in supplied to the electron gas approximately by 12% at the height 210–290 km and a decrease of the heat flux density by 9–16% in the height range 240–340 km.

Comparison analysis results of the SE effects in the geospace of August 11, 1999, May 31, 2003, October 3, 2005, March 29, 2006 and August 1, 2008 were presented.

Ionosphere plasma drift observations during solar eclipses using the Kharkov incoherent scatter radar

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The observation results of ionosphere plasma drift responses to four partial solar eclipses (SE) on August 11, 1999, May 31, 2003, March 29, 2006 and August 1, 2008 at Kharkov are presented. Measurements of vertical plasma drift velocity Vz were performed with the Kharkov incoherent scatter (IS) radar (the carrier frequency – 158 MHz, the sounding radio pulses duration – 0.65 ms (in 1999 – 0.8 ms), the pulse power – 2 MW, the pulse repetition frequency – 24 Hz). Velocity Vz was determined from the measured quadrature components of the IS signal correlation function.

The dynamic effects in the ionosphere over Kharkov during SE were observed in 11 August 1999 first up to 1500 km altitude. The effects of ionospheric plasma caused by SE on August 11, 1999 (maximum of the solar disk square obscuration was about 75%), May 31, 2003 (66%), March 29, 2006 (72%) and August 1, 2008 (33%) are qualitatively similar. The SE leads to a change in behavior of the vertical plasma drift velocity, especially at altitudes above the maximum ionization height. We observed the characteristic (2– 3

hours) ionospheric processes reconstruction during the solar eclipse first to nightly and then to daily conditions. Velocity of the downward plasma movement increased by 10–60 m/s with altitude within the altitude range of 200–550 km, plasma reversed movement from upward to downward direction at altitudes above the maximum ionization height (above 400–600 km), and the altitude profiles of velocity Vz became similar to the nighttime ones near the main SE phase.

Distinctions of SE effects were associated with different geocosmos conditions. The index of solar activity F10.7 on the day of SE in 1999, 2003, 2006, 2008 was equal to 131, 113, 82, 66, respectively. Eclipses in 1999, 2006, 2008 occurred in the daytime under quiet conditions (index Ap = 8, 6, 3, respectively) while SE in 2003 occurred after sunrise during the recovery phase of geomagnetic storm (Ap= 17).

Long-term changes of rate of formation of a cosmogenic isotope ^{10}Be for last 10 thousand years and a variation of virtual dipole moment of the Earth

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The spectral analysis of data of project GRIP on rate of formation of cosmogenic isotopes ^{10}Be for last 10 thousand years is carried out. As a result of the fulfilled research it is shown, that ^{10}Be rate of formation is cyclic. The most significant cycle has the period of 2300 years which also is observed in radiocarbon data. Changes of the virtual dipole moment for 7–8 thousand years has been analysed. On a periodogram of data for location of geomagnetic dipole moment the significant components are revealed that point to cyclic change of a longitude of geomagnetic pole. The basis cycle has the period about 2300. Apparently, occurrence of the 2300-year-old cycle in rate of formation of cosmogenic isotopes ^{10}Be and ^{10}C is connected with cyclic change of position of a geomagnetic pole. Except the 2300-year-old cycle, on a periodogram of ^{10}Be data a number of lines are presented which can be considered as display of a 1000-year-old cycle in ^{10}Be rate formation. Occurrence of these lines, apparently, is not connected with change of size or position of geomagnetic dipole moment. So on a periodogram of data on VADM for 12 thousand

years there are no significant lines which periods are less then 2300 years. On the other hand, variations of ^{10}Be rate formation which periods less than 1000 are compatible to the mechanism of influence of solar activity on a flux of cosmic rays. Considered variations arise, apparently, because of decreasing of solar activity during epoch of deep minima of Maunder type.

Variations of aurora emissions during substorms at Spitsbergen archipelago

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The variations of the intensities of the green 5577 Å auroral emission and the red 6300 Å one will be examined. The dynamics of these emission intensities during substorms, observed over the Spitsbergen archipelago will be studied. Data from simultaneous measurements of the photometer and the all-sky camera from the 2007/2008 and 2009/2010 winter seasons installed at the Barentsburg Observatory, plasma and solar wind magnetic field data from the WIND satellite and data from the ground-based magnetic stations from the IMAGE network have been used. It was shown that the precipitation of most energetic electrons occurs at the polar edge of the auroral bulge, and inside the bulge precipitation of less energetic electrons is observed.

Scaling of the electron diffusion region of antiparallel magnetic reconnection

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Magnetic reconnection is usually considered to be the one of the most efficient energy conversion process in various space plasma environments. Recently, full-scale kinetic simulations became popular with wide availability of high-performance computational resources. This allows for detailed resolution of X-point structure, distribution

functions and small-scale kinetic process. Two-dimensional approach is used with the mass of electrons varying $m_i/m_e = 64,\ 256,\ 512$. Plasma non-gyrotropy as the source of collisionless dissipation is investigated. Particles follow two distinctively different trajectories in the field-reversals with uniform perpendicular electric field: Larmor gyration superposed with slow convection into the current sheet (magnetised particles) and meandering oscillation during direct acceleration by reconnection electric field (unmagnetised particles). Appearance of these two distinct plasma populations near the X-point (slow convecting particles and fast accelerating particles) creates the skewness of the distribution function which is responsible for the non-gyrotropy and collisionless dissipation in magnetic reconnection. Based on this approach, Sweet-Parker scalings of electron diffusion region (EDR) were developed. Such typical parameters of reconnection, as EDR width and acceleration of electrons up to electron Alfven velocities are resolved. Reasonable agreement of this scaling with the results of PIC simulations for different initial electron temperatures and mass ratios is found.

Guide-field magnetic reconnection: generation of electron holes

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The process of magnetic reconnection is investigated in detail in our work. We apply two-dimensional particle-in-cell approach to study the signatures of the process with guide-field added (component reconnection). Recently developed implicit PIC code Parsek2D is utilised, which is capable of realistic m_i/m_e electron to ion mass ratios. Of particular interest are the following features: the structure of electron density cavities along the separatrices, intense electron flows as well as polarisation electric field structure within these cavities and generation of electron holes because of Buneman-unstable electron jet. Reconnection signatures reported could be used as a proxy for reliable detection of separatrix or diffusion region crossings. Spatial extent and velocity of the electron phase space holes are studied in particular as they are easily detectable by *in-situ* satellite observations. Electron holes are found to scale as electron inertial length

and are abundant within the electron flow channel near the separatrix at large distances (10s of ion inertial length) to the X-line, thus suggesting an additional indication of reconnection exhaust region proximity.

Three-dimensional visualisation of numerical simulation of space plasma

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Numerical simulations of plasma emerged in past decades as a powerful tool to study the dynamics of plasma. With more and more computational resources being available, better accuracy of modelling is achieved in terms of both extensive parameters (e.g. domain volume) and physics invoked (e.g. the inclusion of small-scale kinetic effects into the model of plasma). Typical simulations in the approach of three-dimensional MHD or those using high-mass-ratio PIC codes require massively parallel (multiprocessor) computer clusters with up to thousand(s) of cores utilised simultaneously. Greater detailing and accuracy is traded for dramatically increased volume of data to post-process and analysed. Post-processing is getting a major issue, with data mining and visualisations being a separate problem to study. Proper scientific visualisation should follow the criteria: it must represent the outcome clearly, it should be readable for non-expert in the field at best and it must utilise recent developments in the field of imagery and data processing. We propose the advanced technique of volume rendering by using the so-called anaglyph images in application to the study of magnetic reconnection and magnetosphere dynamics. Independent pictures are created with red and blue colormaps and then superposed to render the depth of the image. Common projector could used to show the pictures and animations. The technique reveals the dynamics of three-dimensional structures in detail and could further be applied to other problems.

Magnetic field in the period of extreme geomagnetic storm 2 September 1859 modeling

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A reconstruction/interpretation of the Colaba (India) magnetometer record for the great magnetic storm on September 2, 1859, is presented. Simulations were undertaken on the base of the IZMEM model of high-latitudes current systems and the model, which is valid for big storms quantifies the contribution of current on the magnetopause, ring current, and magnetotail current to Dst variation. Results of our modeling testified that the magnetic disturbance recorded at the Colaba Observatory, which is characterized by a very rapid and big decrease in the horizontal intensity of the geomagnetic field during the main phase, followed by a sharp recovery, is related to temporal dynamics of the tail current system in this period and high-latitudes current systems that was displaced to equator on considerable distance as a result of strong magnetopause compression. It includes the rapid Earthward-directed propagation of the front edge of the plasma sheet in the main phase of the storm to a distance of 2–3 Re from the Earth's center and the subsequent rapid return back to a distance of ∼7–8 Re in the magnetospheric tail. And it includes the rapid equator-ward displaced (to ∼40°) auroral electrojets and field-aligned current.

Using of the high altitude magnetic observatories data to the definition of the geomagnetic pole coordinates

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The geomagnetic pole coordinates are calculated using the magnetic surveys data processed with the Gauss method. Gauss was the first mathematician to use the data of 12 mid-latitude observatories to define location of the Earth's magnetic dipole. Following his calculations on the base of the data gained by a few observatories, we take

into account the data of high latitude observatories, received in 2007–2008, a period of a solar activity at very low levels. Furthermore, we choose the time intervals when at the point of the ACE satellite location the solar wind and the interplanetary magnetic field have minimum impact on the magnetosphere. Our aim is to emphasize that the geomagnetic pole coordinates and the relative geomagnetic coordinate systems are not true because represent the result of a specific mathematic processing of concrete geomagnetic data set.

Spherical hybrid model development at FMI: First results

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The Hybrid approach provides an efficient way to model how the cosmic plasma interacts with non-magnetized and magnetized planetary objects. In a hybrid model ions are modeled as particles while the electrons form a massless, charge neutralizing fluid.

The HYB hybrid model family has been developed at the Finnish Meteorological Institute (FMI) over ten years. So far the model has been used successfully to describe how the flowing plasma interacts with various solar system bodies: Mercury, Venus, the Moon, Mars, Saturnian moon Titan and asteroids.

One limitation factor of the HYB model is, however, that it assumes cube shaped grid cells. In order to expand the usage of the HYB model we have initialized a project which goal is to develop a spherical coordinate version of the model. A spherical grid would give us certain obvious advantages compared with a cartesian grid, such as: 1) A good grid resolution, because the grid size decreases automatically near the obstacle (the planetary surface) and 2) Natural boundary conditions for the obstacle, because the planetary surface overlaps r-constant surface of the grid.

In this presentation we introduce lessons from the grid development project and illustrate the usage of the new model by showing preliminary test runs. Finally, we emphasize important plasma physics problems which may be modeled more effectively by the developed hybrid model with a spherical grid.

Dynamical processes in the ionospheric F-region

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Incoherent scatter (IS) method allows to determine plasma transport velocity in the ionospheric F-region and then to calculate a diffusion component as well as components caused by thermospheric winds and electric field influence. The Vz value is obtained by processing of measured complex correlation functions of IS signal. The accuracy of transport velocity determination is within 2–20 m/s (at 15-minute samples and signal-to-noise ratio ≤ 0.2). Analysis of the component caused by electromagnetic plasma drift shows that initial source of the plasma motion is dragging of plasma at dynamo-region by neutral winds similar as it occurs at F-region. Such wind influence is almost contrary to neutral wind effect in the F-region. In full height interval horizontal neutral wind has the same direction, but in F-region its value is greater then one in dynamo-region. Observation data of altitude-temporal variations (autumn equinox 2007) of vertical transport velocity demonstrate upward total velocity in daytime topside ionosphere. Then plasma supplied during daytime in protonosphere become nighttime source of ionization. These ideas corroborated by observed downward plasma transport at nighttime. If one will subtract the diffusion velocity component, it will be seen that neutral wind meridional component change its direction from polarward at daytime to equatorward at nighttime. Such results of ionospheric plasma transport velocity promote to mid-latitude thermosphere circulation model development.

CHAMP satellite measured and UAM modeled high-latitude thermospheric winds

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We have calculated numerically the global patterns of the thermospheric winds using UAM (Upper Atmosphere Model) and compared them with the CHAMP satellite accelerometer measured high-latitude thermospheric winds at the height 400 km for October 28, 2003. The instantaneous model patterns of neutral wind at high latitudes for this particular day are similar to the statistical CHAMP wind pattern (the CHAMP data averaged for the whole 2003 year). The high-latitude coupling between thermospheric circulation and solar wind driven magnetospheric plasma convection vortexes is clearly seen in both satellite observed data and theoretically modeled results. The UAM results obtained with standard electric potential solution agree better with the crosswind speed measured along the CHAMP tracks for the time periods when the IMF B_y component was near zero. The standard UAM solution of the electric potential equation corresponds to the symmetric FAC1 pattern used as input, i.e. for IMF $B_{z0}, B_y = 0$. We tried to take into account the By dependence of the electric potential by the turning and shifting the UAM calculated potential pattern. Such correction improved the agreement between the UAM calculated and CHAM measured crosswind speed.

Auroral structures produced by scale-free electric field of magnetospheric origin

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Assuming that auroral structures at scales 30 km are the direct result of turbulent/scale-free electric field imposed from the magnetosphere, we have modeled the auroral scaling behavior at the early breakup stage by setting the electric fields as synthesized self-similar distributions with known scaling index α_E and reproducing the time

evolution of auroral scaling index α_A. For the range of scales here considered the following simplifying assumptions hold true: (1) there is a perfect mapping of the magnetospheric electric fields to the ionosphere; (2) the magnetosphere-ionosphere coupling takes place in a voltage generator manner; (3) auroral features are produced by electrons accelerated in the inverted-V potential structures rather than in the wave-particle interaction; (4) the *Lyons* [1981] and *Spiro et al.* [1982] equations can be used to describe magnetosphere-ionosphere coupling at the beginning of substorm expansion. A good agreement between the observed and modeled behavior of auroral scaling properties obtained in the present study suggests that a plausible solution to the long-standing problem of auroral structuring has been found.

Contribution of dayside and nightside sources to the cross-polar cap electric potential drop

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Since the work of Dungey [1961], the global circulation pattern with two (dayside and nightside) reconnection regions has become a classic concept. However, the contributions of dayside and nightside sources to the cross-polar cap potential (PCP, φ_{ion}) are not fully understood. The dayside merging process has been intensively studied, particularly, by investigating the response function of various activity parameters including the polar cap potential drop against a variety of combinations of geoeffective solar wind parameters. On the other hand, the relative role of the nightside source is poorly understood both in quantitative and qualitative terms. To fill this gap, we address the contributions of dayside and nightside sources to the PCP using global MHD simulation runs both of an idealized solar wind input and a real event driven by measured solar wind parameters. The dayside source was parametrized by 'dayside merging potential' (DPD, φ_d), represented by either the solar wind based $\varepsilon* = LVB_t \sin^4(\frac{\theta}{2})$, or by the computed dayside merging potential. The nightside source was characterized by cross-tail electric potential (NPD, φ_n) in the plasma sheet, computed at a fixed distance in the midtail ($X = -15$ Re). In the idealized case, in spite of a high correlation between time-shifted PCP and $\varepsilon*$ (CC$\sim$ 0.93, variance

= 5.3 kV), time intervals of dominant contribution of the nightside source are easily identified, and combined action of both sources (using fitting function $\varphi_{fit} = a\varphi_d + b\varphi_n + \varphi v$) considerably increase the fit quality for PCP (CC$\sim$ 0.98, variance = 3.4 kV). The nightside source contribution to PCP has a fast response time (5 min) and modest efficiency ($K_t \sim 0.1$); this is closely linked to the primarily inductive character of electric field during these periods, which does not directly map to the ionosphere along magnetic field lines. These time intervals are marked by strongly enhanced nightside (lobe) reconnection and can be ascribed to substorm expansion phase. By running two simulations using the BATSRUS code with identical inputs but different ionospheric coupling, we confirm that transfer efficiency of the nightside source depends on the choice of ionospheric model, basically by changing the PCP level.

On the generation of the interplanetary reverse waves inside the terrestrial magnetosheath

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The generation of the reverse fast shock wave inside the magnetosheath before the magnetosphere of the Earth in the frame of the magnetohydrodynamic (MHD) approach is considered. It is shown that the contraction MHD fast wave going from the magnetopause in the result of the reflection of a forward rarefaction wave may be nonlinearly overthrown on the way to the bow shock wave front rear. The reverse shock wave affects the bow shock wave motion away from the Earth. This kind of its motion was often observed on board of some spacecrafts. It is useful to distinguish this type of the reverse shock wave from the secondary shock wave possibly going from the plasmapause outside the terrestrial magnetosphere. The work was done with the support of OFN 15 program and the grant of RFBR 08-01-00-191.

Behaviour of the 5577Å and 6300Å emissions during substorms

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The behaviour of the auroral emissions 5577Å and 6300Å and the ratio I6300/I5577 during substorms has been examined. The development of the substorm bulge is followed up. The variations of the emissions depending on the different locations of the substorm bulge with respect to the point of observation have been studied. Estimations of the particle precipitation spectra at the polar edge of the auroral bulge and inside it have been obtained. For the study, data from the All-Sky Imagers at Andøya Rocket Range (ARR), Andenes, Norway (69.3°N, 16.03°E) and at the Auroral Observatory, Longyearbyen, Svalbard (78.20°N, 15.83°E) from the observational season 2005-2006 have been used.

Additional data concerning the solar wind parameters, IMF, the precipitating particles and the magnetic field are used from the WIND satellite and the IMAGE magnetometer network to determine the interplanetary conditions and the substorm development.

It is shown that the emissions ratio is lower at the polar edge of the auroral bulge than inside the bulge, which gives evidence of most energetic particles precipitation at the polar edge of the substorm bulge.

On the solar wind dependence and ionospheric mapping of large plasmoids

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The energy from the solar wind drives magnetospheric dynamics. The main mechanism of extracting and releasing solar wind energy is called a magnetospheric substorm, during which a part of the tail is released downwind. These large structures are called the plasmoids, which are complicated 3-d magnetic structures with spatially alternating closed and open magnetic topologies. Using our global magne-

tohydrodynamic (MHD) simulation GUMICS-4, we investigate how different parameters of the solar wind affect the formation of plasmoids. Specifically we concentrate on the role of the solar wind magnetic field parameters. We also investigate the solar wind dependence of plasmoid foot points, which are the end points of the plasmoid magnetic field in the ionosphere. Based on our simulations, plasmoid formation and plasmoid foot point location in the ionosphere strongly depend on the solar wind magnetic field parameters. We also present an operational definition of plasmoids, which enables their automatic detection in simulations. Our work is of importance when interpreting some of the observed, but unexplained, ionospheric phenomena.

The project has received funding from the European Research Council under the European Community's Seventh Framework Programme (FP7/2007-2013)/ERC Starting Grant agreement number 200141-QuESpace. The work of IH and MP is supported by the Academy of Finland.

Overlap dynamics of the ring current and plasmasphere during substorms according to ground photometric and geosynchronous observations

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Observations of the diffuse aurora (DA) and stable auroral red (SAR) arc are the informative investigation method of magnetosphere-ionosphere coupling 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, which is mapped by the SAR arc occurring at that time. The development of luminosity pulsations in the N_2^+ emissions at SAR arc latitudes during the recovery phase of intense substorms unambiguously indicate to the appearance of energetic particles in the outer plasmasphere (Ievenko et al, Adv. Space Res., 2008).

In this work 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 SAR arc dynamics to the substorm injection by the geosynchronous measurements is analyzed. It is shown that the intensity increase event of the SAR arc in a direction from evening up to midnight MLT sector is due to the expansion of substorm injection region towards the midnight-dawn sector. It is consistent with recent study results of the ring current dynamics with IMAGE satellite. We suppose that the interval of latitudes where SAR arcs are observed during weak and moderate storms is a statistical map of the outer plasmasphere region, into which the developing ring current penetrates and damps during substorms.

Dominant influence of a solar extreme ultraviolet on the excitation of 630.0 nm nightglow emission in the 23 cycle

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It is well known that in maximum of solar activity cycles the intensity of 630.0 nm nightglow emission is increased up to two times. It was supposed that this phenomenon was caused by the solar ultraviolet variations in solar activity cycles (Barbier, 1965; Fishkova, 1983).

In this report on the basis of photometric observations in magnetic quiet days at the Yakutsk meridian (130°E) at the geographical latitude 63°N the connection of the 630.0 nm emission intensity with solar activity in the 22nd and 23rd cycles is shown. The close relationship of the atomic oxygen red line intensity in the nightglow to the solar extreme ultraviolet (EUV) intensity by SOHO/SEM data with a correlation coefficient 0.8–0.9 in 1997–2007 has been found. Two independent samples of the data for February and March indicate to the functional linear connection of the 630.0 nm emission brightness with the EUV stream in the 23rd solar activity cycle. The observed increase of red line intensity essentially exceeds the possible influence of density variations of the upper thermosphere by the MSIS-86 empirical model on the excitation this emission. Thus, the experimental confirmation of dominant role of the solar EUV in the excitation of 630.0 nm nightglow emission has been obtained.

Spectrophotometric registration of the auroral substorm expansion onset at 56° geomagnetic latitude during the major magnetic storm. Comparison with satellite observations

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It is known that the first onset of the auroral substorm expansion is connected with the brightness increase and break up of the most equatorial arc. The subsequent substorm activizations can be shown in the intensification of auroral arcs at higher latitudes. In result there is a formation of auroral bulge and poleward shift of a westward electrojet maximum. The development of the auroral bulge maps the precipitation dynamics of the energetic particles during magnetospheric substorms.

In this report the spectrophotometric observations results of the equatorial arc break up at low geomagnetic latitude of 56°N (first onset of the substorm) in the Yakutsk zenith (CGMC: 56°N; 199°E) during a major magnetic storm with Dst =-150 nT on March, 20 2001 are submitted. Observations were carried out using the digital meridian-scanning photometer in the 630 and 557.7 nm (OI) emissions and the zenith photometer in 630, 427.8 (N_2^+) and 486.1 nm (H_β) emissions with the time resolution of 1 s. The ground optical observations are compared with measurements of precipitating fluxes of electrons and protons and also the aurora image obtained on board the DMSP F15 satellite which has passed close to the observation meridian prior to the break up onset. The aurora dynamics during the substorm expansion onsets is considered in connection with development of the westward electrojet at the Yakutsk meridian, the geosynchronous measurements of the energetic particles flux and also with the global images of aurorae obtained with the Image satellite.

Fractal properties of the ULF (f = 0.002–0.5 HZ) magnetic fluctuations at high latitudes bazed on the Barentsburg and Lovozero stations data

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Fractal analysis of the Earth's magnetic field fluctuations in the ULF range (f = 0.002–2 Hz) has been fulfilled on the basis of data obtained at the high-latitude stations Barentsburg ($\Phi_m = 76°$N) and Lovozero ($\Phi_m = 64°$N) for one year period of 2008 (materials of Polar Geophysical Institute). The available sampling rate, which is 10 Hz, allows us to investigate appropriately the fractal properties of ULF fluctuations in the frequency range from f=0.001 Hz up to f=3 Hz. The Higuchi method has been used for monofractal analysis and WTMM and MF-DFA methods have been applied for calculation of the multifractal spectrum. It is revealed that there are two intervals of scaling (high frequency and low frequency) with a turnover frequency being in the range of 0.01–1 Hz. The high frequency branch of fractal scaling at the cusp latitude (Barentsburg) exhibits the antipersistent behavior at all local times, whereas in the auroral zone (Lovozero) there exists transitions between persistent and antipersistent behavior. It is shown that the high frequency branch is more variable and informative in relation to variations of geomagnetic activity (Kp and AE indices) if compare with the corresponding behavior of the low frequency branch. Multifractal spectrum appears to be wider during geomagnetic disturbances in comparison with quite periods. An example of influence of the solar wind dynamic pressure on the fractal characteristics of ULF fluctuations is demonstrated. The results obtained show that fractal properties of the ground-observed ULF emissions allow insight into dynamics of the solar wind – magnetosphere – ionosphere system and thus they could be taken into account in methods of space weather monitoring.

Grad-Shafranov reconstruction of magnetic clouds at 1AU

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Grad-Shafranov reconstruction (GSR) is a method of estimating the orientation (invariant axis) and cross section of magnetic flux ropes using the data from a single spacecraft, which can be applied to magnetic structures embedded into magnetopause or magnetic clouds. We develop a number of improvements of this technique and use it for analysis of interplanetary coronal mass ejections (ICMEs) registered at 1AU by STEREO, WIND and ACE spacecraft during the minimum of 23rd solar cycle. The analysis is conducted not only for ideal localized ICME events but also for non-trivial cases of magnetic clouds in fast solar wind (or followed by SIR), small flux ropes, large impact parameters (i.e. the closest approach of a spacecraft to invariant axis), etc. We also compare invariant axes of ICMEs derived from GSR with ones defined with minimum variance analysis (MVA) method and show the constraints of the latter when applied to complicated events.

Features of the quiet Earth's magnetosphere during 2009 epoch

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Unprecedented solar wind conditions in 2009 gave us nice opportunity to study the quiet magnetosphere. Global magnetospheric structure and dynamics were studied on the base of satellite measurements and theoretical modeling. Data on electron fluxes with energies more than 200 keV measured by "Coronas-Photon" satellite were used to study the outer radiation belt external boundaries variations in both hemispheres. The average location of Northern and Southern boundaries was determined based on regular measurements during March-November 2009. It was found that outer radiation belt high-latitude boundary is controlled by both main Earth's and magnetospheric magnetic fields. The extremely quiet conditions in 2009 allow separating the effects induced by both internal and external factors. It was found that high-latitude ionospheric boundary of the outer radiation belt rotates in solar-magnetic coordinates during 24

hour together with the Earth and slightly shifts to the night side due to large-scale magnetospheric currents. The radiation belt variations on high latitudes have been reproduced in model calculations, the amplitudes of variations have been determined in dependence on UT and solar wind parameters. Magnetospheric structure during small magnetospheric disturbances taking place during 2009 was investigated on the base of "Themis" satellite measurements. The magnetic field variations during 14 March 2009 geomagnetic disturbance were calculated in terms of paraboloid model of the Earth's magnetosphere and compared with measurements.

Particle fluxes on the outer boundary of the outer radiation belt and the position of the auroral oval

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The enhancements in the fluxes of relativistic and subrelativistic electrons are observed at the outer boundary of the outer radiation belt. Cases are revealed when increases of particle fluxes with energy 200 keV, are observed consequently during multiple crossings of the outer radiation belt boundary on CORONAS-PHOTON satellite (launched January 2009). The comparison of simultaneous observations of particles with energies till 0.1–10 keV are produced using data of METEOR-M–1 satellites during October–November 2009 (the months of simultaneous operation of these two satellites). Such comparison shows that practically for all events when such comparison was possible, increases of fluxes of relativistic and subrelativistic electrons were observed inside the auroral oval. The nature of observed events is discussed. It is shown that the hypothesis of the appearance of local traps for energetic particles can help to explain the observed phenomena.

Reasons of the diurnal/longitudinal anomaly in the ionospheric plasma density

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From the Intercosmos-19 topside sounding data the zone of the irregular variations in foF2 in the Southern hemisphere has been evolved. In this zone in local summer the night-time foF2 values exceed the day-time ones. Such behavior is known as Weddell sea anomaly, WSA. WSA covers all the longitudes of the western hemisphere 180–360° and latitudes of 40–80°S, the maximum effect (up to 5 MHz) is observed at the longitudes of 255–315° and latitudes of 60–70°S (50–55° ILAT). The reasons of the anomaly formation on the basis of the quality and quantity analysis are examined. To accomplish this, the longitudinal variations in the ionospheric parameters for the midday and midnight conditions are in detail considered. They are mainly determined by the vertical drift effect induced by the neutral wind. The neutral wind effect is related to the longitudinal variations in the geomagnetic declination and inclination, and changes of the velocity of the wind itself. The longitudinal variations in foF2 are strongly at the fixed geomagnetic latitude as a result of additional action of the solar radiation. A contribution of the neutral composition and temperature is no more than several percent. The main ionospheric trough forms the poleward border of the anomaly. The other possible reasons are discussed.

3D-Spatial structure of magnetic-plasma heterogeneity of solar wind from "ACE" spacecraft magnetic field measurements

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Problems of research steady plasma heterogeneity an interplanetary magnetic field of abnormal density, speed, temperature of plasma, the sign magnetic field and the magnetic field configuration (named Piddington J.H. by "magnetic clouds") according to the "Ace" spacecraft are considered. For acknowledgement of abnormal physical pa-

rameters considered interplanetary magnetic-plasma clouds are analyzed the independent geophysical data of other spacecraft ("WIND", "GOES", etc.) for the investigated period of the "Ace" spacecraft work in the flight orbit. Such steady magnetic-plasma heterogeneity at collision with the magnetosphere of the Earth are capable to cause the magnetic indignations correlating with the periods of occurrence of strong earthquakes. The scheme of the possible mechanism of the transmission of the energy of interplanetary "magnetic clouds" through a chain of the physical processes leading finally to earthquakes is considered. The activity is executed at support of Russian Foundation of the Basic Research grant N 10-05-00343-a.

Numerical modeling of the ionosphere behavior during geomagnetic storm sequence on 9–14 September 2005

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We carried out the comparative analysis of model calculation results of ionospheric effects of geomagnetic storm sequence on 9–14 September 2005 obtained with use of GSM TIP model, developed in the WD IZMIRAN in two statements of a problem. In the first statement the changes of such input parameters of the model as a potential difference through polar caps, field-aligned currents of the second region and particle precipitation were set depending on a three-hour Kp-index. In the second statement the model calculation block of particle precipitation was changed according to particle precipitation model by Zhang and Paxton (2008) in which the energy and energy flux of particles depend on a Kp-index, and also the change of position of the particle precipitation area with change of geomagnetic activity is taken into account. Besides in this statement the changes of the potential difference through polar caps and field-aligned currents of the second region depend on AE-index with minute time resolution. Also the 20-minute delay of field-aligned currents of the second region relative to the changes of potential difference is taken into account. At last, in this statement the effects of 5 solar flares having a place for the considered time period are taken into account. The analysis of

the physical mechanisms responsible for ionospheric effects obtained in model calculations is carried out. The obtained model calculation results are compared among themselves and to the observational data of separate stations of ground ionosphere sounding and incoherent scatter radars. It is concluded concerning the obtained model calculation results and discussed the reasons of discrepancies between calculation results and observational data.

The research is carried out at financial support of the Russian Foundation for Basic Research (Grant N 08-05-00274).

Numerical modeling of the Weddell sea anomaly

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The Weddell Sea Anomaly (WSA) is a peculiar phenomenon occurred in the F2 peak electron densities over the Weddell Sea region of Antarctica. The numerous observations showed that in summer the electron densities in that region were larger at night than during the daytime. The WSA investigations present a statistical processing of the experimental data and a qualitative analysis of the WSA forming mechanisms. Obviously this anomaly is related to the thermosphere-ionosphere interaction. The three-dimensional models should be used for the quantitative analysis of the problem. At this work we present the results of the WSA modeling using the global numerical Upper Atmosphere Model (UAM). The model calculates concentrations, velocities and temperatures of the neutral and charged components by solving of the corresponding time-dependent 3D equations of the continuity, momentum and heat balance and the electric potential equation. The model simulations have been carried out in two variants: 1) using the fully self-consistent UAM configuration and 2) using the UAM configuration with neutral composition and temperature taken from the empirical thermospheric NRLMSISE-00 model. The calculations were performed for the quiet conditions of the December solstice under the different levels of the solar activity. The results of the f0F2 global distribution modeling were compared with the data obtained from the empirical ionospheric model IRI-2001. The conclusion has been made that the UAM reproduces the Weddell Sea Anomaly. The most evident effect has been shown by the fully self-consistent UAM configuration. In numerical results the night-time

f0F2 values exceed the day-time ones to a greater extent under the high solar activity than under the low activity.

Influence of solar radiation on dust particle charging in near-Earth space

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Near-Earth space plasmas contain often nano - and microscale particles. Sources of the particles are meteoric streams, formation of particles by condensation of supersaturated water vapor and adsorption of substance of a meteoric origin. As a result of charging of these particles dusty plasma in near-Earth space is formed. The effect of solar radiation on the charging of dust particles is investigated. Influence of the effects of a resonant discharge of ions in the process of their interaction with neutrals, and also heating of electrons by photoemission (efficiency of electron heating depends on the density of neutrals, meteor activity, intensity of solar radiation, etc.) are discussed. The altitudes at which the above-mentioned effects can have a noticeable effect on the charging of nano- and microscale particles of different origin are determined. It is shown that the effect is important when describing the noctilucent clouds, polar mesospheric echoes and particles of meteoric origin. This study was supported by the Division of Earth Sciences, Russian Academy of Science (research program "Nanoscale particles in nature and technogenic products: conditions of existence, physical and chemical properties, and mechanisms of formation") by the Division of Physical Science, Russian Academy of Science (research program "Plasma physics in the Solar system"). One of the authors (S.I.P.) acknowledges the support of the Dynasty Foundation.

Auroral structures at the northern part of the oval and their relation to breakup, dipolarization and reconnection

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For the season 2007–2008, TV data from Loparskaya, Lovozero and Barentsburg observatories were selected and processed combined with

THEMIS data for the time intervals when two or more spacecraft were located inside the plasma sheet. It was found that when TV camera is inside auroral oval, and breakup centre is not far from the camera field of view) at the northern part of the oval 30–40 minutes before breakup some specific rather bright auroral structures are always appear. Periodic activations of those structures generate moving southward weak subvisual auroral forms, and one of these moving forms becomes a prebreakup arc. Northern structures themselves do not demonstrate southward motion. They always fade 2–4 minutes before breakup, and appear again 1–3 minutes after. Postbreakup northern auroral structures activation often correlate with a strong increasing of high energy electrons fluxes (more than 30–50 kev) detected by THEMIS spacecraft at the distance about 18–20 Re. Electrons energy spectra, and their time variations are radically different in compare with a spectra detected by TMEMIS at the distance about 5–9 Re during dipolarization wave satellite position crossing. Data analyses allow us to offer a preliminary hypothesis that reconnection process in the tail (20–25 Re) can be subdivided in a two stages. The first stage corresponds to preliminary substorm phase, starts 30–40 before breakup, and generates northern auroral forms. We can call this stage a quasi-stationary reconnection, it probably reflects direct solar wind energy penetration into magnetosphere, and repeats variations of solar wind parameters. Periodical activations of this reconnection generate waves and plasma fluxes moving to the inner magnetosphere, and this process sooner or later triggers auroral breakup. The second stage (main reconnection phase) happens after breakup, and produces large fluxes of high-energy electrons.

Auroral arc splitting observed by ground-based television observations and its possible explanation

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The splitting of auroral arcs was observed January 26, 2000 near zenith of Lovozero station. Auroral data were provided by SIT vidicon television (TV) camera with all-sky lens. Computer framegraber videocard and special software allowed digitization of TV frames and

the arbitrary chosen frame fragments. The special methods for the television images processing were used to detect fine subvisual structures and to trace the details of motion of fine auroral structures. The process of splitting is discussed taking into account the growth of large-scale field aligned currents. The model, which can explain the process of splitting, is suggested.

Simultaneous TV and THEMIS observations of substorm manifestations in non-conjugated magnetosphere regions

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

On the base of PGI TV cameras at Lovozero, Loparskaya and Barentsburg, different ground based equipment, and THEMIS spacecraft data (electron and ion fluxes in energy range from 100–200 eV up to 1–2 MeV, electric and magnetic fields, plasma flows, etc) reaction of the different magnetospheric regions on the night side substorm events was studied (about 40 events total). Different possible situations have been analyzed (for example, satellites inside the disturbed plasma sheet and TV cameras in the evening, morning and dayside oval sectors, and vice versa, observing auroral breakup night side TV cameras and THEMIS satellites in the different magnetosphere domains). Continuous and close interconnection (though sometimes rather fine and not obvious) between different non-conjugated parts of "magnetosphere organism" was found. Data obtained can be a good background for very perspective and promising future study.

2.5D EHMHD analytical model of steady-state Hall magnetic reconnection in a compressible plasma

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An 2.5D analytical EHMHD model of steady-state magnetic reconnection in a collisionless compressible plasma with a constant electron

temperature is developed. It is shown that as like as in incompressible case, solution of the Grad–Shafranov equation for the magnetic potential is a basis for the problem analysis. Formation of the double electric layers and layers of low density plasma mapping the magnetic separatrices is investigated. It is found that formation of depletion layers should not be imputed to the out-of-plane magnetic field, but rather origin of this layers lies inside the electron diffusion region, where number density should attain the local minimum due to the inner dissipative processes. The double electric layers are found to be thin separatrices-elongated sheets in the order of electron diffusion region half-width in there cross-section. These charged layers provide the presence of the strong electric field orthogonal to the in-plane magnetic field, that force electrons to accelerate in the out-of-plane direction. Out of the double electric layers condition of the electroneutrality of plasma is found to be held to a high precision. The extremum values of the electron velocity and electric field are found to be controlled by the width of the electron diffusion region. Thus, last one seems to be the fundamental parameter of the reconnection process.

Double gradient instability in a compressible plasma current sheet

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A linear MHD instability is investigated of the electric current sheet characterized by a small normal magnetic field component B_z varying along the sheet. The tangential magnetic field component (B_x) is modeled by hyperbolic function describing Harris-like variation of the field across the sheet. This work is an extended numerical study of the so called "double gradient instability" which was analyzed previously in a framework of the simplified analytical approach for incompressible plasma. For this problem formulated in 3D domain, the conventional compressible ideal MHD equations are applied. By assuming Fourier harmonic along electric current, the linearized 3D equations have been reduced to the 2D ones. Finite difference nu-

merical scheme is applied to examine the time evolution of small initial perturbations of the equilibrium background. Finally, dispersion curves are obtained for both kink-like and sausage-like modes of the instability. It is shown that these curves demonstrate a quantitative agreement with the previous theoretical results obtained in the frame of 1D incompressible model. However, the numerical growth rates are somewhat less than the analytical ones in a factor depending on a ratio of the acoustic and Alfvén speeds. Dependence of the instability growth rates on the magnetic gradient ∇B_z is examined as well, demonstrating a good agreement with the theoretical predictions.

Factors controlling the Dst index during geomagnetic storm (GS) main phase (MP) on evidence of the cluster analysis

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The scale $D_{st} - B_Z$ cluster classification of 31 MPs ($D_{st}^{min} = -37 \div -226nT$, $B_Z^{min} = B_S^{min} = -6.6 \div -24.5nT$) allowed to select the weak (WGS), moderate (MGS), intense (IGS), and very intense (VIGS) storm MPs (the samples) associated with interplanetary magnetic field (IMF) component B_Z. The content physical analysis of the obtained MPs samples is carried out on the base of correlativity clustering of 32 interconnected physical processes (IPPs) characterizing every MP. It has been found that the MPs of all samples have common part of tight IPPs structure ($CP = [D_{st}] + [B_Z] + (B_Y) + B$), and in turn the MPs of every sample has own common IPPs structure depending on the D_{st} index scale. From our cluster analysis it follow that: 1) the subset of factors (causes) controlling D_{st} index during the GS MPs are different for different levels of storm intensities; 2) the extent of the interrelation tightness between D_{st} index (or injection function Q) and V^2B_S, VB_S, B_Z, B and $F_M^* = VB_S(nV^2)^{1/3}$ decreases sequentially from strong to moderate, i.e. the relationships $D_{st}(V^2B_S)$ or $Q(V^2B_S)$ are most tightly coupled; 3) the IMF component B_S along with some coupling functions (namely, V^2B_S, VB_S) incorporating B_S or B_Z IMF components play crucial role in determining of GS main phases; 4) the B_Y IMF component plays a distinct role in the MPs physical development; 5) the role of Akasofu

coupling function ε is less appreciable, but the relationships $D_{st}(\varepsilon)$ and $Q(\varepsilon)$ are in existence, but are more complex and not so tightly connected; 6) the D_{st} index (or Q function) and AL index have essential relationship in between only during WGS, MGS, and partly IGS MPs; 7) the most relevant coupling function for development of the AL index is the V^2B_S coupling function, but only during WGS, MGS, and partly IGS MPs.

Transformation and absorption of magnetosonic waves generated by solar wind in the magnetosphere

Kozlov, D.A. (Institute of Solar-Terrestrial Physics SB RAS, Irkutsk, Russia)

Resonant transformation of fast magnetosonic (FMS) wave flux into Alfven and slow magnetosonic (SMS) oscillations is investigated in the one-dimensionally inhomogeneous magnetosphere. Spatial distribution of energy dissipation rate of FMS oscillations penetrating into the magnetosphere from the solar wind is studied. The FMS wave energy dissipation rate caused by magnetosonic resonance excitation is shown to be several orders of magnitude greater than that caused by Alfven resonance excitation at the same surface. It is connected with the spectrum of incident FMS waves. The Kolmogorov spectrum is used in numerical calculations. Magnitude of the Fourier harmonics exciting resonant Alfven oscillations is much smaller than that of the harmonics driving lower-frequency magnetosonic resonance. It is shown that resonant transformation of FMS waves into SMS oscillations can be an effective mechanism of energy transfer from the solar wind to the magnetosphere.

Comparison of Pc5 geomagnetic pulsation associated with CIR-driven and CME-driven storms

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The dayside Pc5 pulsation activity has been analyzed during the selected succession of 10 recurrent magnetic storms (CIR-driven storms) and compared with Pc5 pulsation associated with CME-driven storm

in 2006. The ULF-index, as a measure of the wave level activity in the Pc5 frequency range of 2–7 mHz, was calculated according to the ground-based 1-min globally distributed observations in the morning (03–12 MLT) and afternoon (12–18 MLT) sectors at auroral (60–70°) and polar (70–90°) geomagnetic latitudes. It was found that in all phases of the CIR-driven magnetic storms under consideration, the enhanced ULF-activity was found at the auroral and the polar latitudes. The daytime polar zone ULF intensity was of the same order or even higher (in the storm initial phase) then at the auroral zone. As usual, in the main phase of the studied CIR-driven storms, the value of the solar wind velocity was very large (more 600 km/s), which could provide the Kelvin–Helmholz instability progression and, correspondingly, the Pc5 ULF wave generation. The ULF-index, calculated for the fluctuations in the Interplanetary Magnetic Field (IMF), indicated the enhancement of the strong ULF waves in the initial and main phases of the analyzed magnetic storms. We assume that some of these fluctuations could penetrate into the open polar cap and provide an enhancement of the dayside ULF geomagnetic pulsations at the high latitudes. The ULF-index, based on the geostationary GOES data, demonstrated increasing of the intense ULF pulsations in the magnetosphere in the storm main and recovery phases, but not in the storm initial phase. The comparison of the ULF-activity during the CIR-driven storms (typical for the solar activity minimum) and CME-driven storms (typical for the solar activity maximum) showed that the ULF-activity associated with the CIR-driven storms was observed at the higher latitudes then in the CME-driven storm.

Substorm "current disruption" in the near-earth portion of the plasma sheet: a fast dynamical bifurcation

Kropotkin, A.P. (Skobeltsyn Institute of Nuclear Physics, Moscow State University, Moscow, 119992 Russia)

A series of recent papers addresses the question of the ballooning type specific modes which can be excited according to the linear theory, in the near-Earth portion of the plasma sheet in the geomagnetic tail; and with the use of powerful MHD simulation codes, another question is addressed: what is the path of their later nonlinear evolution, and does the "substorm detonation" really exist?

We draw attention to an additional factor capable to significantly

alter the results of such an analysis, when applied to disturbances with a small scale perpendicular to the magnetic field: in that case a fast evolution of the configuration must be taken into account, namely its "dipolarisation". However, the effect of phase mixing appearing in that case, is insignificant for a large-scale disturbance. If applied to such a disturbance, a proper description approach is a nonlinear loss of equilibrium — a dynamical bifurcation delayed in relation to the moment of crossing the marginal stability point.

Unified approach to chromospheric spicules and magnetic field concentrations generated by convective motions in the photosphere

Kropotkin, A.P. (Skobeltsyn Institute of Nuclear Physics, Moscow State University, Moscow, 119992 Russia)

We present the basics of a theory unifying the approach to such phenomena in the solar atmosphere as localized magnetic field concentrations at the feet of coronal magnetic arcs, chromospheric spicules, twisted coronal magnetic field tubes, Alfvenic wave energy flow from downside into the corona.

We study the structure of photospheric currents which are localized near the supergranule borders and are generated there by the material convective motions. The currents exist mainly in the "dynamo layer". That layer with extremely increased transverse conductivity appears in the weakly ionized thermal photospheric plasma, in the Sun's gravity field. Motion of electrons and ions in that layer is quite different: ions are driven in collisions by the flow of neutrals while electrons are drifting in the crossed electric and magnetic fields. The electric field which maintains the currents, arises due to polarization charge separation of electrons and ions.

On the other hand, such a field gives birth to an Alfvenic disturbance traveling upside, into the corona, as well as to the associated parallel currents. With such a "load" taken into account, the system of fields and currents appears unambiguous. Besides, the momentum flux of the Alfven waves should be passed to the cold chromospheric gas, thus producing its vertical propulsion and formation of a spicule, as it has been first proposed in [Haerendel, 1992].

On the connection between variations of atmospheric electric field as measured at ground surface in the Central Antarctica and ionospheric potential

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The solar wind generator contributes in a variable manner to the ionosphere-to-ground potential difference at sites in the Polar Regions. It averages ∼20% of the contribution of the meteorological batteries at such sites. At times of strong solar wind interaction, much larger contributions to the atmospheric circuit in Polar Regions can occur. Regular measurements of the variations of atmospheric electric fields performed at Vostok Station ($\varphi = 78.45^o$ S; $\lambda = 106.87^o$ E, elevation 3500 m) in Antarctica are compared with the value of electric potential above the station derived from the Weimer model as well as with PC index. Observed positive correlation of ΔE_z with Φ_i affirms the truth of this statement.

Comparison of flapping oscillations observed by Themis with the double gradient model

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Flapping oscillations observed in the current sheet of the Earth's magnetotail, represent rather slow waves propagating from the center to the flanks with a typical speed ∼20–60 km/s, amplitude ∼1–2 Re and quasiperiod ∼2–10 minutes. The relevant model is based on double gradient of magnetic field: gradient of tangential (B_x) component along the normal (z) direction and normal component (B_z) along the x-direction [Erkaev et al., doi:10.1103/PhysRevLett.99.235003]. In the framework of this model the rotation of the vector of magnetic field in the plane Z–Y as well as vector of plasma velocity is investigated to find differences between kink and sausage modes of the flapping oscillations. It is also shown that the speed of the rotation of the vector ($\mathbf{v}$ or $\mathbf{B}$) gives the fundamental parameters of the model

including double gradient frequency. The theoretical results are compared to the flapping oscillations observed by space mission Themis on 03.05.2008 in the morning sector of the magnetotail. The observed rotation of the velocity vector simultaneously on two spacecrafts of Themis mission corresponds to the kink mode of the flapping oscillations. The results obtained show that data on rotation of **v** and **B** vectors can give important information about modes and characteristics of the flapping waves.

Modelling of the magnetospheric polar cusps based on spacecraft data

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The goal of this work is to create a data-based model of magnetic depression in polar cusp area and to derive its parameters from spacecraft data. The simplified T02 model was used in this work, whose parameters were fitted to all available data. Then a cusp depression module was added and its parameters were fitted to the dayside data. The data of following spacecraft were used in this work: Geotail (1995–2005), Polar (1996–2003) and Cluster (2001–2007). The essence of the modeling method is to apply a deformation to the dipole field, which results in a local rarefaction of magnetic field lines inside the cusps. The result model reflects main features of the polar cusps: a depression of the magnetic field inside the cusps and a local increase if the field near their poleward boundaries.

Can geomagnetic activity cause geomagnetic jerks?

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It is considered that geomagnetic jerks likely result from dynamic processes inside the Earth. In the detection of geomagnetic jerks the average annual of the Earth's magnetic field vector components is investigated, using a smoothing method for the long-period variations of magnetic field associated with the 11-year solar cycle, so that the

external geomagnetic field could be disreguarded. Meanwhile, the geomagnetic field average annual reflects the regular solar activity and relative geomagnetic variations generated by the ionospheric conductivity changing following to the solar wave radiation. Besides of that, this geomagnetic field is influenced by the stochastic geomagnetic activity determined by disturbances during magnetospheric storms and substorms. During the minimum of solar activity cycle, in 2007–2008 the solar activity and, as a result, the geomagnetic activity were extremely low. To estimate annual geomagnetic disturbances observed by ours stations in the pre-minimum period, we introduce a parameter that corresponds to the level of the quiet state of the Earth's magnetic field, in addition to the standard of the secular variation rate. The quiet state implies the average annual of the geomagnetic field gained in 2007. A standard rate of the secular variation observed by a station is calculated as a difference between the average annual of 2008 and that one of 2007. Thus, it is possible apply the traditional mathematic method, used in the detection of geomagnetic jerks that proceeds from the difference between the average annual rates of adjacent years. Meanwhile, we take into consideration the difference between the annual geomagnetic activity deviation and the level of the quiet state. As our research demonstrates, the jerks detected applying the traditional method and considering the main field generated in the Earth's core as a source of the jerks, should be explained with the variation of the geomagnetic activity and its deviation from the activity of 2007–2008.

Modeling of the IPDP generation

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The generation of ion-cyclotron waves with increasing frequency (IPDP) in the evening sector is considered using the numerical modeling under suggestion that the generation is due to the drifting cloud of energetic ions injected in the night sector. The behavior of the IPDP frequency is investigated at different L-shells as function of energetic spectra and pitch-angle anisotropy of injected particles as well as characteristics of the cold plasma. It is shown that results of the modeling are consistent with the observed IPDP properties.

Space weather effects in the behavior of the ionospheric total electron content

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The total electron content (TEC) of the ionosphere is an important parameter characterizing the space weather, because its behavior depends on the state of the ionosphere and plasmasphere, so even the magnetosphere. The trend towards replacing the use of TEC instead of the maximum plasma concentration NmF2 when setting the conditions for the propagation of radio waves, reducing the number of ionospheric stations, the attempts to create an index of disturbance of the ionosphere, allowing to predict the variation of NmF2 based on the global distribution of TEC, forced to return to the evaluation of the relations between the TEC and NmF2, ΔTEC and ΔNmF2. Disturbances in the ionosphere and the magnetosphere may have different causes, which changes the nature of correlations, so we need to associate these changes with changes in various geophysical factors. One of examples of the paper includes results for April 2002, for which the work of Goncharenko et al. [JGR, 2006] conducted a comprehensive analysis of interplanetary and geomagnetic conditions and identified 2 cases (14–16 and 26–28) when a strong positive B_y-component of IMF provides a transfer of disturbed zone to low latitudes. In addition, this month included a classical disturbance (17–22.04, min Dst ~ -150 nT). Using data of foF2 from the database SPIDR and TEC JPL maps at meridional chain of stations in the U.S. and European zones, we estimate the correlation coefficients between NmF2 and TEC, ΔTEC and ΔNmF2, NmF2 and the equivalent ionospheric slab thickness tau. Also, for some stations, where there are no data of foF2 during the disturbances, or the F2 layer is shielded by the Es layer, an attempt is done to restore the behavior of foF2 using TEC data, an empirical model of the ionosphere and the experimental median values of tau. Restoration provides agreement with experimental data a factor of 2 better than the model.

Numerical modeling of the seasonal and longitudinal effects of the plasmasphere filling

Martynenko, O.V., Botova, M.G. (Murmansk State Technical University, Murmansk, Russia)

The influence of field-aligned ion diffusion features on formation of 3D spatial structure of the Earth's ionosphere and plasmasphere has been studying. The study was conducted by a computer simulation method using the global numerical model of the Earth's upper atmosphere UAM. In order to select exclusively the role of the diffusion all other transfer processes were eliminated in this calculation. Convection drift and neutral wind were set completely absent. In the initial state the ionosphere and plasmasphere were uniformly filled with plasma of very low density. Then the ionization started and the plasma began field-aligned motion into upper parts of the field tubes. The tubes geometry controls details of this process. They are the subject of our study.

This paper presents the first results of the investigation of longitudinal and seasonal variations of the plasma density and ion composition.

It is shown that the longitudinal variations are insignificant in the system of ionosphere-plasmasphere, formed only by the field-aligned diffusion processes. Thus, the formation of longitudinal variations is the result of other processes, which are disabled in our simulation, for example the neutral wind action.

In order to study the seasonal variations we have simulated and compared the plasmasphere formation "from scratch for the equinox and solstice conditions. A significant asymmetry between the hemispheres appears in the solstice state. An overall plasma density is more in summer hemisphere, but the maximal O^+ density area in some local time sectors is shifted into winter hemisphere. This is most visible in the vertical sections.

The physical mechanism leading to this effect will be discussed.

The 3D numerical modeling of the field-aligned ion diffusion and its role in the plasmasphere refilling

Martynenko, O.V., Botova, M.G. (Murmansk State Technical University, Murmansk, Russia)

We have studied the role of field-aligned diffusion in formation of 3D spatial structure of the ionosphere and plasmasphere by a computer simulation method. Convection drift and neutral wind were absent. The geographic and magnetic axes were superposed. The Sun was located exactly above the equator.

Our study shows that the field-aligned ion diffusion causes the plasmasphere formation in a few days of modeling time. We have got the repetitive diurnal variation of all modeling parameters. The overall picture is fairly realistic. Thus, we assume that the model with all simplifications is still physically appropriate.

The resulting plasmasphere is mainly uniform in the longitudinal direction (altitudes 1500 km and over). It consists of the central region filled with H^+ ions and near-auroral areas (in the form of "horns" at the meridional cut) populated by a significant amount of O^+.

The main features of plasmasphere filling process obtained by our simulation are:

1. Quantitatively the rate of plasmasphere refilling process in our simulation corresponds in order of magnitude to known experiments and estimations.

2. In the night sub-auroral ionosphere in the 1st day the maximum of O^+ appears. It extends up to 10000 km (above-mentioned "horns"). During the next days the latitudinal extent of it decreases due to "melting" of its low-latitude margin as the "constant population" of H+ grows in the corresponding tubes.

3. This maximum is clearly correlated with the strong fluxes of O+ ions. They also are strongest in the 1st day and getting weak after.

4. In the 1st day there is a substantial concentration of O^+ in the upper part of mid-latitudinal tubes. Later H^+ is accumulating there, O^+ concentration falls (H^+ pushes out O^+), and the distinctive shape of the meridional cross-section of the O+ concentration is being formed with a central "hole" and "horns" on the edges.

5. In the mid-latitudinal plasmasphere the maximum of H^+ appears gradually (3–5 day). If T_i was assumed constant in the calculation,

this maximum absent. It forms as the result of coincidence of 2 factors. Daytime flow of ions filling the tube increases with increasing T_i. But the tube volume grows very rapidly with latitude. At the latitudes of 30–40 there is an area where a relatively small tube volume coincides with power daytime ion flow.

Dispersion relationship and instability criteria for the ballooning mode in the magnetospheric plasma

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The ballooning disturbances in a finite-pressure plasma immersed into a curved magnetic field are described with the system of coupled equations for the Alfven and slow magnetosonic modes. Commonly this disturbance is characterized by the local dispersion equation which is widely applied for the description of ULF oscillatory disturbances and instabilities in the nightside magnetosphere. However, the exact form of this equation used by various authors is somewhat different. We have reduced the basic system of MHD equations in a mathematically strict way to the local dispersion equation for the small-scale in transverse direction disturbances. As a result, we have obtained a mathematically correct relationship which can be used for the geophysical applications. In particular, from this relationship the modification of the ballooning instability threshold is obtained.

Spatial structure of ULF waves in near-Earth space according to Themis observations

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ULF waves in the Pc5 frequency range recorded on 5 THEMIS satellites during the first stage of the mission ("pearl-on-string" configuration) were analyzed. In essence, these observations can be considered as gradient installation in space. Analysis of these gradient measurements allows to determine the local spatial-temporal structure of the waves and to identify their physical nature. The relationship between

Pc5 waves in the Earth's magnetosphere and their ground response observed at worldwide magnetometer network was also examined.

The results of Tsyganenko T01 model use for the study of geomagnetic variations characteristics of external current sources

Melnyk, G.V., Maksimenko, O.I., Shenderovska, O.Ja. (Institute of Geophysics of NASU, Kiev)

The longitudinal variations of the total vector and magnetic field component disturbances during the storm main phase for the latitudes 50–60° are showed. The regions of the best agreement with experiment data and the spatial changes of the direction and amplitude of magnetic storm field components were detected. Characteristics of the north-south (NS) asymmetry (10–20%) of the total and the ring current fields in the meridional sector were calculated. The azimuthal dependences with the predominance amplitude value in the conjugate northern hemisphere at longitude 150Λ equal of +40 nT for the total magnetic storm field and −19 nT for the ring current field near 270Λ at latitude 60° were determined.

NS asymmetry differences in the distribution of the magnetic storm field and its peak component position for the total magnetic fields were estimated: the displacement on opposite sides from the evening meridian in northern and southern parts of the magnetosphere.

The seasonal and secular variations of NS asymmetry for the magnetic storm fields depending on the longitude (MLT) in the interval over 1990–2010 were calculated.

Interaction of coherent Alfvénic structures in the lower magnetosphere: simulation results

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We try to interpret the electric turbulence on scales from 100 m to first tens of km observed in the ionosphere in terms of interaction of coherent Alfvénic structures, as was first proposed by *Chang et*

al. [2004]. The coherent Alfvénic structures are field-aligned flux tubes, arising in the lower magnetosphere ($\beta m_e/m_i$) as a result of non-linear dynamics of inertial Alfvén waves. The motions and interactions of the coherent structures under the influence of Ampere's force are studied numerically within reduced MHD description with applying a specially developed macro particle method. We set the initial distributions of the flux function and field-aligned current densities, corresponding to the coherent structures, as a white noise of small amplitude and follow their time evolution in the plane transverse to the background magnetic field. The evolution involves migration, merging, and repelling of the magnetic flux tubes. There is a clear tendency for clustering of the structures accompanied by the formation of strong magnetic shears (intense field-aligned currents). This means a reverse energy cascade in k-space. Scaling properties of resulting multiscale fluctuations are investigated using the discrete wavelet analysis.

Effect of major solar energetic particle events on polar stratospheric aerosols for cycle 23

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The present work is focused on evaluation of the possible influence of the greatly enhanced ionization caused by extremely strong solar energetic particle (SEP) events likes ground level enhancement events upon formation of new and growth of pre-existing aerosol particles in the low stratosphere over the polar region. A detailed analysis of variations of the daily profiles of aerosol extinction, obtained by space-borne POAM III instrument in different wavelengths, for both Arctic and Antarctic polar regions during periods of major SEP events was done. We found statistically significant changes in the aerosol parameters associated with the SEP events. This means that increasing of solar cosmic rays induction ionization rate in the polar atmosphere leads to changes of physical-chemical properties (specifically the mean size of aerosol particles) in this area. A statistical test confirms that the observed changes of the chemical and physical properties of the polar troposphere are significant and are unlikely to be related to a spatial or temporal independent meteorological fluctuation of the aerosol and others contents.

Generation features of the artificial magnetic pulsations in Pc1 range at Spitsbergen

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A series of heating experiments have been carried out on 2006 at SPEAR heating facility at Spitsbergen. 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. Moreover observations of the ionosphere response to ionosphere heating are not clear in the frame of a conventional model of their generation. Frequently for two events with very similar ionospheric condition artificial emissions may to be observed or not observed. This peculiarity was named as a sporadic nature of the artificial pulsations. Series of the heating experiments on the pulsation excitation at Spitsbergen give more features to the sporadic nature. Probability of their excitation is rather small (10%) and independent from local magnetic activity, although the artificial amplitude should be depended strictly on ionospheric electric field magnitude. The event study of the convection velocity and electron density also shows its insignificant correlation with the emission intensity. Moreover magnitude of artificial pulsations is independent from variations of ionospheric currents. New ideas are needed to fit the experimental findings with the numerical model.

Detection of the second-order aberration-angle

Mocnik, K. (Space Research Institute, Austria)

In their publication of 1887, Michelson and Morley presented two experiments. The first one (Michelson-interferometer, MI) showed a null-result, the physical essence of which was discussed lately [Mocnik, K., "Coronation of Maxwell's Stationary Aether", Proc. Int. Conf. 'Problems of Geocosmos', St. Petersburg, 2002], and the second one was an alternative experiment based on the investigation of the reflection law, suggested by Michelson in the supplement of his paper [Michelson, A.A., Morley, E.W., Am. J. of Sci., 134, 1887, p. 33]. Through refined theoretical fundamentals [Mocnik, K., "On

Closing a Gap in Space-Time Physics", Proc. Int. Conf. 'Problems of Geocosmos', St. Petersburg, 2008] the sensitivity of his method was considerably enhanced, by diffraction-preserving multiple reflections of the light cone of a laser-diode. Two specific constructions of the experimental assembly, and the measurement results obtained will be discussed.

Peculiarities of sudden commencement manifestation in VLF-emission generation and cosmic noise absorption

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The variation of the VLF emission, energetic particles precipitation (cosmic noise absorption) parameters and magnetic disturbances peculiarities during the magnetic storm sudden commencement (SC, SI) are considered. The majority are the joint events, manifested both in riometric absorption and in the VLF emission generation (SC_VLF_RA). The VLF emission measured at Yakutsk station (L∼3), and riometric absorption measurement conducted at the Yakut meridional chain of stations (L ∼ 3-8, MLat ∼ 190 deg). For the selected events the azimuthal components of the solar wind electric fields (Esw) and induction electric fields (Eind), change of the field in the magnetosphere (dBz), reflecting the degree of the magnetosphere compression at L shell of Yakutsk and geomagnetic disturbance level for the 6-hour interval prior to the SC by Dst, Kp and AE indices were estimated.

The following features are founded:

1. The SC_VLF_RA which were registered in the noon sector MLT, preceded by intervals with higher values of the Kp index (Kp ∼ 3-6) in comparison with the SC_VLF_RA in the other MLT sectors (Kp ∼ 1-4). Some SC_VLF_RA events were registered at L∼3-8 in spite of low geomagnetic disturbance level.

2. The SC which were not accompanied by the VLF emission and riometric absorption registered at small values of dBz = 6-8 nT and Eind = 0.7-0.9 mV/m. The direction of Esw (to the east) in such events is opposite to Eind direction, which were directed to the west.

3. It is follows from the comparison of Dst and AE-indices prior to the SC_VLF_RA, that the geomagnetic disturbances level at equatorial and auroral latitudes for the majority of events are similar.

4. Among the considered magnetic disturbance types during the SC there are sudden auroral energization and high latitude magnetic impulse events. SC_VLF_RA at L∼3-8 predominantly on morning MLT sector were registered. Such of events by impulse magnetic field variation at auroral latitudes and negative bay at L∼3 are characterized. It is assumed that except the magnetosphere compression magnitude and the preceding geomagnetic activity, the induction and convection electric fields and magnetic disturbances on the SC_VLF_RA observation have an influence.

This work was supported by the Presidium RAS program N 16, part 3, by the RFBR grant N 09-05-98546 and also supported by the SB RAS project N 69.

"Trimpi" effect associated with the electron precipitation in the auroral oval

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This paper deals with the investigation of the "Trimpi" effect (short-time variation in the amplitude and phase of the VLF signal) induced by the auroral oval. The problem of the propagation radio waves in the plane waveguide Earth-ionosphere is researched. The source is a VLF transmitter. The location of the transmitter and receiver are chosen so the propagation path crossed polar oval.

The surface impedance concept is used to model the waveguide Earth-ionosphere. The parameters of the regular waveguide (height and impedance) are obtained using given electron concentration and collision frequency height profiles for unperturbed ionosphere. The auroral oval, the local irregularity on the upper wall of the waveguide, induced a sharp increase in electron concentration that leads to a local change of the waveguide height. In consideration of this the problem is modeled as plane waveguide with the local irregularity on the upper wall which is taken as truncated cylinder.

The approach is based on the preliminary asymptotic integration of the rigorous two-dimensional integral equation in order to facilitate

its further numerical handling. An original computational algorithm (proposed by O.V. Soloviev) is used to obtain a solution of the approximate equation.

Increases of electron fluxes in polar regions and auroral UV-radiations according to "Universitetsky – Tatiana" satellite

Myagkova, I.N., Antonova, E.E., Garipov, G.K., Klimov, P.A., Khrenov, B.A. (SINP MSU, 119991, Moscow, Russia)

Simultaneous measurements of electrons with the energy 70 keV and ultra-violet radiation (UV) of the night atmosphere, carried out on-board "Universitetsky – Tatiana" satellite are presented. The energetic electron fluxes local increases were selected. Results of measurements are compared with simultaneous solar wind observations. Some of these electron flux increases were observed during 2–3 consecutive orbits. The measured increases of electron flux to a pole from the external border of the outer radiation belt of the Earth and high-altitude increases of UV-radiation were observed simultaneously. It shows that electron increases were observed inside the auroral oval. The nature of observed events is discussed. It is shown that the hypothesis of the appearance of local traps for energetic particles can help to explain the observed phenomena. This work was partly supported by RFBR foundation grants 09-05-00798-a and 07-02-92004-HHC_a.

Near-Earth space environment dynamics based on "CORONAS-Photon" and "Meteor-m1" satellites measurements

Myagkova, I.N., Panasyuk, M.I., Antonova, E.A., Kalegaev, V.V., Ryazantzeva, M.O., Bogomolov, A.V., Barinova, V.O., Parunakian, D.A., Ovchinnikov, I.L. (SINP MSU, Moscow, 119991, Russia)

Radiation condition investigation in the near-Earth's space is one of the main goals of the space experiments on-board solar observatory "CORONAS-Photon" and "Meteor-m1" satellite. Particle fluxes dynamics measured by "Electron-M-Pesca" and SKL instruments were

used to study the outer radiation belt dynamics in the Earth's magnetosphere during the last solar minimum epoch. Low altitude polar orbits of both satellites permit to observe electron precipitations in Polar Regions every 1.5 hours. The peculiarities of precipitation electron flux with the energies more than 200 keV have been studied. Localized electron precipitations were observed poleward from the external boundary of the outer radiation belt by both "CORONAS-Photon" and "Meteor-m1" satellites. Location of external boundary of the outer radiation belt was studied by data of 200 keV electron fluxes measured during "CORONAS-Photon" regular passes around the globe. It was found that radiation belt location is controlled mainly by Earth's internal magnetic field. During the quiet 2009 high-latitude ionospheric boundary of the outer radiation belt rotates in solar-magnetic coordinates during 24 hour together with the Earth and slightly shifts to the night side due to large-scale magnetospheric currents. Although geomagnetic activity during 2009–2010 was insignificant, ERB variations were typical for moderate magnetic storms. The increased fluxes of the relativistic electron in ERB were measured after the small magnetic disturbances caused by high-speed solar wind stream incoming to the Earth's orbit. These observations show that near-Earth's environment is strongly controlled by solar activity even during solar minimum. The variations of particle fluxes at the external boundary of the external electron radiation belt are analyzed and compared with plasma observations. The events of the appearance of local increases of energetic electron fluxes are selected. Some of these increases have near the same profile and values during 2–3 consecutive orbits. Comparison of analyzed increases and fluxes of plasma particles with energies till $\sim$10 keV show that practically for all events when such comparison was possible increases of fluxes of relativistic and sub-relativistic electrons were observed inside the auroral oval. The nature of observed events is discussed, it is shown that the hypothesis of the appearance of local traps for energetic particles can help to explain the observed phenomena. This work was partly supported by RFBR foundation grants 09-05-00798-a and 07-02-92004-HHC_a.

Extra-galactic gamma ray burst as a source of ELF transient pulse

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We demonstrate that sudden reduction of ionosphere height caused by an extra-galactic gamma-burst may produce an extremely low frequency (ELF) radio pulse in the Earth—ionosphere cavity. Displacement of the charged ionosphere carrying the potential of +250 kV builds up the 'parametric' vertical electric current being the source of electromagnetic pulse. We compute amplitude spectra and waveforms of transients induced by the extra-galactic gamma burst of Dec. 27, 2004. We show that parametric ELF pulse is coincident with the gamma-burst; it has the amplitude substantially exceeding the regular ELF electromagnetic background; its spectrum and waveform carry a substantial 60 Hz component.

Comparison of magnetic field observed by GOES spacecraft with predictions of new version of substorm current wedge magnetospheric models

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The substorm current wedge is a main cause of magnetic field global reconfigurations and particles acceleration. The magnetic disturbances observed by the GOES spacecraft during substroms are contributed by different processes such as substorm current wedge (SCW), partial-ring current (DRP), R2 current systems, global reconfigurations and etc., whose current systems tentatively known. To explore which part of magnetospheric magnetic effects during substorms are produced the substorm current system (SCW) in magnetosphere's tail, we estimate linear and non-linear parameters of the SCW (based on interpretation of midlatitude ground-based magnetic observations using inversion algorithm) and apply these parameters to the new magnetospheric model of SCW (TS09SCW and TS10SCW). We compare predicted and observed magnetic disturbances on the nightside

of geosynchronous orbit to obtain their average ratio and indicate that standard SCW model should be considerably modified.

Regions on the Sun responsible for the high speed streams of the steady solar wind

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As it is very well known a mechanism of the high speed (V≥500 km/s) steady solar wind (SW) formation is not found yet. For a long time coronal holes (CH) were considered as sole sources of such outflows. After spacecrafts, extra-ecliptic Ulysses and near-Earth SOHO, have been launched, the regular data deliver on the SW parameters and EUV solar disk images was provided through near 1.5 solar cycles. On the base of these data the fast SW flows have been identified using the coronal or the solar magnetic field structures. A comparison of two minima reveals similar configuration of coronal features typical for the same phases of the solar cycle. For two minima monitoring Ulysses/SWOOPS presents the same picture: beyond the streamer belt the Sun emanates only high velocity SW with top steady speed 700–800 km/s, related to the weakest (background) magnetic fields on the Sun. Inside the streamer belt in minimum as well as over the whole Sun in maximum slow SW dominates. Coronal holes (open magnetic configuration) may be the sources of fast SW streams either within the streamer belt in activity minimum or at middle and low heliographic latitudes in activity maximum, with flow speeds mainly 800 km/s≤V≤500 km/s.

Fine structure of hydromagnetic emission in the frequency range around 1 Hz from ground-based measurements

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The spectral resonant structure in the frequency range 0.5–5 Hz, caused by the occurrence of the ionospheric Alfven resonator (IAR), is a ubiquitous, but not very regular phenomenon. We analyze clear

IAR signatures at low-latitude stations Moshiri and Paratunka equipped with sensitive search-coil magnetometers. To reveal the fine structure of Pc1 emission we have applied the dynamic FFT and wavelet spectra, static power spectra, and polarization spectrum. For several selected days we monitored the time evolution of spectral structure of the IAR pattern. These results are compared with the predictions of the realistic model of IAR based on the numerical solution of coupled MHD/electrodynamic equations in the system ionosphere-atmosphere-ground, modeled with IRI-derived profile. This joint analysis raises some important questions about possible mechanisms of the IAR excitation, and nature of spectral resonant structure of Pc1 emission.

On the partial coherency of Pi2 sources field

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

Properties of Pi2 magnetic pulsations generation process were found on the base of comparing dynamics of their 2D field distribution with results of Pi2 local ionosphere sources positions determining by applying generalized gradient technique. The main property is these sources partial coherency in the narrow frequency band 0.006–0.010 Hz. It means that intensities of different ionosphere Pi2 sources are redistributed between themselves not only during fundamental Pi2 period but even during every semi-period of their generation. Other ones are alternation of stationary and non-stationary sources behavior during every Pi2 semi-period and the points of time existence when the sources of same Hall-current directions are groups in the ranges of two different spatial zones. These properties are not in the contrary with well known ones of Pi2 behavior being averaged during their period that is supported by comparing their 2D magnetic field distribution dynamics with peculiarities of their auroral luminosity spatial distribution.

Long-period ULF wave activity in the cusp region

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The data of long-period ULF wave activity simultaneous observations at different latitudes are compared from the Svalbard/IMAGE profile of flux-gate magnetometers covering geomagnetic latitudes (74–76°). Irregular IPCL pulsations and narrow-band Pc5 waves were found to be ubiquitous element of ULF activity in the dayside high-latitude region. Their meridional spatial structure is compared with the equatorward cusp boundary determined from SuperDARN return signal width. The narrow-angle photometers of Polar Geophysical Institute in Barensburg were also used to determined position of the cusp by relation of 557.7/630.0 emissions. The occurrence of Pc5 waves in the dayside boundary layers is a challenge to modelers, because so far no mechanism has been identified. The observed structure corresponds to the occurrence of a localized peak in the latitudinal distribution of ULF power about 3° southward from the equatorward cusp boundary, but not under the cusp proper.

The nature of the global Pc5 pulsations

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The nature of so called global Pc5 pulsations was studied in this work. The global Pc5 pulsations have an amplitude as large as hundreds nT, whereas the amplitude of ordinary Pc5 is of the order of tens nT. The global Pc5 pulsations are observed in wide range of latitudes and longitudes. Cases of the global Pc5 pulsations generated by quasi-periodic fluctuations of solar wind dynamic pressure on 31 October 2003 were considered in detail. Data from the IMAGE magnetometer network were used for the analysis. The global Pc5 pulsations were observed in the morning and afternoon MLT sectors. Frequency of these Pc5 pulsations was the same at different latitudes, which indicate that global Pc5 pulsations might be generated

as magnetospheric cavity oscillations. This physical nature is different from one of the ordinary Pc5 pulsations associated with the shear Alfven eigenmode oscillations of magnetic flux tubes. We also used the EISCAT radar data from the tri-static Tromso-Kiruna-Sodankyla system allowing for calculating vectors of the F-region ionospheric plasma flow and electric field. The Pc5 frequency band pulsations were clearly seen in the Hall and Pedersen ionosphere conductivity, ionosphere plasma density, electron and ion temperatures, and the ionospheric electric field. For the both intervals when the Pc5 pulsations were observed in the magnetic field on ground, hodographs of the electric and magnetic fields were made. The angle between polarization axis of the electric and magnetic fields may show whether the pulsations relate to the Alfven mode (indicated by the angle of 90°), or the magnetosonic wave. From these considerations we conclude that the morning Pc5 pulsations were predominantly Alfven waves. For the afternoon Pc5 pulsations the picture is more complicated indicating a mixture of Alfven and magnetosonic waves. The present result agrees with the statistical studies by Rostoker and Sallivan, [1987] and Liu et al., [2009] who have shown that the morning Pc5 pulsations are mainly the Alfven waves generated by the K-H instability at the magnetopause, whereas the afternoon Pc5 pulsations are mainly magnetosonic waves generated by the impulses of the solar wind dynamic pressure.

Relationship between sharp increases of the solar wind dynamic pressure, proton aurora flashes, and geomagnetic pulsations in the Pc1 range

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The relationship between sharp increases of the solar wind dynamic pressure, flashes of sub-oval proton aurora on the dayside, and geomagnetic pulsations in the Pc1 range is statistically considered on the basis of solar wind data from the OMNI database, proton aurora observations from the IMAGE spacecraft, and observations of geomagnetic pulsations at ground station Lovozero ($L = 5.3$). It is shown that some 70% of the solar wind pressure jumps are associated with proton aurora flashes equatorward of the proton aurora oval on

the dayside. It is also noted that pressure jumps related to interplanetary shocks correspond to proton flashes more frequently than those related to other (presumably, tangential) discontinuities. This is evidently related to stronger compressions of the magnetosphere during interplanetary shocks, as demonstrated by consideration of variations in the SYM-H index. As known, solar wind pressure increases frequently (but not always) associate with the appearance or sharp change of the regime of geomagnetic pulsations Pc1. We found that such Pc1 response is always observed when the ground station registering the pulsations is conjugated with the region of the proton aurora flash. The probability to observe the response is sharply decreases when the ground station is outside the proton aurora flash area. Thus, the proton aurora flash "highlights" the location of the Pc1 source. Since the pulsations in the Pc1 range are an indicator of the electromagnetic ion-cyclotron waves, we conclude that the flashes are the result of the ring current proton precipitation due to ion-cyclotron instability developing on the dayside under magnetospheric compression and related increase of the ring current proton anisotropy.

Peculiarities of the geomagnetic pulsation behaviour during the recent solar minimum

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The time period from 2007 till 2009 was a period of the deepest and longest solar minimum in the past two centuries. Following the sunspot dip the magnetic activity also dropped to very low values. Nevertheless, solar coronal holes continued to throw off high speed streams (HSS) of the solar wind, thus producing individual isolated magnetic disturbances in the Earth's magnetosphere. This situation provides great scope for experimental research in the solar wind–magnetosphere–ionosphere system dynamics including ULF wave phenomena and wave-particle interaction in their pure form, without a superposition of concurrent events or extraneous turbulence. In this work, we study various manifestations of weak magnetic disturbances in the ULF activity during the sunspot minimum using data from both polar and mid-latitudinal stations, as well as in situ measurements in the solar wind. To illustrate advantages of the

extremely quiet solar and magnetic conditions, we analyse a case of direct penetration of 3–4 mHz MHD waves from the solar wind into the magnetosphere. The lack of an interplanetary shock wave ahead of the HSS in that case made it possible to separate penetrated oscillations from those generated inside the magnetosphere due to dynamic pressure pulses. In spite of low intensity of the penetrated waves they produced a detectable increase in relativistic electron fluxes at the geosynchronous orbit. Statistics of different kinds of geomagnetic pulsations observed during the period under consideration is also given. Characteristics of oscillations were analysed in relation to the magnetic disturbance and the interplanetary parameters. The work was partly supported by RFBR grants 09-06-00048 and 10-05-00661.

The connection of coronal holes magnetic topology with geomagnetic disturbance

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It is well known that high-speed streams of a solar wind connected with the low latitude coronal holes at the Sun are the main source of geomagnetic disturbances is from coronal holes during the solar minima. The magnetic structure of coronal holes was investigated at chromospheric and coronal levels, and compared them with solar wind and geomagnetic disturbance characteristics for the time period July-November 2006. It was found that if magnetic flux at chromospheric and coronal levels was connected with south polarity of magnetic structures, the most intensive and long duration storms (Dst and Kp indexes) and sub-storm (Ae-index) activity was observed. The strong dependence between amplitude of geomagnetic disturbances and magnetic flux of coronal holes wasn't found. The results of potential extrapolation of photospheric magnetic field to coronal levels demonstrate that noted cases have been connected with the especial configuration of a coronal holes magnetic field which included combination open components of a magnetic field with high (up to solar radius) loops closed out of the coronal hole. The solar "quasi-open" magnetic field configurations contributing geomagnetic disturbances were investigated.

Very intense magnetic storms in 1841–1870 registered by the Russian geomagnetic network

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Our report poses the problem of the use of the Russian historic geomagnetic data for the purposes of space weather. The Russian network of geomagnetic observatories was constructed in 1830, when regular measurements in Yekaterinburg, Barnaul, Nerchinsk, Tiflis, Sitka and Beijing (connected to the Russian embassy) were added to the magnetic measurements already performed in St. Petersburg. In this work we present an analysis of very intense magnetic storms registered in 1841–1870 by these observatories. A catalog of very intense magnetic storms during 1841–1870, which covers 9–11 solar cycles, has been constructed. The catalog contains initial moments of the storm, the most disturbed day (periods) and the storm's duration common for all Russian observatories. Maximal range of magnetic field components H and D and Z for St. Petersburg and information on solar and geomagnetic activity are given. Statistical characteristics of intense magnetic storms during considered period are found. Our results testify that high solar activity plays a critical role in generating very intense storm in the considered period of time. For our collection of storms it is found only one peak in solar cycle which falls into years of maximal activity (or little earlier): magnetic storms in years around solar maximum were double that those in less active periods. Such distribution is characteristic for the storms which are associated with interplanetary magnetic clouds. Yearly distribution of 1841–1870 storms shows a peak in September-October and a secondary peak in February. In addition it is found an inverse dependence of the storm intensities from their duration.

Magnetopause pressure balance at the subsolar point in accordance with data of THEMIS mission observations

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Magnetic field and plasma measurements onboard the THEMIS satellites are used to study the plasma pressure balance across the magnetopause. Both plasma flows and magnetic field vary significantly in the magnetosheath. Nevertheless, it has been shown, that despite such great variations and restrictions to the applicability of MHD approximation in case of the noncollisional plasma, the condition of stress balance is fulfilled with comparatively high accuracy. Cases are selected when the direction of the magnetic field in the solar wind does not coincide with the direction of the magnetic field near the magnetopause at the subsolar point (has the opposite direction). The amplitudes of magnetic field fluctuations in the magnetospheath are compared to the values of magnetic field inside the magnetosphere at high latitudes. It is shown that magnetic pressure in the magnetosheath is the important factor of magnetopause stress balance at high latitudes.

Electron density retrieval algorithm using GPS/LEO Observations

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Probing the Earth's atmosphere and ionosphere via GPS radio occultation (RO) observations from Low Earth orbiting (LEO) satellite is widely used to study the ionosphere. Radio occultations occur when the ray path between a GPS transmitter on a GPS satellite at 20600 km and a GPS receiver on a Low Earth Orbit (LEO) satellite (at typically 600–1000 km altitude) is eclipsed by the Earth. Formosat-3/COSMIC (Constellation Observing System for Meteorology, Ionosphere and Climate) is a joint scientific mission between Taiwan and the U.S.A. 6 LEO satellites with GPS receivers on board are able

to provide about 2500 occultations per day. In order to take advantage of such unprecedented amount of occultations, it is necessary to prove different retrieval techniques. The standard Abel inversion technique assumes that the ionosphere is spherically symmetric with no horizontal density gradients. When there are substantial ionospheric density gradients present, the Abel inversion technique yields poor results due to an inability to handle gradients.

In this report the new algorithm retrieving the ionospheric profile from RO observations with taking into account the presence of ionospheric irregularities with different scale sizes along the ray-path is presented. The retrieving of the ionospheric height profile is an ill-posed formulated problem of the mathematical physics. The task has only approximate solution. To obtain an adequate information it is necessary to use the regularizing algorithms and to have prior knowledge including statistical information of the derived solution. It is shown that in the presence of the minimum aprioristic information, the given technique is able to minimize the influence of large-scale (10 km) irregularities and to exclude the impact of the instrumental errors.

Solar corpuscular influence on different Earth's atmospheric layers

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Solar excited interrelated events of different Earth's atmospheric layers are reviewed in frame of systematic paradigm TAIM (tectonosphere – atmosphere – ionosphere-magnetosphere), including seismoelectromagnetic phenomena. The hypothesis is advanced, that solar cosmic rays are responsible for many of this interrelated processes. Trigger mechanisms are recognized, which may may be effective in such interactions, including polar precipitations, precipitations of charge particles from radiation belts, ion jumps in solar wind, crossings interplanetary magnetic field (JMP) boundaries etc.

Climate periodicities millions of years ago and its relation with solar activity

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Unique palaeoclimatic data with annual time resolution (tree ring widths, annual deposits of varves) are analyzed with the aim of revealing periodicities in climatic processes at time scales from tens of thousands to hundreds of millions of years. The climatic periodicities thus found are compared with the solar and climatic periodicities observed at present.

Intermittency of solar wind ion flux at the scale range till tens of Hz

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Solar wind is a flow of turbulent plasma. The investigation of its characteristics is very important part of the solution of the problem of the energy transport from the solar wind to the magnetosphere. The turbulence of the solar wind has the property of intermittency. Using data of Interball-1 spacecraft gives the possibility to study properties of solar wind turbulence in the not investigated previously frequency range under large statistics. The intermittency of solar wind ion flux fluctuations is studied using high time resolution measurements onboard Interball-1 spacecraft on scales from 0.01 to 16 Hz. The importance of the work is connected with the possibility for the first time to study the earlier unexplored (by plasma data) region of comparatively fast variations (frequency up to 16 Hz). So

we significantly extend the range of intermittency observations of solar wind plasma. It is shown that the intermittency is practically absent on scales more then 1000 s and it grows to the small scales right up till t = 30–60 s. Its behavior is rather changeable on smaller scale (less than 30 sec). Special attention is concentrated on the comparison of intermittency for intervals of solar wind observation containing SCIF (Sudden Changes of Ion Flux) to ones for intervals without SCIF. Such a comparison allows one to reveal the fundamental turbulent properties of the solar wind regions in which SCIF is frequently observed.

Connection between Pc5 ground-based intensity and oscillation mode in the magnetosphere

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The Pc5 events are picked out from GOES-08 data, and they compared with simultaneous pulsations on the earth in PBQ observatory near the footprint of field line passing through the geostationary satellite. Magnetospheric pulsation mode is taken into consideration, and it is found that intensive pulsations on the ground are connected with intensive azimuthal pulsating hn-component in the satellite, i.e. with toroidal mode of oscillation, not poloidal.

Magnetospheric response to an interplanetary shock on 29 July 2002

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An interplanetary shock caused by a solar flare reached the Earth at 13:22 UT on July 29, 2002. The sudden impulse connected with the shock was observed by Geotail, GOES 8, GOES 10, and Polar in the equatorial dawn magnetosphere. The sudden impulse initiated quasi-periodic ULF electromagnetic pulsations with periods of 2.3–4.3 min

observed in the outer magnetosphere. The dayside magnetopause moved inward, causing Geotail to enter the magnetosheath where the spacecraft observed similar pulsations. We connect these pulsations with radial magnetopause motion predicted by the global MHD model BATS-R-US. This event demonstrates connection between transverse Alfven waves at the geosynchronous orbit and compressional waves near the magnetopause.

Distribution of parameters of plasma and magnetic field across reconnection layer: Comparison MHD modelling with the analytical solution

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Magnetic reconnection is universal plasma process which is responsible for solar flares, magnetospheric substorms and solar wind – magnetosphere coupling. In the course of reconnection two outflow regions with accelerated plasma, are formed. Magnetic reconnection occurs very often in asymmetric current layers which separate two plasmas with different parameters. When reconnection started the current layer breaks up to a system of MHD discontinuities such as alfvenic discontinuities, slow shocks, and contact discontinuities. Between them MHD parameters (plasma speed, magnetic field, plasma density and temperature) are constant if initial current sheet can be considered as tangential discontinuity. The problem about decay of tangential discontinuity is known as Riemann problem which can be solved analytically for the case of weak reconnection. In reality an initial current layer has some internal structure and finite thickness. Therefore there is a question on applicability of the theory (analytical solution). To outline the boundary of applicability it is necessary to compare MHD simulation to the analytical solution. The MHD parameters obtained from the solution of the Riemann problem have been compared with the result of MHD simulation of asymmetric reconnection. After some initial period which is necessary for MHD discontinuities to be formed, comparison shows rather good agreement.

Concerning the dependence of electric potential on the meridian dawn–dusk upon the intensity of IMF B_z-component

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In this paper results of previous our researches have been used [Ponomarev, Sedykh, J. of Atm. Solar-Terr. Phys. Vol. 68. 2006; Ponomarev, Sedykh et al., Geomagn. and Aeron., 2009], in which the expressions are obtained for electric current generated in the bow shock front, as well as for the magnetopause potential as a function of solar wind parameters, such as plasma density, velocity and intensity of the interplanetary magnetic field. The solar wind kinetic energy partly transforms to gas kinetic and electromagnetic energy when passage through the bow shock front. A jump of the magnetic field tangential component at front crossing means that the front carries a current. It is concluded in [Ponomarev, Sedykh, 2006; Ponomarev, Sedykh et al., Geomagn. and Aeron., 2009] that according to all parameters MHD-generator of electric power in the bow shock front meets the requirements, made to the power source for magnetospheric processes. The direction of current behind the bow shock front depends on the sign of the IMF B_z, B_y components. It is this current which sets convection in motion. The energy flux into the magnetosphere is closely related to the current through the magnetosphere by the well-known expression. In the paper a question has been discussed concerning physical interpretation of formal solution of a boundary-value problem of the potential within the paraboloid of rotation modeling the magnetosphere. It is shown that the structure of the electric potential that consists of two terms, the first of which depends on solar wind parameters, whereas the second does not under certain conditions, is in agreement with the empirical data obtained on the dawn–dusk meridian.

The two-stage development of substorm active phase

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Bow shock is a powerful transformer of the solar wind kinetic energy into the gas dynamic and electromagnetic energy. A jump of the magnetic field tangential component at the bow shock front crossing means that the front carries an electric current [Ponomarev, Sedykh, J. of Atm. Solar-Terr. Phys. Vol. 68. 2006; Ponomarev, Sedykh et al., Geomagn. and Aeron., 2009]. The process of penetration of the external current from the generator (located at the bow shock front) into plasma is a two-stage one. Initially, the polarization electric field is produced, which penetrates into plasma layer by layer. Or, more exactly, the momentum corresponding to this field penetrates into plasma. Here, if the system is inhomogeneous, the flow can redistribute pressure in such a manner that an electric current arises in plasma because of the appearance of gradients. Energetically, this current is necessary for maintaining plasma convection in the inhomogeneous system. Any change in external current through the magnetosphere causes a convection restructuring within a time on the order of the travel time of the magnetosonic wave from the magnetopause to the center of the system, because the restructuring wave comes from both flanks. Until a new distribution of gas pressure is established, the role of the force counteracting the Ampere force is played by the inertial force. This corresponds to the acceleration of plasma and hence to a change of the electric field. The energy flux into the magnetosphere is closely related to the current through the magnetosphere by the well-known expression. The establishment time of the electric field in a system here is about $t_e = L/V$, and the time of the current establishment — of about $t_i = L/V_c$, where L — the system size, V_f — phase velocity of the electromagnetic signal propagation across the system, V_c — plasma convection velocity. An approximate estimate used to magnetosphere gives the time of electric field establishment — hundreds of seconds, the electric current establishment time — of about an hour. Thus, there exist two time characteristic parameters, which are connected with the development of substorm active phase. Results of research of processes in the bow shock region and process of external current penetration into the magnetospheric plasma lead to the scenario of a substorm with two-stage active phase as an alternative of the traditional scenario of

a substorm with growth phase, expansion phase and recovery phase. It may be noted that such two-stage development of an active phase of a substorm is observed in reality and it is possible to note it according to some observations. Researchers, who are engaged in substorm phases description, note that the active phase of a substorm may be two-stage process. Instead of traditional description of three phases of a substorm (growth, expansion, recovery), e.g., some researchers separate the active phase of a substorm on active-convectional and expansion phase. Also, for example, the chain of 4 substorms has been described, and in development of an active phase two-level process has been marked.

Multi-instrumental analysis of the ionospheric effects during 11 October 2008 geomagnetic storm

Shagimuratov, I.I., Zakharenkova, I.E., Yakimova, G.A., Koltunenko, E.M. (West Department of IZMIRAN, Kaliningrad, Russia)

In report we present analysis of the ionospheric response to the moderate (Dst70 nT), 11 October 2008, geomagnetic storm using different observation techniques — GPS TEC measurements of the European network, radio occultation (RO) and digisonde measurements of DIAS network.

The distinctive feature of the moderate geomagnetic storm was the short duration of the positive ionospheric effect during 10-15 UT. The strong TEC enhancement reached the factor 2 relative undisturbed conditions. Amplitude of the surge reached the factor 2 and slowly decreased to the equator. This effect was associated with wave process propagated from auroral ionosphere to equator with speed of about 450 m/s. TEC maps demonstrated that during storm the horizontal ionospheric gradients over Europe were essentially increased. The disturbance leads to the change of the TEC gradients structure against to the regularly gradients observed in quiet ionospheric conditions. Maximal latitudinal gradients took place near equator and polar walls of main ionospheric trough. After noon the main ionospheric trough was shifted equatorward and reached the geographical latitudes of 57°. The high degree of correlation between TEC behavior and foF2 values observed at the European midlatitudinal digisondes.

FormoSat-3/COSMIC RO measurements were applied in the investigations of the ionosphere height structure and its modification during this geomagnetic disturbance. It was shown that there is a possibility to complement the ionosphere studies based on the standard ground-based GPS measurements with the information about the vertical electron density distribution retrieved from LEO GPS measurements. This positive effect was revealed distinctly in RO electron density profiles and products based on these data - ionospheric electron content and global maps of electron density.

Comparison of different magnetotail magnetic flux estimates

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A comparison of simultaneous magnetotail magnetic flux estimates, obtained from (1) in situ spacecraft measurements in the tail and solar wind (F_T) and (2) from global auroral images (done separately using proton-induced or electron-induced emissions, F_p or F_e, respectively), was carried out. We compared them both on the basis of event studies and statistical analysis. Simultaneous imager-based F_p and F_e estimates do not show perfect agreement between them (the correlation coefficient CC=0.74 in our data set), indicating that these measures are not absolute. Regression analysis of F_T versus F_e and F_p gave CC values 0.73 and 0.50, correspondingly. F_T values are systematically higher (by 20–30%) than F_p and F_e ones, resulting from closed magnetic flux contribution to F_T.

Diverse results, published by different groups, motivated us to reanalyze the magnetic flux dependence on the dayside merging electric field , averaged by preceding hour(E_m), for subsets, characterizing different dynamical states. The linear regression $F(E_m)$ for a subset, grouping substorm onsets (SO), gives a large dependence of tail magnetic flux on the solar wind driver with a slope of ∼0.07–0.12 GWb/(mV/m) for all F_p, F_e and F_T , confirming the loading-unloading substorm scheme. For steady magnetospheric convection (SMC) intervals this slope is only ∼0.03 GWb/(mV/m). A limited statistical analysis shows that the $F(E_m)$ regression slope is smaller for sawtooth onsets than for SO, possibly due to a saturation effect.

Substorm current system as viewed from observations in the magnetotail lobes

Smirnov, M.V., Sergeev, V.A., Tsyganenko, N.A., Apatenkov, S.V. (St.Petersburg State University, St.Petersburg, Russia)

General purpose of our study is a testing of new Substorm Current Wedge (SCW) model (T09SCW, N.A.Tsyganenko, 2009, not yet published) by comparing observed and predicted magnetic field during substorm dipolarizations. Input parameters of T09SCW (location and total current) were determined by inversion algorithm based on interpretation of ground magnetic field observations (INTERMAGNET data). We identify substorm-related magnetic field variations measured onboard Themis-C and Cluster (C1 and C2) spacecraft in southern and northern tail lobe, correspondingly. Spacecraft are required in the nightside magnetosphere near/inside of SCW sector and outside of the plasma sheet. Then we compare predicted SCW B-field with spacecraft observations and found that new SCW model underestimates real magnetospheric variations: observed B_z component typically exceeds the modeled B_z by a factor of 1.5–2.0. It occurs that real current system is much more complicated than "cartoon SCW" model.

Simultaneous radial and pitch angle diffusion of radiation belt protons

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

The equation of radial and pitch angle diffusion is offered, which allows to model change of pitch angle distribution from time and distance. 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.

The solar wind influence on tail reconnection

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We reexamine 13 previously published reconnection events in order to understand how different conditions in the solar wind and in the magnetotail influence the properties of the reconnection process. Each of these events were identified based on in-situ Cluster measurements in the plasma sheet. This project consist of two parts. In the first part we study how the total pressure in the plasma sheet vary before and after reconnection onset, and how it is influenced by local parameters like density and B_z. In the second part we study how the electric field and the dynamic pressure in the solar wind influence the reconnection process in terms of flux transfer from the dayside to the nightside and flux storage in the magnetotail. For this purpose we apply a method which was recently published by Shukhtina et al. [2009] in order to estimate the magnetopause flaring angle and the tail radius.

Research features of the meridional and azimuthal dynamics of auroral electrojet under different conditions of solar wind and IMF during superstrong magnetic storms

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According to the global ground geomagnetic observations in the six meridian chains and analysis of satellite measurements the auroral electrojet features at various conditions in the solar wind (SW) and the IMF: during a sharp rise of dynamic pressure up to ∼15–60 nPa and variations in the intensity and sign of the IMF B_z-component to ~ -40 – 50 nT. The data obtained during super strong magnetic storms of October 29–30, 2003, November 20–21, 2003, November 07–08, 2004 and November 09–10, 2004 (Dst ≈ -300 – 400 nT) are analysed.

The following scientific results are obtained:

1. It is shown that a sharp increase of the SW dynamic pressure (Pd) and the excitation of a sudden impulse (SC) during IMF B_z negative ($B_z < 0$) leads to a simultaneous (with accuracy 1–3 min) increase of DP2 current system and the intensity of the western electrojet (J_w) in a broad sector of longitudes and expansion of J_w to the pole up to the polar cap latitudes with the velocity of $V_N \sim$ 1–3 km/s.

2. It is found that during the sharp rise of Pd up to 60 nPa for IMF B_z positive ($B_z > 0$) $\sim$ 35 nT is the amplification of eastward magnetopause currents and DP2 current system are observed. Strengthening and dynamics of the westward electrojet is not observed.

3. We find that during periods of intensity growth of negative values of IMF B_z to -50 nT within a few hours there is a shift of the centers of auroral electrojet to the equator up to latitudes about 10–20 degrees along the meridian with a speed of 0.1–0.4 km/s with a simultaneous amplifications of Jw repeated in 1–2 hours with a duration of 1–2 hours at latitudes from low to auroral latitudes and with a possible extension to electrojets up to the polar cap latitudes and the abrupt extension of the subsequent Jw electrojets localization region by azimuth.

4. It is shown that after the electrojet displacement to the equator during southward direction of IMF B_z and enhancement of the SW electric field the IMF B_z turning to the north accompanied by the poleward expansion of Jw electrojet at a speed of $\sim$ 1 km/s in a wide range of longitudes is observed.

5. It is found that the electrojet expansion to the pole during superstorms often occurs up to the polar cap latitudes due to the extension of the precipitating particles and increased ionospheric conductivity region from the low and auroral latitudes, but not due to the movement of localized westward electrojet along the meridian, as is the case in the substorm.

The report discusses the possible causes of the dynamics of auroral electrojets under different geophysical conditions.

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The role of meridional circulation in solar dynamo models

Stepanov, D.I., Ponyavin, D.I (Institute of Physics, Saint-Petersburg State University, Russia)

This work is devoted to the analysis of kinematic model of solar dynamo. The main components of this model are: differential rotation, meridional circulation, alpha-effect, turbulent diffusion and magnetic buoyancy mechanism. Each of these components plays its own role in the whole dynamo-orchestra.

Until a recent times it was a little known about meridional circulation. Meridional circulation is a weak flow in meridional plane. It is directed toward the poles on solar surface. The relevance of this flow in different dynamo models is conventionally accepted. Data of last years has thrown light on the behavior of meridional circulation during the solar activity cycle. This data caused the idea of researching this phenomenon.

We investigate the degree of influence of meridional circulation and its variability by modeling solar dynamo with real profile and approximate features of the flow.

Auroral current fluctuations as a source of ULF electromagnetic background noise

Surkov, V.V., Goncharov, S.V., Ignatov, V.N., Popov, V.D. (National Research Nuclear University "MEPhI", Moscow, Russia)

An origin of electromagnetic natural noise observed on the ground surface in the frequency range $10^{-2} - 10^{-4}$ Hz was examined. In the model it is conjectured that the random field-aligned currents, coming from the magnetotail, generate in the F-layer MHD-waves, which incident on the conducting E-layer of the polar ionosphere that, in turn, produces electromagnetic fluctuations. A flicker noise, provided by auroral current fluctuations, is assumed to be a possible source of the ULF electromagnetic noise. Random electromagnetic variations in the atmosphere are related to the field-aligned currents in the magnetosphere by virtue of a transfer function, which is supposed to be a deterministic function. A correlation matrix and power spectra of the random electromagnetic fields on the ground surface were calculated. A correlation radius of random ionospheric currents is supposed to

be controlled by neutral gas transfer and by acoustic/gravity wave propagation inside the E layer. 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 were demonstrated to be sandwiched between two theoretical lines, which correspond to low and high geomagnetic activity. The variations of the ULF power spectra amplitude in the auroral region may be indicative of large-scale reconstruction in the magnetotail, which in turn may be used for the magnetospheric substorm prediction.

Experimental evidences for the permanent presence of charged dust in the auroral dynamo layer

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Correlation features between temporal variations of the ion and electron temperatures, T_i and T_e, respectively, as measured by the EISCAT facility within the dynamo layer (DL) altitudes over Tromsø during the ERRRIS auroral campaign are studied as a function of the radar integration time and the strength of the ionospheric electric field. The data covers about 60 hours of measurements for 20 near-midnight MLT sector events in two 1988–89 spring seasons. It is found that: 1) Typical anticorrelation of the ion and electron temperature variations is found in more than 70% of measurements. It means that the auroral DL plasma permanently mainly exists in either one of the two non-equilibrium thermo-dynamical states: with heated electrons and cooled ions or with heated ions and cooled electrons. 2) Transition from one metastable level to another one takes place every 30-60 seconds, i.e., the average lifetime of the metastable levels was less than 1 minute. 3) The correlation coefficient between T_e and T_i measured at the 106 km altitude increased from 0.2 up to 0.9 in about 40 minutes (for the March 23, 1988 event) when the moving average of the electric field strength smoothly increased below the Farley-Buneman instability threshold of about 10 to 17 mV/m. In contrast, the correlation coefficient sharply decreased to about zero in the next 10 minutes when the E-field exceeded the threshold growing up to 30 mV/m. The results are interpreted within the framework of the three-component scheme of the auroral midnight DL plasma consisting of electrons, ions and meteor dust grains. It is assumed

that the negative polarization of the dust E-fields is responsible for the antiphase heating of ions and cooling of electrons. The presence of numerous meteors for the events is supported by independent data of the IMO site. Besides, the permanent thermodynamical non-equilibrium found in the data explains the puzzling huge scatter of ion and electron DL temperatures reported by our predecessors for small E-field conditions.

Data-based magnetospheric models: Meeting the challenge with new resources

Tsyganenko, N.A. (St.Petersburg University, St.Petersburg, Russia)

Last four decades witnessed a remarkable progress in our ability to realistically model the distant geomagnetic field and its response to external driving by the solar wind. Two major factors have been instrumental in the continuing success of the data-based approach: (i) rapid accumulation of archived satellite data, largely boosted in recent years by the advent of multi-point space observations, and (ii) a nearly exponential growth of the performance of computing hardware (the Moore's law). The new resources offered by the modern space and computing technologies open the way to significantly improve spatial resolution of the models, making it possible to use them for studying the temporal evolution of the distant geomagnetic field and magnetospheric currents on a global scale. This talk will focus on some recent results in that area, in particular, on the modeling of azimuthally asymmetric equatorial currents and associated Birkeland currents.

CR cutoff rigidity in the magnetic field of the Tsyganenko TS04 magnetosphere model during stormy period in November 2003

Tyasto, M.I., Danilova, O.A. (SPbF IZMIRAN, St.Petersburg, Russia), Sdobnov, V.E (Institute of Solar-Terrestrial Physics, SD RAS, Irkutsk, Russia)

Cosmic ray cutoff rigidities regulate access CR particles to any position into magnetosphere and so they are important factor of space

weather. The accuracy in determining of geomagnetic cutoff rigidities substantially depends on a magnetospheric model used in calculations. Using the trajectory tracing method and the Tsyganenko magnetosphere Ts04 we determined effective vertical cutoff rigidity changes during the strong stormy period in November 2003. The results obtained were compared with geomagnetic cutoff rigidities calculated in magnetic field of the Tsyganenko Ts01 model and cutoffs calculated by the spectrographic global survey method based on the neutron monitor world net data.

Numerical modelling of Cosmic Ray Induced Ionization in the Earth's atmosphere

Usoskin, I.G. (Sodankyla Geophysical Observatory, University of Oulu, Finland)

Cosmic rays form the main source of the atmospheric ionization in low and middle atmosphere. A major progress has been recently achieved in numerical modelling of this process, basing on a full Monte-Carlo simulation of the complicated cascade initiated by cosmic rays in the atmosphere. Here we present our numerical model, based on CORSIKA Monte-Carlo tool, that is capable of computing the cosmic ray induced ionization in the entire atmosphere, from ground up to the mesosphere. We discuss also other existing models and approaches, their inter-comparison, range of validity, advantages and missing points. We also perform an extensive comparison between model simulations and direct measurements and provide practical recommendation for a correct choice of the model parameters.

Fractal dimension of solar wind plasma flows in solar minimum

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

Last solar minimum is especially interesting to research of long-term phenomena of solar activity. It is necessary to notice that historical view on the solar activity, only as about level of sunspot generation

on solar disk, today cannot be satisfactory. Now the concept of solar activity becomes much wider, than representation about sunspots on the solar disk and W numbers, as the characteristic of spot generation. The retrospective analysis of solar cyclic repetition and disorder of the published forecasts specify in insufficiency of earlier accepted estimations. Deviation from empirical Gnevyshev–Ol' rule speaks us about change of the tendency in processes of sunspot appearance. However, Wolf's numbers represent a solar activity in general features, therefore it is necessary to research of variations of global solar physical characteristics. Energy transformations on the Sun provide a variety of solar activity, which never stops, finding other forms in time of realization. Data of synoptic charts of the Sun, coronal holes and high-speed streams of solar wind, dynamics of large-scale solar magnetic fields and heliospheric plasma layer characterize heliophysical processes in a minimum. A lot of information is completed by data in near-Earth cosmic space. Plasma and interplanetary magnetic field of solar wind were treated with help of fractal methods. The fractal estimations of time series of solar wind parameters (Wind data) allow us to evaluate the altered structure of flows, connected with change of the origins on photosphere, in solar corona and with the propagation on 1 AU from the Sun to the Earth. Geomagnetic disturbance is in use as additional information about solar wind action on the Earth. Solar wind flow structure is the valuable characteristics in solar cycle. The growth phase beginning of 24-th solar cycle is connected with the transformations of fractal dimension values of solar wind. It confirms increase of the sporadic phenomena in a new cycle.

The connection of secular variation of solar activity, atmosphere circulation and air temperature of Northern hemisphere

Val'chuk, T.E. (Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation (IZMIRAN) RAS, Troitsk of Moscow region); Kononova, N.K. (Institute of Geography RAS, Moscow)

The analysis of annual values of sunspot numbers W shows that the least values in XX century were marked in 1913 (W=1.4, solar cycle minimum 14). At the beginning of XVIII and XIX centuries were marked deeper minima: in 1711 and 1712 – W=0, in 1810 – W= 0.

The aa index, calculated since 1868, has appeared of minimal value aa= 8.6 nT in 1913 too. Thus, within three centuries secular minima of solar activity had place on the beginning of the century. The analysis of Northern hemisphere atmosphere circulation in typification of B.L. Dzerdzeevsky, V.M. Kurganskaja and Z.M. Vitvitskaja, conducted since 1899, has shown that in the beginning of XX century circulating mechanisms at which simultaneously in several sectors of a hemisphere there were powerful arctic intrusions dominated, the arctic anticyclone incorporated strips of a high pressure to subtropical anticyclones therefore the western zonal carrying over was blocked. Total duration of such processes was the greatest in 1915 and equal 278 days in a year. The analysis of average temperature of air of Northern hemisphere, data on which are available since 1850, has shown that the lowest average annual temperature was marked in 1917 (the deviation from average for 1961–1990 has made -0,544° C). It is natural, since advancement to the south of arctic air should lead to a cold snap with inevitability. Thus, the chain is built: a minimum of solar activity (1913) – a maximum of blocking processes (1915) – a minimum of average annual temperature of air on Northern hemisphere (1917). In the end of XX century the solar activity minimum covered 1995–1997 and was deep. In 1997 total duration of circulation groups with two and more blocking processes on Northern hemisphere prolonged only 147 days. Since 1998 growth of blocking process duration has begun. In the beginning of XXI century the prolonged minimum of solar activity proceeded per 2006–2010. In 2009 total duration of blocking process duration amounted to 265 days – it exceeds average value for 70 days. The maximum of average annual temperature of air on Northern hemisphere was marked in 2005; a deviation has made 0,626°C. Since this year the temperature has started to go down gradually, and in 2009 the deviation has made already 0,518° C. As the evolution process of atmosphere circulation has occurred only 12 years ago, and fall of air temperature goes only 4 years, now there is no saying when these characteristics will reach extreme development. What will be their values? We look now a communication of solar activity minimum – atmosphere circulation – the climate fluctuations, as B.L. Dzerdzeevsky noticed still in 1956, in the middle of XX century. Presently it is possible to assume repetition of the similar scenario.

Multiscaling modelling of random extreme events stream of space weather

Varlamov, A.A. (Saint-Petersburg State University, St. Petersburg, Russia); Yakovchuk, O.S. (Institute of Nuclear Physics, Moscow, Russia)

In report, a problem of modeling of extreme events using the infinitely divisible cascades (IDC) is being discussed. Events, which are called as "Extreme", are accepted to exceed the given threshold value in any or several types of parameters. It is convenient to learn statistics of the events using time of recurrence notion, i.e. reiteration in events' stream. In many cases the statistics of time of recurrence looks like a Pareto power law. Power laws reflect the properties of statistical scaling invariance (multifractal concept). But in fact, multifractal models are limited by finite resolution in experiment. Recently proposed IDC models take into consideration that the scales are finite and allow us to obtain ensembles of events with given scaling properties. We apply this technique to several time series of extreme (NOAA classification) events and also great magnetic disturbances in Dst-index events. Frechet distance is being used to measure the similarity between model and observation.

Long-term variability of solar activity and cosmic ray effects on the lower atmosphere circulation

Veretenenko, S.V., Ogurtsov, M.G. (Ioffe Physical-Technical Institute RAS, St.Petersburg, 194021, Russia)

Studies of solar-climatic relations are of significant importance to understand a variability of the Earth's climate and to forecast its future evolution. However, these relations reveal instability in both time and space that sometimes gives rise to doubt a reality of solar activity influence on atmospheric processes. In this work we studied the spatial and temporal distribution of long-term effects of solar activity (SA) and galactic cosmic rays (GCR) on the lower atmosphere circulation as well as possible reasons for the peculiarities of this distribution. The results of this study show that the SA/GCR effects on pressure variations in the lower troposphere are characterized by a strong regional variability which depends on the specific features of the atmospheric circulation in the regions under study.

The distribution of the correlation coefficients between the pressure variations and sunspot numbers/GCR intensity was found to be determined by the climatic positions of the main atmospheric fronts. The most pronounced pressure changes associated with solar activity and GCR variations were detected in the areas where the most important elements of the large-scale atmospheric circulation (namely, the polar vortex at high latitudes and the planetary frontal zone which is an area of intensive cyclogenesis at middle latitudes) are usually formed. It was also shown that the SA/GCR effects on pressure in the high-latitudinal region reveal a strong 60 yr periodicity which seems to determine a character of the atmosphere response to solar activity and GCR variations at middle and low latitudes. The detected changes in the character of SA/GCR effects on pressure variations in different regions were found to be related to the changes in the large-scale circulation epochs which in turn may be caused by the long-term solar variability.

Observations of Pc5 pulsations with ionospheric radars

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Ionospheric signatures of Pc5 pulsations are often observed by ionospheric radars and ground-based magnetometers. According to theory these pulsations are field line resonance Alfven waves generated by solar wind-magnetosphere interaction and induce electric currents in the ionosphere. In this study we are considering two afternoon Pc5 events when they have been observed using STARE radars and IMAGE magnetometer network. The use of complementing EISCAT, STARE and IMAGE measurements allows to study the observed ionospheric irregularities in greater details. It has been found that irregularities in STARE backscatter are not associated with increase in overall electron density, caused by particle precipitation associated with Alfven waves, but rather with intensification of its variations on certain scale-lengths driven by electric field of such waves. Electric fields and ionospheric conductivities have been estimated based on the radar data. Good agreement with data from ground-based magnetometers has been found.

Inferring IMF polarity from geomagnetic records

Vokhmyanin, M.V., Ponyavin, D.I. (St. Petersburg State University, St. Petersburg, Russia)

Interplanetary Magnetic Field (IMF) is a large-scale magnetic field of the Sun extended into the heliosphere. Heliospheric Current Sheet (HCS) separates magnetic field of opposite polarity and makes a sector structure of the IMF in projection to the ecliptic plane. Thus extracting the sector structure of the IMF from ground based proxies is very useful in analyzing the global magnetic processes at the Sun. In this work we construct a method of inferring IMF polarity by using geomagnetic records at polar stations. The methodology is based on the Svalgaard-Mansurov effect. Currently we have the following results. For each station it was identified characteristic timescales of the effect and seasonal variation over the year. Also we introduced a technique of calculating the background geomagnetic field. The accuracy of inferring polarity compared with the satellite data (from 1965 to 2005) is around 75% for single station Godhavn (76.8° N), and near 80% for Thule (86.2° N) and Godhavn when used together. We have applied a smoothing procedure to our results that leads to allocate the main large-scale features of the sector structure. Construction of a new catalogue of IMF polarity will allow us to study the evolution of the sector structure over the solar cycle for the period of about 80 years.

Effect of precipitation of charged particles on the magnetic field lines dipolarization

Volkov, M.A. (Murmansk State Technical University, Murmansk, Russia)

During the expansion phase of the substorm in the nightside magnetosphere enhancement of the magnetic field and decrease the plasma pressure is observed simultaneously. Enhancement of the magnetic field is recorded at first in the tail of the magnetosphere, and then at more closer distances from the Earth. This process takes a few minutes and covers the region in the magnetosphere of 10 Earth radii. One of possible explanations of this phenomenon is associated with cooling magnetic flux tubes caused by the precipitation of the energetic particles in the ionosphere. We have made evaluation of the

effectiveness of this mechanism. According to the received results, the effect of the precipitation is essential for a distance not exceeding 10 Earth radii. At large distances the cooling of the magnetic tubes is difficult to explain only by precipitation of the particles.

Nonlinear electrostatic vortex structures in magnetospheric plasma

Volosevich, A.V. (State University, Mogilev, Belarus)

The formation of two-dimensional vortex electrostatic structures in the magnetospheric plasma is investigated. Basing on the MHD system of equations for the electrons and ions and taking into account the effects of the non-isothermal hot electrons or ions the evolutionary equations with mixed nonlinearity are derived. It is shown, that in plasma with the beams of ions and electrons two types of structures can be formed: the solitary structures moving with the velocity comparable to local ion-acoustic velocity (IAS), and the solitary structures moving with the velocity comparable to electron thermal velocity, electron acoustic structures (EAS). For these two-dimensional models the solution in the form: cylindrically symmetric (round) solitons, cnoidal waves and two-dimensional chains of solitons are possible. From the analysis of the coefficients of nonlinear evolutionary equations the characteristics of solitary structures include waveforms of density and electric field, the velocity, and the oblateness ratio $R = L_\perp/L_\parallel$ (where $L_\parallel$ and $L_\perp$ — field-aligned and perpendicular scales) is also determined. This theoretical models is in good agreement with experimental data obtained by satellites FAST, POLAR and GEOTAIL.

Nonlinear electrostatic waves structures in the collisional ionospheric plasma

Volosevich, A.V. (State University, Mogilev, Belarus)

Interaction of the nonlinear electrostatic waves and spatially limited electrostatic structures in the auroral E-region ionosphere are investigated. Basing on the system of magnetohydrodynamic equations, the evolution of the electrostatic Farley-Buneman (FB) instability

in the E-region auroral ionosphere is considered analytically and numerically. It is shown: a) different scenarios of the stabilization of the FB instability - periodic, multi-periodic, nonlinear cnoidal and quasi-stochastic behavior are possible in the collisional ionospheric plasma; b) the main nonlinear mechanisms of stabilization of the FB instability are the coherent interactions of three and four FB waves, nonlinear waves are generated in the region of linear damping of the coherent waves. This region corresponds to large aspect and flow angles of the waves; c) different examples of the nonlinear temporal evolution of the FB instability are represented in this work on the basis of studying phase portraits of nonlinear evolution FB instability; d) in the considered dissipative plasma model at the certain parameters of plasma and the certain initial data the chaotic behavior is possible.

The change of magnetic configuration due to increase of plasma pressure during magnetic storms in the inner magnetospheric regions

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The distortion of the magnetospheric magnetic field is developed due to the increases of plasma pressure inside the magnetospheric trap. Such distortions are especially pronounced during magnetic storms. The azimuthally symmetric part of this distortion produces the Dst variation. The role of ring current in Dst formation was criticized in a number of works in the suggestion of the existence of tail current at geocentric distances 10 Re. The obtained proofs of the existence of the surrounding the Earth current system till the geocentric distances $\sim$10 Re named cut ring current (CRC) gives the possibility to restore the traditional dominant role of ring current in Dst formation. The problem of Dst formation is reanalyzed taking into account the nonlinear character of the change of magnetic field by fixed distribution of plasma pressure. The obtained results of computer modeling are compared with the data of experimental observations for the great magnetic storm of February, 1986. It is shown that the nonlinearity of the problem is the important factor determining the contribution of ring current in Dst variation.

Seasonal and UT variations of auroral precipitation boundaries and the polar cap position

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An influence of a geomagnetic dipole tilt angle on the latitudinal position of auroral precipitating boundaries in the pre-midnight (21–24 MLT) and pre-noon (09–12 MLT) sectors were examined by using DMSP F7 spacecraft observations for 1986. At all geomagnetic activity levels the nightside high-latitude zone of soft diffuse precipitation (SDP) and the polar cap (PC) boundary were found to be at higher latitudes in the winter and at lower latitude in the summer concerning an equinox. While the latitudinal position of the diffuse auroral precipitation (DAZ) boundaries equatorward of the auroral oval does not depend on a season. In the daytime sector, on the contrary, the SDP zone was observed at the lower latitude in the winter and at the higher latitude in the summer. The complete value of the PC boundary displacement from the winter to the summer at both night- and dayside makes $\sim$2.5°. It was found out the daily wave in the latitudinal position of nightside precipitation which is most brightly expressed during winter and autumn periods, is much weaker in the spring and actually absent in the summer Twenty-four-hour variations of precipitating boundaries represent quasi-sinusoidal oscillations with the latitudinal maximum at 03-05 UT and minimum at 17–21 UT. The complete value of daily displacement of boundaries is about 2.5° of latitude. The obtained results show that, testing seasonal and twenty-four-hour variations, a polar cap as a whole displaced in a direction opposite to the geomagnetic dipole tilt angle changes. Seasonal displacement of the polar cap and its UT variations in the winter were occurred without essential change of the PC area.

Control of the plasmapause location using observations of sub-oval proton auroras

Yahnin, A.G., Yahnina, T.A. (Polar Geophysical Institute, Apatity, Russia)

Recent investigations showed that sub-oval proton auroras are the result of interaction of the ring current protons with ion-cyclotron

waves. It is known that the interaction predominantly occurs in the vicinity of the cold plasma gradients. This leads to the idea that observations of the proton auroras can be used for monitoring the plasmapause. Mapping of the evening side "proton arcs" and morning side "proton spots" onto equatorial plane and comparison with plasmasphere configuration prove this idea. In addition, we demonstrate that even in the case when the ion-cyclotron instability develops mainly outside the region of the cold plasma (the case of sharp increase of the temperature anisotropy of energetic protons during the magnetosphere compression) the plasmapause can be "illuminated" by the equatorial edge of the "proton flash".

Stretching of the near-Earth magnetic field during different solar wind conditions

Yahnina, T.A., Yahnin, A.G. (Polar Geophysical Institute, Apatity, Russia)

As known, the latitude of the isotropy boundary of energetic protons closely relates to the stretching of the magnetic field in the near-Earth magnetotail. The lower the latitude, the more stretched the magnetic field lines. We investigate long-term variations of the magnetotail stretching using the particle precipitation boundary b2i, which is a proxy of the isotropy boundary revealed from the DMSP satellite data. The data from 1984 till 2009 including three minima and two maxima of the solar activity are used. The more stretched magnetosphere is found during solar maxima. The most dipolar magnetic field lines are obtained during extremely long solar activity minimum observed since 2007. The difference in the magnetotail configuration during interaction of the magnetosphere with different solar wind structures is also considered. It is shown that during "magnetic clouds" with southward magnetic field the latitude of the isotropy boundary is minimal in comparison with other types of the streams. This associates with the most stretched magnetic field lines in a wider longitudinal sector and explains why auroral substorms during geomagnetic storms related to the magnetic clouds occur at low latitudes and develop in the wide longitudinal sector.

Peak electron density derived from radio occultation measurements

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The Radio Occultation technique using GPS signals has been proven to be a promising technique to retrieve accurate profiles of the ionospheric electron density with high vertical resolution on a global scale. FormoSat-3/COSMIC (Constellation Observing System for Meteorology, Ionosphere and Climate), a joint scientific mission between Taiwan and the U.S.A., placed six micro-satellites into six different orbits at 700–800 kilometer above the earth surface.

In the given report we present results of statistical comparison of NmF2 values retrieved by independent measurement technique - radio occultation and vertical ionospheric sounding. We used the ionospheric data recorded by European digisondes of DIAS network for different seasons of 2008 and compare these ground measured data with the GPS COSMIC RO ionospheric profiles. NmF2 was calculated from the observed critical plasma frequency foF2 of the F2 layer. Values of foF2 have been scaled manually from ionograms for all considered time-location cases to avoid the evident risks related with using of the autoscaled data. For every season of 2008 we collected 1500-1700 matches from those occultations which has the tangent point location of the F2 peak within 5 degrees of the ionosonde sites in latitude and longitude and when the digisonde measurements were within 15 min of each occultation observing time. As a result we receive the scatter plots of NmF2 values, correlation coefficients and values of mean and standard deviation. The second result of this investigation is the creation of NmF2 maps on the base of COSMIC data. These maps were created with temporal resolution of 2 h and describe the diurnal NmF2 behavior for different season of solar minimum period.

We acknowledge the Taiwan's National Space Organization (NSPO) and the University Corporation for Atmospheric Research (UCAR) for providing the COSMIC Data. We are grateful to European Digital Upper Atmosphere Server (DIAS) for providing the ionosondes' products.

"Anisotropic" plasma equilibria in the Earth's magnetotail with magnetic shear

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The self-consistent theory of relatively thin anisotropic current sheets (CSs) in collisionless plasma is developed taking into account a presence of a shear magnetic field By that is often observed in experimental observations. It is supposed that plasma sources from both sides of CS are symmetrical and B_y component is quite small, therefore the ion motion is not magnetized in CS. Self-consistent Vlasov–Maxwell equations for this plasma equilibria are solved numerically and investigated. Contrary to the case $B_y = 0$ the interaction "particles - current sheet" is changed. The coefficient of reflection of particles in the North and South directions visibly becomes to be asymmetrical, this depends on the value and sign of B_y component. As a result the asymmetry of plasma density at the edges of CS is characteristic for CS with nonzero B_y. This leads to the asymmetry of both current density and magnetic field. In the presence of nonzero guiding field the curvature drift of electrons (giving a narrow strong maximum of current density in the center) decreases; this leads to the real thickening of CS. Due to asymmetry of plasma density the force balance of CS is changed, this is followed by the deflection of CS as whole from the symmetrical position. The comparison with experimental data is discussed.

Longest and compound solar cycles

Zolotova, N.V., Ponyavin, D.I. (St.Petersburg State University, St.Petersburg, Russia)

The problem of solar cycle length is considered. Special attention is given to the reconstruction of the butterfly diagram just before the Dalton Minimum and during the current time. Is the length of the 4th cycle (from 1784 to 1799) exceptionally large or it is really composed of two short cycles? Resolving these puzzles seems to be very important for dynamo theories trying to explain the solar long-term variations. We present simulations of sunspot butterfly geometry

based on (i) suggestion of compound solar cycle, (ii) the phase differences of the northern and southern hemispheric activities, and (iii) impulses of solar activity distributed over the latitudes. The problem of hidden impulses is discussed.

Wave impacts of a sudden impulse and a substorm onset in the inner morning magnetosphere

Zolotukhina, N.A. (Institute of Solar-Terrestrial Physics, Irkutsk, Russia)

A comparative analysis has been performed of ULF-waves registered by Cluster satellites at the distance L $\sim$ 4 from the Earth center after a sudden impulse (SI) and a substorm onset (SO) going after SI in 13 min. It was revealed that both phenomena activated the 40-200 c oscillations of geomagnetic field in the equatorial morning magnetosphere and that ULF-waves accompanying SI and SO events had analogous spectral compositions but different polarizations. Polarized differences were most pronounced in the main spectral maximum (100–130 c) where the transition from SI to SC was attended with the change in the direction of rotation of the disturbed magnetic field vector and its polarized ellipse reorientation.

In the framework of known models of Alfven wave generation, the obtain results can be explained as follows. External (SI) and internal (SO) impulses amplify the odd mode of Alfven oscillations of the same magnetic shell, but the sense of rotation of the vector of geomagnetic field disturbance depends on the location of an impulse source. In case of SI, a source of surface waves, exciting Alfven oscillations is situated at the dayside magnetopause, and primary waves penetrating into the morning magnetosphere have a westward velocity. In case of SO, a primary impulse source is in the nightside outer magnetosphere, and Alfven oscillations are excited by the disturbances propagating eastward. The change in the direction of primary disturbance expansion associated with substorm onset leads to the change in the direction of rotation of the disturbed magnetic field vector and its polarized ellipse reorientation. Judging from the sense of rotation, the studied wave phenomena were observed outside the resonant magnetic shell.

The anthropogenic impact on the magnetospheric phenomena

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

This research addresses to the phenomena of synchronism in Geospheres under the influences of technosphere. The report deals with the problem of human impact on the magnetospheric processes. The attention is focused on the statistical analysis of the long-term observations to study the so-called Big Ben effects (clock pulse effect), which are the 60- and 30-minutes modulation of the Ipdp electromagnetic waves activity (frequency band is 0.1–5 Hz) and the slow magnetic field variations (quasi-periods are tens minutes). It is supposed that such effects are evidently of the human origin. The ample data on the magnetospheric Ipdp waves and Earth's magnetic field accumulated in the catalogs are examined. The synchronous detection method in the form of the superposition epoch analysis has been used. The main conclusion is that the Big Ben effects is the real geophysical phenomena, and evidently human in origin. The statistical reliability of our results is very high. These effects indicate that there is some nontrivial impact caused by industrial activity on the natural processes in the magnetosphere. The possible influences of the technosphere on the magnetosphere are discussed. The work was partly supported by the grants RFBR (09-05-00048) and Presidium of the Russian Academy of Sciences (Program 16).

Geophysical manifestations of the ponderomotive forces

Zotov, O.D. (Geophysical Observatory Borok, IPE, RAS, Borok, Russia), Guglielmi, A.V. (Institute of Physics of the Earth, RAS, Moscow, Russia)

In our report we analyze the diversity of geophysical manifestations of the ponderomotive forces arising due to excitation of the ULF electromagnetic waves in the space plasma. After exposition of the theoretical grounds, we focus our attention on the following three topics. (1) The impact of the Alfvén waves on the space plasma. Ponderomotive acceleration of the solar and polar winds, plasma cavities formation in the auroral zone, acceleration of the heavy ions like O^+ in the high-latitude magnetosphere are considered here shortly.

(2) The ponderomotive self-action of the ULF waves which leads to the anharmonicity of the standing waves and self-modulation and self-focusing of the travelling waves. (3) The role of ponderomotive forces in the multistep processes of interaction between the geospheres. This topic is of special interest to us due to recent nontrivial observations of the seismic impact on the magnetospheric ULF wave activity in the Pc1 frequency band (0.2 – 5 Hz) [Bortnik et al., 2008; Guglielmi and Zotov, 2010]. In this relation we discuss also the solar cycle modulation of Pc1 waves [Guglielmi, Kangas and Potapov, 2001] and the effects of synchronism of Pc1 and seismic events in the dynamical system "magnetosphere-technosphere-lithosphere" [Zotov and Guglielmi, 2010].

The work was supported by RFBR grants (09-06-00048, 10-05-00661) and Presidium of the Russian Academy of Sciences (Program 16).

Movement of the geomagnetic and of the "true" modeling magnetic poles of the Earth during last eight years according to the data of the satellite CHAMP

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The daily average spherical harmonic models of the main geomagnetic field ($n = m = 10$) with an interval of 4 days for vector data of the satellite CHAMP were built. The period from May 2001 to April 2009 (total 728 models) was used. The coordinates of the North's and South's magnetic poles (the so-called true modeled magnetic poles, i.e. the points at which the magnetic field lines are vertical) were calculated. Their changes during these eight years were received. Both poles continue to move in a northerly and westerly direction. North pole was shifted to 400 km during this time. Its speed is constantly decreasing: from 62 km/year in 2002 to 47 km/year in 2009. In addition, the speed in the longitude direction is of more than 4 times the speed in the latitude direction. South pole is moved in 10 times slower. On this period it is shifted to 42 kilometers. The coordinates of the geomagnetic poles (the dipole poles), the magnetic dipole moment were also calculated. The speed of the geomagnetic poles is negligible compared to the speed of "true" poles. The rapid movement of the "true" poles associated with nondipolar part of the field.

Section P. Paleomagnetology and Rock Magnetism

Influence of mechanical stress on the ground state of heterogeneous particle

Afremov, L.L., Kirienko, Y.V. (Far-Eastern National University, Vladivostok, Russia)

To assess the effect of mechanical stress on the magnetic state of the chemically inhomogeneous grain we use the following simple model. Let the grain, represented by two neighboring homogeneously magnetized ferromagnetic phases of different composition, has the shape of the box. For simplicity, we assume that the vectors of spontaneous magnetization of the phases are located in the plane of one of the faces (plane xOz), and the axis of the crystallographic anisotropy of both ferromagnets are parallel to the edge belonging to a selected side (axis Oz). The external magnetic field H is directed along the axis Oz, and mechanical stresses are parallel to the plane xOz, and applied at an angle β to the magnetic field.

- In the first ($\uparrow\uparrow$)-state the magnetic moments of both phases are parallel and directed along the axis Oz;
- in the second ($\uparrow\downarrow$)-state phase magnetized anti-parallel, and the magnetic moment of the first phase is directed along at the axis Oz;
- third ($\downarrow\downarrow$)-state differs from the first in anti-parallel to the axis Oz orientation of the magnetization phases;
- in the fourth ($\downarrow\uparrow$)-state the magnetic moment of the second phase is directed along, and the first - against the axis Oz.

If the magnetostatic interaction between the phases dominates the exchange one then the first and third states are metastable. Otherwise, the metastable are second and fourth states.

The critical fields of magnetization reversal of heterophase grain located in a field of mechanical stresses

Afremov, L.L., Kirienko, Y.V. (Far-Eastern National University, Vladivostok, Russia)

Analysis of the total free energy of grain consisting of crystal anisotropy energy, magnetostatic energy, exchange interaction energy of neighboring phases and the energy of the magnetic moment of grain in an external magnetic field, shows that the approximation of plane-parallel phases in the absence of an external magnetic field, two-phase particle can be in one of the following states:

- in the first ($\uparrow\uparrow$)-state the magnetic moments of both phases are parallel and directed along the axis Oz, which coincides with the axis of the crystallographic anisotropy;
- in the second ($\uparrow\downarrow$)-state phase magnetized anti-parallel, and the magnetic moment of the first phase is directed along at the axis Oz;
- third ($\downarrow\downarrow$)-state differs from the first in anti-parallel to the axis Oz orientation of the magnetization phases;
- in the fourth ($\downarrow\uparrow$)-state the magnetic moment of the second phase is directed along, and the first - against the axis Oz.

In an external magnetic field, transitions from one state to another are possible. For example, the transitions from the third state to the second or the fourth corresponds to the rotation of the magnetic moment of one of the phases. The transition to the first state — the rotation of the total magnetic moment of the grain. Moreover, the critical fields of these transitions differ significantly. The critical field of transition from the third state to the second, as the fourth state to the first, is determined by the effective anisotropy constant (tensor sum of the crystallographic anisotropy and stress) of the first phase. Critical field transitions from the third to the fourth and the second to the first condition defines the effective coupling constant of the second phase.

The critical field reversal of the particle with the transition from the third state in the first must differ significantly from the critical field of the transition from second to fourth. In the first case it determined

by the sum of the effective anisotropy constants, and the second — by their difference.

Anisotropy of the oriented magnetization: computer simulation and theoretical estimations

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We considered the system of precipitated ferromagnetic single domain particles. The magnetostatic energy of each particles is essential more then kT. Particles are capable to change their orientation in the external magnetic field before the consolidation in the sediment. It is suppose that the external field h is less then the intrinsic interaction field H. The theoretical estimation which one based on Preizah-Neel model, indicates on third derivative jump $I_{ri}(h)$, (I_{ri} — the anhysteretic magnetization) at $h = h_0$ — the field of the formation of the oriented magnetization. However this estimation supposes the stability of Preizah-Neel diagram (PND).

The Monte-Carlo simulation of the single domain particles system assumes the random distribution of particles coordinates and orientations of easy magnetization axis. The value of the system was found as the concentration of the particles was 0.001. The dispersion of interaction fields was in the limits from 0 to 1 Oe. Distribution of critical fields was in limits from 20 to 50 Oe and the probability density was similar with normal law of distribution. The result of the field influence on system from 500 particles was calculated for 200 realizations with the next average.

We determined that: 1) The "randomization" of image point on PND is property of zero magnetic state (ZMS) of particles system which one was obtained by the alternate magnetic field $H\uparrow H_s$, where H_s — saturation field. This one connects with reconstruction of low-coercive neighbors of the high-coercive particles. Some particles, which ones initially were in weak interaction field in the ultima analysis can move into area of high field, therefore the effect of transition from $h = h_0$ practically vanish. 2) Appreciable effect can be obtained by change of the oriented magnetization to partial anhysteretic magnetization $I_r(h, H)$, which one can be received in alternate magnetic field $H\uparrow H_s$. In this case we have minima of magnetization difference at $h = h_0$.

On the application of magnetic susceptibility measurements in astrochronology

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

Astrochronology (or cyclostratigraphy) is the method of the absolute or relative age calculation of cyclically formed sedimentary layers. It is based on extraction of orbital periodicities from sedimentary records. The records of the magnetic susceptibility (MS) are often used for such object. For instance, the spectral analysis of MS parameters carried out by Beget and Hawkins (1989), and by Kukla et al. (1990) revealed periodical changes of MS values in the Pleistocene loess-soil sequences of Alaska and China, which are comparable with variation cycles of orbital elements. Regretfully, changes of sedimentation rate have not been taken into account in the first case, and incorrect physical prerequisites have been used in the second attempt to take this factor into consideration. In other words, time scales in both cases were primarily inconsistent and incorrect, however, the results of the spectral analysis did show that periods of MS variations are correlative with orbital cycles (Bol'shakov, 2000, 2002). Such examples of interpreting MS measurements cause the distrust only. Of cause, the application of MS in astrochronology for much more ancient deposits should be much more substantiated. However, it is not so in fact. In many works there are not correctly established the physical mechanism of connection between not only changes in MS and the orbital elements variations, but yet between lithological cyclicity, and climatic, or orbital changes. There are some other mistakes also concerning the understanding of the sense of orbital variations and its influence on climate changes and sedimentation during different geologic epochs. So, the conclusions of many similar works can't be correct without such substantiation.

Paleomagnetism of mid-paleozoic sedimentary rocks of the Amur plate

Bretshtein, Yu.S., Kosygin, Yu.A. (Institute of Tectonics and Geophysics, Far East Branch, Russian Academy of Sciences, Khabarovsk, Russia)

Complementary paleomagnetic study of terrigenous assemblages composed of the Silurian and Devonian rocks was conducted. Previously obtained paleomagnetic data for the Amur plate geologic sections of the same age were generalized, on the whole. Paleomagnetic results are supported by different tests, which have affirmed the priority of revealed ChRM with high degree of probability. Low paleolatitudes of the ChRM formation were established for the rocks studied during the Mid-Paleozoic and the geographical coordinates of paleomagnetic pole locations were calculated both for the isolated terranes and the entire of the Amur plate. Magnetization directions in headings of West the compass in the ancient coordinate system were assumed to be the direction of straight polarity. As for pole locations of the Silurian and Devonian rocks in the Khentei-Dauria, Agin, Argun, Oldoi, Mamyn, Malo Hinggan, Bajal, Galam, Spassk and Laoelin-Grodekovo terranes, they are compared to a small number of contradictory data on North China Craton. Spatio-temporal stability and proximity of the paleolatitudinal positions is noted for the above terranes located in the near-equatorial zones of the Northern and Southern Hemispheres during the entire Silurian and Devonian. In sampling areas local "intraplate" rotations of the above geoblocks about the Euler pole were revealed without significant latitudinal relative displacement. Two groups of paleomagnetic poles are observed in the Mid-Paleozoic: one of these located in the near-equatorial zone of the West Indian Ocean (predominantly in the Southern Hemisphere), the other group is attributable to the near-equatorial part of the Atlantic Ocean in the Northern Hemisphere. On the APWP trajectory separate poles of the latter group are displaced to the Late Paleozoic poles (Carboniferous and Permian), which may be evidence of either inaccuracy in the geological age determination, or the fact of rock remagnetization in these sections during a later time span. The average value of angle rotations of these groups of terranes relative to one another attains 86.9°. The work was partially supported by FEB RAS (Project 09_III_A_08_442).

Pecularities of magnetic minerals of paleozoic volcanic rocks of Primorye

Bretshtein, Yu.S. (Institute of Tectonics and Geophysics FEB RAS), Nourgaliev, D.K. (Kazan federal University), Tselmovich, V.A. (Geophysical Observatory "Borok", Institute of Physics of the Earth, RAS)

Based on data of thermomagnetic analysis magnetic properties of Devonian volcanites of Primorye are suggested to depend on the presence of dominating, often high temperature oxidized ferrimagnetic magnetite and of hematite, to a lesser degree, in the bulk of these rocks. Judging from coercivity Hc and Hcs parameters, and, also, ratios of Is and Irs values in different temperature intervals, the blocking temperatures exceeding more as 700°C and are observed in some cases in extrusive differences of rhyolites on the plots of temperature demagnetization Is(T) and Irs(T), which may correspond to Tc (blocking temperatures) of pure iron. Microprobe analysis yielded a detection of microspherules of native iron, nickel, and, also, of their magnetic oxides: magnetite and avaruite, as well as some sulphides. The quantity (in percentage ratio) of a range of elements in the studied (scanned) grains may amount as follows: Fe for metallic iron and magnetite — to 100% and 74%, respectively, Ni — to 35%, Cr and Co — 1–3%, tin and copper — to 20% and 68%, correspondingly. Separate grains are represented by different alloys of Fe, Ni, Cr and Cu. Grain morphology is variable starting from the ideal metallic balls and miscospherules sized the first units and tens of μm to aggregates of bended spindle-shaped and imbricated plates and single spiral "corrugated" microparticles. Commonly, the cosmic origin is attributable to the iron and nickel balls (widespread in different-aged sedimentary rocks occurred in different localities). At the same time, a number of papers postulates endogenic genesis of numerous magnetic spherules detected as aggregates known as inclusions at the walls of cavities of solidified volcanic rocks, originating in the magma crystallized due to gas injections. They can form in the volcanites as caused by non-equilibrated magma "boiling-up" in the process of cavity formation resultant from rapidly occurring gas transfer reactions while high-temperature reducing fluid transmission. At this stage of case study the convergence of indications prevents from a non-ambiguous conclusion on the genesis of magnetic particles. So far as even very small-sized (especially defect-free) grains of native iron, nickel, and, also, unalloyed very "soft" pure magnetite should be predominantly

multidomain, their contribution to the total remanent magnetization of rocks (independent of the probable source of their supply to the rock) should be considered insignificant. Preliminary comparison of paleomagnetic data for the rocks, containing these "anomalous" inclusions of ferrimagnetics and those rocks lacking them supports this conclusion.

The work was partially supported by RBRF (Project N 10-05-00117) and FEB RAS (Project 09_III_A_08_442).

Dating ceramics by rehydroxilation in archaeomagnetic research

Burakov, K.S., Nachasova, I.E. (Schmidt's Institute of Physics of the Earth RAS, Moscow)

Data on the ancient geomagnetic field, which we receive as a result of investigations of the remanent magnetization of baked clay (bricks, ceramics, tiles), are related to the time of the last burning of these materials. This time does not always correspond to the dating of archaeological sites from which these materials are selected, as may occur later restoration materials and fires. Therefore, a method of determining the time of the last firing made of clay materials of archaeological sites. In this paper, we tried the method rehydroxilation, developed by M. Wilson, Manchester University. The physical basis of this method is the fact that crystals of clay minerals, are lost when firing their constituent molecules of water, after cooling, re-enter into chemical reaction with atmospheric moisture, is rehydration of these minerals. The rate of accumulation of such water does not depend on the ambient humidity, but depends on temperature, with the apparent mass of water depends on the time to degree 1/4. Accumulated over time, water is easily removed when re-heating clay to a temperature of 450-550°C. To determine the age of ceramics to determine the weight of accumulated moisture in the sample and determine its rate of accumulation, but also must be known to the average temperature during the existence of ceramics. The most successful method rehydroxilation can be used to determine the time of the last firing hearths and ovens, which were buried and preserved at a temperature corresponding to the surrounding area. Comprehensive study on dated material to determine the average temperature of the environment that existed in the territory of the storage facility. Based on

data obtained from the baked clay from London and Kerch, we can say that at the beginning of our era, the average annual temperature in these areas was on $1 \div 1,5$ degrees higher than today. This work was supported by RFBR, grant N 09-05-00329.

The location of the Dzavhan microcontinent in the Neoproterozoic (on paleomagnetic data)

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In Early Riphean time, The Dzavkhan terrain was a part of the supercontinent margin, which broke away from Rodinia as a result of rifting at about 755 Ma. We tried to determine the position and kinematics of the Dzavkhan microcontinent in the Neoproterozoic and studied trachy-rhyolites of the Dzavkhan Series (777 ± 6 Ma) and granites of the Yamankul massif (46.9°N, 96.5°E). Acquisition of a high-temperature component in the lavas (Dec= 70.0°, Inc= 20.1°, k= 16.0, $\alpha 95$= 8.7°) far away from the intrusion can be constrained between 777 ± 6 Ma and the intrusion age of 752 ± 3 Ma. The high-temperature component in granites and baked lavas (Dec= 68.6°, Inc= -56.0°, k= 23.4, $\alpha 95$= 6.4°) is connected with the intrusion of the granites into the Dzavkhan Series lavas. Two secondary components with steep inclinations (Dec= 210.0°, Inc= -85°, k= 26.5, $\alpha 95$=5.2° and Dec= 334.5°, Inc= -78.4°, k= 21.6, $\alpha 95$= 8.1°) that have been recognized in granites are of unknown age and origin. According to our data, the Dzavkhan microcontinent occupied a near-equatorial position as a part of the Rodinia supercontinent margin at about 777 Ma and considerably moved to the North (to 30–44°N) having been decoupled from Rodinia. A similar paleomagnetic inclination and hence a similar latitude of 47 ± 16°N (770–805 Ma) has been reported on the Dzavkhan Series by Levashova et al. [2010].

Hysteresis parameters as a reflection of unusual magnetic behavior of nano-sized goethite, synthesized under surface active substances influence

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The specific magnetic behavior of nano-sized well known Fe-minerals strongly depends not only on particle dimensions but also on pathway and environment at formation. Usually for researching these peculiarities the different type of synthesis is used. One of methods to prevent the process of magnetic nanoparticles agglomeration and to form most narrow grain size distribution is the application of different surface-active substances (SAS) during synthesis from salt solution. In present work the comparative analyses of hysteresis parameters such as J, Js, Jr, Hc, Hcr of goethite nano-powder, obtained with (and without) of different SAS, was carried out both in initial (also as after ageing about 1 year) and in annealed in air states. It is also important for rock magnetism because goethite is itself a typical low temperature weakly magnetic Fe-mineral in red sediments and very often it is the hematite precursor. Hysteresis loops were measured at room temperature in fields up to 1T, J(T) dependences were measured at interval 20–700°C in the field 400 mT. Preliminary thermomagnetic analyses for goethite nanoparticles obtained both with using of SAS and without had showed inhomogeneous composition of different samples. In temperature region of 200–500°C peaks of magnetization which are unusual for heating of pure goethite in the air appear. These peaks have different width, intensity and Tmax. Curie points of forming intermediate strong magnetic phases are 500–600°C. These phases are mainly unstable, but in the case of $C_{12}H_{38}ClN$, used as a SAS, forms the stable maghemite with Tc=660°C. All initial samples demonstrate typical for superparamagnetic goethite linear dependences of J(H) with different bias for various SAS, and absence of coercivity and Jr. Hysteresis parameters of intermediate phases reveal wide range of magnetic parameters value: Js=0.6-42, Jr= 0.02-12 Am^2/kg, Hc=0-17, Hcr=.0-62 mT. Final product of annealing for all the samples is hematite with Tc=670°C, but its hysteresis parameters are also different for different SAS used: $J_{H=1T}$ =0.13-0.27, Jr=0.025-0.140 Am^2/kg, Hc=150-220, Hcr=250-1200 mT.

Thus, the different SAS application during the same synthesis pro-

cedure have a strong effect not only on goethite particles size but also on phase inhomogeneity, changes the way of transformation into hematite, and magnetic behavior of forming hematite. It seems that these peculiarities are connected with various surface layers formed on the goethite nanoparticles under SAS influence. This process can be similar to the epigenetic goethite formation in nature, when it is precipitated in small quantities from circulating ground water of different chemical composition. Unusual and variable magnetic behavior was observed also previously for natural goethite of different origin.

Paleomagnetic investigation of Cretaceous deposits of south of the West Siberian Plate

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The integrated paleomagnetic, geological, stratigraphic, and paleontological investigation of Cretaceous deposits in borehole 8 (ϕ = 53°31'N, λ = 73°34'E) at the south of the Western Siberia has been performed. Tectonically, this region belongs to the Omsky depression. The Cretaceous deposits intersected by the borehole are represented by clays, siltstones, sandstones, and sands of the Pokurskaya, Kuznetsovskaya, Ipatovskaya, Slavgorodskaya, and Gankinskaya suites within the upper part of Lower Cretaceous and throughout Upper Cretaceous. From Cretaceous deposits, the total thickness of which is 320 m, about 360 cubic specimens have been taken; the sampling density being 0.8-1.0-1.5 m. The age of deposits has been determined based on the study of dinoflagellates, foraminifers, and on ascertainment of palynocomplexes (determinations by N.K. Lebedeva, V.M. Podobina, and T.G. Ksenova). Step thermal and alternating field (AF) demagnetization have been performed. The reliability of the obtained paleomagnetic data is stipulated by a possibility separate characteristic remanent magnetization (ChRM) of natural remanent magnetization. Characteristic remanent magnetization directions were identified by analyzing stereographic projections and Zijderveld diagrams. The ChRM directions were determined by principal component analysis. Magnetic mineral fraction of the studied Cretaceous deposits mainly consists of magnetite and hematite. The paleomagnetic section of Cretaceous deposits by borehole 8 is charac-

terized by the prevalent normal polarity and the subordinate reverse polarity. This paleomagnetic section is compared together with biostratigraphic data and than with the magnetostratigraphic [Khramov, 2000] and magnetochronological [Gradstein et al., 2004] scales. The research was supported by RFBR grant No 10-05-00021.

Peculiarities of thermal phase transformations of natural lepidocrocites from X-ray powder diffraction data

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X-ray powder diffraction (XRPD) researches of phase composition, texture and microstructure characteristics (crystallites sizes and level of lattice microstraines) are carried out on the products (maghemite, γ–Fe_2O_3, and haematite, α–Fe_2O_3) of thermal dehydratation of natural well-crystallized lepidocrocite, γ–FeOOH. It is established, that (1) the observed diffraction-line profile describes by the Voigt function (i.e. a convolution of a Gaussian and a Lorentzian), (2) the XRPD lines for γ–Fe_2O_3 are considerable broader than those for α–Fe_2O_3, (3) the XRD pattern of γ–Fe_2O_3 lacks superstructure peaks, (4) the reflections from net planes consisting of only metal ions are much broader than those from net planes including oxygen ions and (5) the non-uniform X-ray line broadening phenomenon decreases with increasing dehydratation temperature. These results are discussed and ascribed to the small crystallite size, an elongated crystallite shape and the presence of defect structures (unordered distribution of vacancies on the octahedral sites of the spinel lattice, incomplete displacement of iron atoms to the equilibrium lattice point in Fe_2O_3 during the transformation of lepidocrocite via maghemite to haematite, substitution of hydroxyl groups in the anionic sublattice). The work was supported by the Russian Foundation for Basic Research, project N 09-05-00471.

"Short" (500–4500 years) characteristic times of paleomagnetic and magnetic data fluctuations of the Matuyama chron sediments

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Paleomagnetic and magnetic characteristics of the Adzhidere section (Western Turkmenia) sediments have been studied. The investigated intervals include a part of the Matuyama chron far before the Early Jaramillo reversal, the central part of the Jaramillo subchron and the Matuyama-Jaramillo transitional zone. The investigated parts of the sediments were sampled step-by-step and represent near 1750 sampling levels. Paleomagnetic characteristics of each level are the mean for 5 specimens after full thermal demagnetization and component analysis. As a result of wavelet-analysis of "a high-frequency part of a spectrum" (times of fluctuations there are less than 5 thousand years) the following conclusions have been made:

1. Characteristic times of paleomagnetic data fluctuations are different for various parameters and for the petromagnetic data.

2. Characteristic times of fluctuations of all characteristics are extremely unstable in time.

3. The greatest power of declination and inclination fluctuations is marked for an interval of sediments in which the field direction change is fixed. The same interval is characterized by the least power of fluctuations of the parameter reflecting intensity of the magnetic field.

4. In the rock magnetic data we can see fluctuations of variable power with the period of 3–4 thousand years. It may be connected with changing of sedimentation conditions with specified time.

On relation between the geomagnetic field behavior and evolution of biota in the Phanerozoic

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Recent studies of the secular variations over the last 400 years re-

vealed persistent decay of the geomagnetic field which may be considered as evidence for a possible imminent onset of a reversal or an excursion. As far as these phenomena are associated with the strong decrease of the intensity of the geomagnetic field, the concerns are voiced that this decrease will lead to the disruption of the magnetic shield protecting the Earth from the outer radiation. In fact, the decrease itself is not dangerous: the magnetosphere contracts only less than two times when the intensity drops by an order of value. A real danger comes from the transition of geomagnetic poles through the equatorial area during a reversal or an excursion. In the "normal" magnetosphere, irrespective of the intensity of the field, the polar cusp is located in the polar region. But during a reversal or an excursion the solar wind will blow directly into the cusp resulting in a great increase of the concentration of energetic particles in the magnetosphere and ionosphere. This radiation certainly will influence the rate of mutagenesis of biota but though hardly will bring its extinction. The last conclusion follows from the observations that the juxtaposition of data on geomagnetic reversals and biozones does not show any correlation between them. At the same time there is an agreement between the frequency of the reversals and degree of changes in the organic world. This apparent contradiction might be linked to long-term changes in the angle of Earth axis and in angular velocity of the Earth rotation.

Visual evidence of geomagnetic excursion?

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In the Bible's Old Testament Book of Ezekiel there is a description of the Ezekiel vision of "a great cloud with brightness round it" to the north of the observation site. The event described in the Bible occurred in 593 BC, i.e., approximately 2600 years ago, Ezekiel was at that time approximately 100 km south of Babylon (latitude $\sim$ 32°N, longitude $\sim$ 45°E). Auroral specialists interpret the Ezekiel's vision as observation of coronal auroral displays at low latitudes. However, to support this hypothesis, it is necessary to understand

the physical mechanism responsible for generation of coronal auroras at low latitudes.

Analysis of palaeo- and archaeomagnetic data, including our data on magnetic properties of sediments of the Barents and White Seas and the literature data, has shown that about 2600 BP, i.e. in Ezekiel's time, development of a geomagnetic "Sterno-Etrussia" excursion took place. The duration of the excursion during which the northern geomagnetic pole wandered to the Southern Hemisphere was no more than 200–300 years. Manifestation of this excursion were found in 16 regions of the Eurasian continent and adjacent seas and also in the North and South America. By plotting the path along which the northern geomagnetic pole wandered to the southern latitudes during this excursion on the basis of palaeomagnetic data, we have found that it wandered in the longitude sector $\pm 30^\circ$, and about 2600 BP the northern geomagnetic pole was at the longitude close to the Babilon longitude, where Ezekiel had his vision. Thus at that time Babilon was at high geomagnetic latitudes where regular coronal auroral displays occur.

Records of observation of the unusual brightness of the sky in the V–VI centuries BC can also be found in Greek chronicles. This indicate that the Ezekiel's vision was not the only observation of auroras at low latitudes during the period considered here.

Paleomagnetism of the Devonian and Carboniferous sedimentary formations of the Spitsbergen Archipelago

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A paleomagnetic results on the collections of the Devonian and Carboniferous rocks from Spitsbergen Archipelago, which were sampled during 1985–1987, are presented here. Detailed demagnetization of the arly and upper Devonian rocks reveals the presence of two components of the natural remanent magnetization (NRM). After removal of a low temperature component (A), which likely represents a recent VRM, high-temperature bipolar component B is definable in the temperature interval of 640–680°C (for Early Devonian rocks, Red Bay and Wood Bay Formation, D1) or 300–650, 670°C (for Upper Devonian rocks, Mimer Valley Formation, D3). The polarity reversal test for component B is positive and corresponds to class C. Both the D1

and D3 components pass fold tests. Both the D1 and D3 components which is carried by magnetite and haematite has distinctly different directions in the different units (mean tilt-corrected declination = 25°; inclination = 5°; k=17; $\alpha 95$ = 9° for the Early Devonian rocks (Red Bay Formation); mean tilt-corrected declination = 30°; inclination = -23°; k=12; $\alpha 95$ = 5° for the Early Devonian rocks (Wood Bay Formation); mean tilt-corrected declination = 213°; inclination = -32°; k=33; $\alpha 95$ = 5° for the upper Devonian rocks (Mimer Valley Formation).

Detailed demagnetization of the middle and upper Carboniferous rocks also reveals the presence of two NRM components. After removal of a low temperature component (A), which likely represents a recent VRM, high-temperature bipolar component B is definable in the temperature interval of 500–665°C and 620–685°C with mean tilt-corrected declination = 26°; inclination =26°; k=19; $\alpha 95$ = 8° and declination = 210°; inclination = -30°; k=36; $\alpha 95$ = 11°. The polarity reversal test for component B is positive and corresponds to class C. Component B pass fold tests.

New Early and upper Devonian, middle and upper Carboniferous paleomagnetic poles are compared with the coeval poles for the East-European plate rocks. Mutual paleogeographic positions of the Spitsbergen, and the East-European platform are estimated along the comparison of the World Paleomagnetic Database with the obtained here ones.

On regularities in stratigraphic distribution of magnetization in loesses

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Uneven deposition of loess particles in time following by different rates of the geological history flow and some outstanding events, such as major earthquakes, volcanoes eruption or global temperature shifts, is reflected in the unevenness of the stratigraphic distribution of particles *in situ*. Unevenness of the stratigraphic distribution of particles of natural magnetic minerals, in particular, accessory magnetite, or titanomagnetite directly determines the type and value of local magnetization. Small magnetite particles with linear dimensions

of the 1-10 nm by order of magnitude under normal physical conditions perform super paramagnetic properties with fluctuating particle's magnetic moment vector. The particles with linear sizes about 10-100 nm perform single-domain or pseudo single domain behavior with stable magnetic moments' vector, fixed in the palaeo magnetic field intensity direction. The plain model for magnetic particles' sedimentation has been considered for the undisturbed water medium. The particles of different sizes and round shape are dropping down in the water under the action of gravity force, suspending "Archimedes force" due to replacing water, and "Stox viscosity" resistance to the dropping particles. The larger velocities and shorter drop velocity relaxation time have been predicted for larger and heavier particles. So for the definite particles portion the lower stratum is to contain larger particles. In general case the later get dropped larger particles can be located close to earlier get dropped smaller ones and turn up in the same strata. For the overall loess medium background, the deeper loess strata of the same epoch or created by one outstanding natural phenomena should contain heavier particles. The same approach is in principle applicable for geological reconstructions for loess sediments containing natural magnetic particles in the air medium, or in the forming ice and glacier medium.

On the evidence of pseudo single domain transition for the magnetite fine particles

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General theory of the magnetic structure of ferromagnetic particles demonstrates that in the absence of an external magnetic field, the size effect of reducing the magnetization depends on the interrelation between the saturation magnetization, magneto crystalline anisotropy constants and the parameter of inhomogeneous exchange interaction of the particles' matter. We consider equidimensional particles, spherical for the first approximation. If under normal physical conditions, the effective anisotropy constant K is greater than $0{,}385 \cdot I^2$, where I – the saturation magnetization, the structure "curling" is unstable under any particle radius. That is this condition is satisfied for particles of magnetite and titanomagnetite containing ulvoshpinel at least less than 0.55 in concentration. According to the

theory the radius of the absolute single-domain magnetite particles of the material with the values of exchange interaction parameter 10^{-6} erg/cm, magnetization of 480 Gauss, first anisotropy constant $1{,}36{\cdot}10^5$ erg/cm^3, second anisotropy constant $0{,}44{\cdot}10^5$ erg/cm3 is equal to $3{\cdot}10^{-6}$ cm, i.e. 30 nm. The critical radius for the violation of single-domain state in zero external magnetic field is equal to 35 nm.

As is known, titanomagnetite particle having the concentration of ulvoshpinel 0.1, the saturation magnetization is equal to 420 Gauss, the first and second anisotropy constants are respectively $2{,}5{\cdot}10^5$ erg/cm^3 and - $0{,}48{\cdot}10^5$ erg/cm^3, the radii of the absolute single-domain and critical one for zero-external magnetic field are respectively equal to 35 nm and 45 nm. For concentrations of ulvoshpinel 0,55 the saturation magnetization is equal to 150 Gauss, first anisotropy constant is equal to $0{,}7{\cdot}10^5$ erg/cm^3, second one can be neglected because of its smallness, the radii are equal to 90 nm and 270 nm.

Existing experiments confirm the clear size effect in the magnetite and titanomagnetite particles and therefore they meet the criteria of PSD performance.

On parasterite relationship of the middle paleozoic kimberlites and traps of the siberian platform in terms of "hot spots" hypothesis and paleomagnetic data

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Despite the existing of numerous models of the origin of kimberlites, their temporal and spatial relationship (parasteritec link) with traps of the Siberian platform looks very clear. The most likely source of energy behind this phenomenon can serve as a hotspot, coupled with the convergent plate boundaries (Kovalenko et al., 2009). According to the paleomagnetic data two collisional events affected on the Siberian craton in the period since late Neoproterozoic up to Silurian. In both cases these events dramatically controlled the direction and rate of the craton drift (Konstantinov, 1998). At this time the Siberian craton was located in the equatorial area and was turned with its modern southern edge to the north. The first event (pre-Vendian) reflects the collision of the Siberian Craton and Barguzin microcontinents (Shatsky et al., 1996). Later this microcontinent

was attached to the craton margin and the territory was covered by common Vendian-Early Paleozoic carbonate strata (Tectonics of the south ..., 1987). At the second stage (440–420 Ma) to the Siberian craton the Eravna microcontinents was collided. In the area of these blocks interconnection the Baikal folded belt was formed (Zonenshayn et al., 1990; Belichenko et al., 1994, Zorin et al., 2008). At the late Silurian – Early Carboniferous (420–320 Ma) the subduction of the Paleoasian oceanic plate beneath the Siberian craton led to melting the crust above the subduction zone (responsible for hot spot producing) and caused the opening of the Vilyui paleorift. This paleorift was generated by clockwise rotation of the Aldan block away from the Angara–Anabar block and accompanied by eruption of basaltic and kimberlite magmas.

Petromagnetism of anorthosites of the Geran Range and its structure as inferred from geopotential field data interpretation

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The anorthosites of the Geran Range are concentrated in the junction of major Early-Precambrian tectonic structures: the Aldan Shield and the Late-Archean to Early Proterozoic Dzhugdzhur-Stanovoy folding area framing it from the south. The anorthosites are attributable to outcrops of an Early-Archean granulite-hyperbasite basement, where they associate with major and high-aluminous crystalline schists, gneisses, calc-aluminosilicate rocks and metaultrabasites.

The problem related to the genesis of anorthosites is one of the most complicated in petrology [Bogatikov, 1979]. A concerted opinion as to pertinence of the anorthosite assemblages, the Geran assemblage, in particular, to the allochtonnous or autochtonnous type does not exist also.

For understanding of the deep structure of the object under investigation the geological-geophysical model has been constructed for the study area. It has been constructed using the following materials: (1) maps of the observed gravity field Δg scales of 1:50000, 1:200000; (2) maps of the observed magnetic field scales of 1:50000, 1:200000;

(3) geologic maps of the study area scales of 1:50000, 1:200000, 1:500000; (4) data on petrophysical properties of rocks in the region. To conduct petromagnetic, paleomagnetic, geochronological and geochemical studies the anorthosite sample collection from the Geran Range was investigated (50 specimens from 4 sampling sites).

According to the model developed the Geran Massif forms a northward dipping tabular-shape body of 6–8 (maximum to 12) km thickness, concordant to the occurrence of host granulites. Presumably, the roots of the massif are cut by Cretaceous intrusions of predominantly granodiorite composition.

Presently, magnetic parameters are investigated on a range of representative specimens from which the Curie temperature (580-590°) of these rock-magnetic carriers is detected. The Koenigsberger ratio Q1 in the specimens, which characterizes these as magnetic rigid and suitable for paleomagnetic studies.

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

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The investigation of the Neogene (24–0 Ma ago) history of the "Paratethys" basin (a large endemic water mass that extended from central Europe to central Asia) is of high importance for the detailed reconstructions of the environment and climate evolution of Eurasia. However, the time scale for the Paratethys basin 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, when the geomagnetic polarity sequences for the Western Turkmenistan and Azerbaijan have been constructed. Later similar researches were spread on the stratotype area sections, located on the Taman-Kerch region. Despite of magnetostratigraphic, paleontological and isotope age data, there are at least two concurrent views on

the correlation of the Eastern and Western Paratethys stratigraphic units, as well as their time positions in the astronomically dated polarity time scale (APTS). This debate is still alive today leading to the necessity of new, integrated investigations of the classical sections of the Eastern Paratethys. Recently in our previous report, we presented some new results of geomagnetic polarity time scale construction for the Eastern Paratethys for the ∼10 Ma to 4 Ma 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. These investigations have been prolonged; here we present the results of geomagnetic polarity time scale constructions for more ancient from 12 Ma up to 8 Ma age of geological history. Specimens from the detailed sampled 600 m standard section Panagia passed through well-known modern paleomagnetic laboratory procedure, including stepwise thermo- and AF-demagnetization and magnetic anisotropy measurements. A sequence of 5 magnetozones, which cover stratigraphic units from Upper Konkian to the top of Sarmatian regional stages, have been revealed; time positions of the Panagia and Zhelezny Rog sections in the astronomically dated polarity time scale are proposed, using magnetic zonation of these sections and our new isotope age data. This investigation was carried on the frame of joint Dutch-Russian collaboration (NWO/RFBR project 047.017.005/05-05-89000).

Magnetic mineralogy of the Onkuchaksky suite, Maymecha-Kotuy region of the Siberian platform

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Now the problems of duration of permo-triassic volcanic activity on the Siberian platform and its links with the mass extinction are widely investigated. The new paleomagnetic data from the Maymecha-Kotuy region allows to estimate the intensity of volcanism in this region. The sequence of the Onkuchaksky suite on the Kotuy river includes 42 lava flows composed of basalts and dolerites. This section is divided into three groups according to quality and character of paleomagnetic record:

1) Flows 1–3 and 16–42 show the clear paleomagnetic signal;

2) Flows 4–15 demonstrate the bad paleomagnetic record without distinctive paleomagnetic components;

3) The "red cap" in the top of flow 15 shows the clear paleomagnetic signal. The targets of this investigation are to reveal the distinctions between these groups, to prove the primacy of paleomagnetic record or to explain its absence. The methods of research are analyze of thermomagnetic curves and microprobe analyzes.

The thermomagnetic curves showed the Curie temperatures about 250–400°C for both clear flows and flows with bad signal. These temperatures are typical for titanomagnetites. The samples from the "red cap" showed the Curie temperature of magnetite – 570°C.

The results of microprobe analyzes confirmed that the main magneticmineral in these lavas is titanomagnetite. In flows with clear record titanomagnetite occurs in fine grains, it is homogenous and unaltered, and indicates the primacy of magnetization. In "bad" flows titanomagnetite and ilmenite forms the larger grains, undergone to the secondary alterations (low-temperature oxidation), the composition of titanomagnetites varies wider. The possible cause of the indistinct paleomagnetic signal in this rocks is the multidomain texture of the large grains of titanomagnetite. In the "red cap" the main magnetic mineral is magnetite with the textures of deuteric oxidation formed during cooling of lava.

Magnetostratigraphy of the continental Cenozoic sediments of the borehole 8 (south of the Western Siberia)

Levicheva, A.V. (Trofimuk Institute of Petroleum Geology and Geophysics SB RAS)

The results of paleomagnetic investigation of Cenozoic oriented specimens of borehole 8 are obtained. The borehole is drilled in the Southern border part of Omsk depression on the boundary with Northern Kazakhstan. More 600 oriented specimens are researched. Magnetic and paleomagnetic characteristics of the oriented specimens such as magnetic susceptibility, intensity of natural remanent magnetization and magnetic inclination of vector of primary remanent magnetization were measured. The basic magnetic minerals of natural remanent magnetization are magnetite, hematite, and hydrated iron oxides. The composition and nature of natural remanent mag-

netization are defined. By results of step thermodemagnetization are present two components of natural remanent magnetization – primary and secondary. Magnetostratigraphic section of Cenozoic sediments of borehole on basis of complex data (paleomagnetic, geological, stratigraphic, and paleontological) is made. Comparison of Magnetostratigraphic section of Cenozoic sediments of borehole with Cenozoic magnetic polarity scale West Siberian plate [Gnibidenko, 2006] and magnetochronological scale [Berggren et al., 1995] are resulted. On the basis of fallout from sections paleomagnetic zones the conclusion is drawn on incompleteness of geological record as a result of erosion of separate parts of formations of investigated sediments.

Relative paleointensity variations as reported for the pliocene-pleistocene sedimentary cores from the Eastern areas of the Northern Equatorial Pacific

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This paper contains the relative paleointensity data obtained for the past 2.5 Ma from two gravity cores (7274-T, 7096-T), which were bored through a northern equatorial nodule-bearing belt. This is the area placed between Clarion and Klipperton fault structures in the Pacific. The age established by the geomagnetic polarity reversal horizons is not contradictory with the time intervals featured by phylogenetic and environmental changes in diatoms and radiolarian. The following test magnetization characteristics were used as standardizing parameters: depositional remanent magnetization (DRM), magnetic susceptibility (K) or induced magnetization (KB) in geomagnetic field B; anhysteretic remanent magnetization (ARM); and saturation isothermal remanent magnetization (SIRM). The curve fragments (cores 7274-T and 7096-T) of the relative paleointensity for the past 2 Ma well agree with the world-wide paleointensity curve Sint-2000 [Valet et al., 2005]. This work is supported under 09-III-A-02-046 grant from Russian Academy of Sciences Far East Branch and Basic Research Program 7 of Russian Academy of Sciences Geoscience Department.

Paleoenvironment changes of the Bering sea during the late Pleistocene based on the petromagnetic parameters of bottom sediments

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The Bering Sea bottom sediments are studied under the joint Russian-German Project "KALMAR" the Kurils–Kamchatka and Aleutian Marginal Sea-Island Arc Systems: "Geodynamic and Climate Interaction in Space and Time". This project is basically aimed at all-round studies of the climate-forming system of the Kurils–Kamchatka and Aleutian Island Arcs in the northwestern Pacific. Magnetic minerals from sea bottoms are the participants of geologic and environmental processes and, therefore, they present a reliable environmental information. Our experience of studying sedimentary cores from the Sea of Okhotsk allowed us to determine a set of magnetic characteristics and their relationships, which reflect the environmental and climatic changes in the study area [Malakhov et., 2009]. We used the paleomagnetic method to examine 5 cores 8 to 17 m long from the Bering Sea. Development of the time scale for these cores is underlain by tephra chronology, and also comparison of changing lithophysical characteristics and sea oxygen isotopic stages (MIS). The age determination results obtained for some horizons display their high similarity in terms of varying lithophysical parameters and paleomagnetic data. A correlational scheme is developed to compare the behavior of normalized magneto-climatic parameters of examined cores and the standard oxygen isotopic curve [Bassinot et al., 1994].

Magnetic field and rheological experimental studies of forming characteristic remanent magnetization of sediments

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Bottom sediments from the Pacific Ocean and its marginal seas were subject to rheological experiments in different magnetic fields and

using modified equipment [Malakhov, Mechetin, 1988]. The following dependences are obtained:

1. The oriented remanent magnetization $I(B, t, w_0)$ versus time t in field B and initial moisture w_0 . The time of magnetization was "switched off" using a biopolymer, which blocked a spatial orientation of magnetic particles, the suspension temperature less than 23° C.

2. Remanent magnetization versus the magnetic field size $I(B, w_B)$ in terms of the Shwedoff–Bingham magnetorheological model (the sediment moisture content w_B causing magnetic particles blocking).

3. The remanent magnetization orientation errors by inclination d_J and declination d_D.

4. The determination procedure of the relative paleointensity was simulated using different standardizing coefficients.

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Paleomagnetic results of the section Bartolomeevka (Saratov Region)

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Paleomagnetic studies of rock samples, taken from the Lower Callovian in section Bartolomeevka were held; they are represented by black clays, noncalcareous in the lower with marcasite nodules. Laboratory studies included definition of the magnetic susceptibility (K), magnetic saturation experiments, the differential thermomagnetic analysis (DTMA), magnetic cleansings by alternating field followed by component analysis.

In samples subjected to magnetic cleansings in wet state the directions of natural remanent magnetization (Jn) were projected on the upper hemisphere and their changes were going great circle. Secondary measurements of samples in dry state fixed projections of Jn directions on the lower hemisphere, a significant decrease of Jn values and a constant magnetic susceptibility, compared to "wet" samples. This phenomenon is associated by us with the acquisition of chemical magnetization by iron hydroxides, formed on the surface of magnetite

grains of submicron dimension due to evaporation of water from the clay interlayer. Magnetite, as the main carrier of magnetization is defined according to DTMA data, the submicron dimension of its grains is shown by a very small values of the ratio K/ Jrs (residual saturation magnetization). The characteristic component of magnetization is defined by the converging remagnetization circles method (D = 177.6°, I = (-34.8)°, MAD = 3.5°) and interpreted by us as a reverse polarity of Early Callovian geomagnetic field.

Magnetostratigraphy result of the research is reduced to the justification of reversed polarity in the section Bartolomeevka, from a methodological aspect, it is clear that such samples should be protected from drying out (for example, by their waxing) until the magnetic cleansings will be finished.

High-temperature magnetic memory of partial thermoremanences of magnetite bearing rocks from the hypergenesis zone: preliminary results

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It was shown previously that the high-temperature magnetic memory (α-memory) of thermoremanent magnetization $\alpha J_{rt,H}$ may approach the J_{rt} itself when the magnetizing field approaches zero, i.e. the relative α-memory $\alpha(J_{rt})$ approaches 100% (Petrov, Muratova et al., 2008). This shows the importance of accounting for α-memory during thermomagnetic treatments. The present work aims on checking the validity of additivity law for partial thermoremanences J_{rpt} and their respective α-memories αJ_{rpt} acquired on magnetite bearing samples from the hypergenesis zone, and on fitting the results of the above experiments into a model of large natural magnetite grain (Petrov et. al., 2005). Magnetite ore samples from Angaro-Ilim were used in the experiment. First, the total thermoremanence J_{rt} and its α-memory were measured. Then the same procedure was repeated for several partial thermoremanences and their respective α-memories. Prior to each experiment the sample had been brought into the true absolute zero state by heating it in zero magnetic field to the temperature ϕ_p at which the α-memory is fully erased. This is necessary in order to exclude the contribution of J_{rpt} of contact particles magnetized in

previous runs into the total J_{rpt} value. The experimental results are as follows:

- dominant contribution to the total thermoremanence comes from the J_{rpt} acquired just below the blocking temperature ϕ_b;
- additivity of partial thermoremanences is better when "old" α -memory is demagnetized;
- relative α -memory increases with increasing upper temperature of J_{rpt} acquisition, and reaches the maximum when the latter approaches the blocking temperature. The analysis of experimental results shows the following trends:
- the higher is $\alpha(J_{rs})$ the closer the temperature ϕ_1 at which $\alpha(J_{rpt})$ shows a maximum approaches the Curie temperature of magnetite;
- on the one hand, the higher is $\alpha(J_{rs})$ the less exact is additivity for both J_{rpt} and αJ_{rpt}, pointing to the multidomain nature of the sample;
- on the other hand, the higher is $\alpha(J_{rs})$ the less are tails on the J_{rpt} thermal demagnetization curves, so that according to the thermomagnetic criterion the magnetization carriers should tend to singledomain — in contradiction to the second observation.

The geomagnetic field in Spain in the second millennium BC, according to data obtained by the the ceramic material of the archaeological monument Ubeda

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Obtained new data on the geomagnetic field in the Iberian Peninsula in the Bronze Age, and refinement of the time interval of existence of settlements verified by comparing data based on the monuments of Ubeda and investigated earlier monument "La Motilla del Azuer". According to information gathered through the material of the monument Azuer, the time interval XX–XIX centuries BC, the

field strength is changing very rapidly from values exceeding 70 mkT to values around 45 mkT. Change the rapid lowering of the field on the gradual increase in falls on line XIX–XVIII centuries BC. The intensity of the geomagnetic field over the entire interval of accumulation of cultural deposits settlement Ubeda varies from about 38 to 60 mkT. Comparison of the limits of changes of the geomagnetic field Ubeda monument with a picture of the changes of the field strength in the time interval of XX – the thirteenth century BC, based on the monument Azuer leads to the conclusion that the time interval of accumulation of cultural deposits of the Bronze Age monument Ubeda can be attributed to the interval end of XIX–XVIII century BC. Built mid-10-annual curve changes of the geomagnetic field from the data obtained through the material of the monument Ubeda (1830–1700 BC). The totality of the data shows drop in the geomagnetic field in the nineteenth century BC, about 30 mkT. A sharp drop in the geomagnetic field at about the same time interval was noted from the data for other areas in the longitudinal sector 0–130° east longitude, and can serve as a rapper when comparing different periods of development of human cultures. This work was supported by RFBR, grant N 09-05-00329.

A domain mechanism for self-reversing remanent magnetization

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A necessary condition for partial or total self-reversing remanent magnetization (SRRM) of inhomogeneous ferrimagnetic grains (IFGs) is their occurrence in a nonsingle-domain (NSD) state. In such a state, IFG zones with the higher Curie temperature are primarily magnetized opposite to the magnetic moment sense of IFGs in a single-domain (SD) state. Changes in the environmental conditions or physico-chemical structure alter the IFG domain structure; as a consequence, the total magnetic moment and the degree of SRM development also change. The major reason for SRRM development is magnetostatic interaction. The distinguishing features of the SRRM mechanism are (i) the first order phase SD-NDS transition on the curves describing the magnetic moment as a function of temperature and the external magnetic field (H_e) (e.g., an abnormal

increase/decrease of the magnetic moment accompanied by absorption/emission of thermal energy, a decrease in the SD-NDS transition temperature (T_{SD-NSD}) with increasing H_e), and (ii) variation in the shape of the above curves as the environmental conditions change. One of the salient features of the SRRM mechanism is the Hopkins peak of the non-existing mineral phase, occurring on the curves describing alternating-field susceptibility as a function of temperature.

An abnormal increase/decrease in the sample magnetic moment and retardation of its heating/cooling rate are characteristic features of the SD-NSD transition. Theoretical assumptions have been experimentally verified by investigating the temperature dependence of H_e using samples of synthetic hemoilmenite of the compositions $0.1X_{hem}0.8$. The T_{SD-NSD} decreases with increasing He and increases with the decreases X_{hem} and the degree of chemical inhomogeneity (ΔX_{hem}) of the investigated samples. The absolute value of the $\partial T_{SD-NSD}/\partial H_e$ derivative varies directly with the value for the spontaneous magnetic moment. The effect of SRRM is observed for hemoilmenite of the compositions $0.3X_{hem}0.5$. The value of SRRM increases with increasing ΔX_{hem} of the investigated samples.

New paleomag data for middle Paleozoic magmatic rocks of Yggyatynskaya depression (Siberia platform)

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Yggyatynskaya depression is northern part of south-west segment of Vyluy palaeorift. The rift established on craton basement of Siberia platform at middle Paleozoic. Rift complexes were covered during Mesozoic-Cenozoic time. These complexes are exposing along northwestern border of Yggyatynskaya depression in fragmentary outcrops along Vylyu, Yggyata and Marha rivers and their tributaries. General thickness of middle Paleozoic not transcends 400m here. Two main levels of sheeted basic magmatic generations are located among middle Paleozoic strata of Yggyatynskaya depression. The lower level is appaynskaya suite and the upper is magmatic horizons inside emyaksynskaya suite. Age of these suites and their dividing and directly covering strata is defined now as D3-C1. More detailed age definitions of these by different authors vary inside the time span because all these age estimations based on limited set of wide time range

paleontology remains from few points and isolated historical bulk K-Ar dating. Basic magmatic rocks of appaynskaya and emyaksynskaya suites were studied in natural shore outcrops of Vyluy River and his tributaries. 158 oriented samples were taken from 14 isolated outcrops. Variations of strike and dip are small. Paleomag record quality of samples of basic rocks from appaynskaya and emyaksynskaya suites is very different. Samples of appaynskaya suite have weak paleomag signal. Often the signal is no interpreted. Remagnetisation rings were finding out in some sites. But averages by outcrops have enough concentrated cluster. The best grouping was found in ancient coordinate system: Ds=287.3, Is=9.1, k=48.3, α95=9.7, n=6. Samples from emyaksynskaya suite have clear paleomag record. Zijderveld diagrams demonstrate single component magnetization. Selected magnetization components have good convergence both single outcrop and average collation. The component (Ds=191.6, Is=69.6, k=80.4, α95=4.9, n=12) is predominantly monopolar (apart from the only outcrop) and prefolded. Appaynskaya suite pole (PLong=1.5, PLat=12.0, α95=6.2) is considered as preliminary pole. The pole is locate on arc of big ring between emyaksynskaya suite pole (PLong=107.8, PLat=26.2, α95=7,8) and pole from kimberlites and basic rocks of Vylyu-Marha region (Kravchinsky et al., 2002). The last pole is considered now as "index pole" for D3-C1 time span. Emyaksynskaya suite pole have very good convergence with magmatic rocks poles from Vylyu, Marha, Olenyok and Lena Rivers (Kamysheva, 1971, 1975; Pisarevsky, 1982) and be distinguished from mentioned D3-C1 "index pole". Preliminary conclusions. Latitudinal displacement speed of Siberia could be 5–11 cm/year and rotation speed could be 1.2–2.6 degree/1 myr if these two different paleomag directions really fixed axial dipole field of D3-C1 span. But, this statement will be true if real age correlation among these poles will be defined. Now, we can notice, what such thinkable drift speeds are collate with speeds of Cenozoic jerk of India to North after outpouring of Deccan traps.

Particles of cosmic iron and Fe–Ni alloy in Cretaceous and Cenozoic sediments: thermomagnetic analysis data

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With the aid of thermomagnetic analysis (TMA) of up to 800° the

composition and distribution of particles of metallic iron and FeNi-alloy is studied in 15 sections from Austria, Crimea, Caucasus, Volga Region, Kazakhstan, Turkmenistan. Their content varies from 10–5% to 0.05% and distribution consists of two groups: a)"zero" group (iron is not found by TMA), b) group of nearly lognormal distribution with a differing modes. There are four types of accumulation of metallic particles: dotty, local, regional and global. The global enrichment by iron particles is discovered in Miocene (12–13 Ma), Maastrichtian-Danian (64–66 Ma), Santonian (84–86 Ma) and Cenomanian (94–96 Ma) synchronous deposits in the sections more than 1000 km apart. The omnipresence of iron particles and global spread of the above-noted intervals of iron enrichment indicates the cosmic dust as their main source. Iron particles fall to the Earth surface irregularly and probably from different sources, as may be inferred from bimodal distribution of their concentration. Distribution of iron particles composition falls into two sets: the first one corresponds to pure iron, and the second set has the nearly lognormal distribution with the modal nickel of 5%. This bimodal distribution implies different origin for of pure iron particles and those with a nickel addition. The lunar magmatic rocks are may be the source for the first type. The difference in quantities of iron and Ni–Fe alloy particles and the absence of correlation between their contents indicates their different origin. If the first ones are mainly produced by the fall of cosmic dust on the Earth surface, the second ones are possibly connected with meteorites and impact events. The concentration of alloy particles with Curie points 360–660°C is below 10–5% in the cosmic dust. This conclusion is valid irrespective of the reliability, with which Ni–Fe alloy particles are detected. Almost in all studied sections the peak of the higher content of iron with a constant mixture of nickel of 5–6% is fixed, i.e. it is the global effect which is not dependent on a place and time of deposition of iron particles.

Paleomagnetism of paleoproterozoic assemblages of the Ulkan trough (SE part of the Aldan-Stanovoy province)

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Reconstruction of evolution of any large geologic structure is a task

often involving unambiguous solution, since large fragments of the Earth's crust generally undergo repeated reworking during the period of their existence, which creates difficulties when reconstructing the chain of geologic processes. Of special importance appear complexes the investigation of which makes it possible to reconstruct the geodynamic setting of their formation based on the features of the composition, and the age permits estimation of time. The Ulkan trough filled with the Upper Karelian sedimentary-volcanogenic rock sequence, which is the stratotype of the Aldan-Stanovoy province, is one of such structures distinguished in the south-eastern part of the craton.

The first paleomagnetic evidence of Ulkan granites and trachydacites of the Elgetei Formation has been derived. The direction of the high-temperature component of granite magnetization in the modern coordinate system is Dec=60.8°, Inc=48.4° (K=5.6, α95=10.3) (we believe that the Ulkan massif together with the Siberian craton did not experience any rotations about horizontal axis after granitoid intrusion). This corresponds to the paleomagnetic pole with the coordinates Plat=-47.4°, Plong=64.4° (dp=8.8°, dm=13.5°) which, considering the Aldan-Stanovoy province turn correction with respect to the Angara-Anabar province in the Middle Paleozoic [Pavlov V. et al.], is close to the paleomagnetic pole by ∼1,730Ma, based on cuseevites of the Angara-Kansk protrusion [Didenko A.N. et al.].

A more reliable paleomagnetic pole, regarding the methods involved, has been obtained for the high-temperature component of Elgetei trachydacite magnetization: a positive test of revolution and high convergence of unit vectors in the ancient coordinate system. The paleomagnetic direction of this component is Dec=293.6°, Inc=-42.9° (K=48.1, α95=4.4), which corresponds to paleomagnetic pole with the coordinates Plat=-8.6°, Plong=11.9° (dp=3.4°, dm=5.4°). The position of this pole, considering the Aldan-Stanovoy province turn correction, differs substantially from the coordinates of paleomagnetic poles of the Angara-Anabar province, Siberian craton, in the interval 1,675-1,860 Ma [Didenko A.N. et al.].

This study was done within the Department of Earth Sciences (RAS) integration program "The Structure and Formation of Major Geologic Structures of Mobile Belts and Platforms" (Project No. 09-1-OH-10) and was fanatically supported by the Russian Basic Research Foundation (Project Nos 09-05-00223a and 10-III-B-08-229).

Structure-sensitive parameters of magnetite from Angaro-Ilim after low- and high-temperature magnetic treatments: preliminary results

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In 1980ies high-temperature magnetic memory, i.e. a partial recovery of pre-existed remanence at room temperature after a heating-cooling cycle to above the Curie temperature in zero magnetic field, was discovered for some magnetite bearing rocks from the hypergenesis zone. The name"α-memory" was coined for this phenomenon by an analogy with the well-known low-temperature memory (γ-memory, Petrov & Metallova, 1973). Rocks with α-memory (specifically, Angaro-Ilim magnetite ores) also exhibit clear evidence for exchange anisotropy (Meiklejohn & Bean, 1957), suggesting a close relationship between the two phenomena. Namely, α-memory is believed to be due to so called contact particles – zones of exchange coupling between spins of magnetite and hematite phases within large crystals (Petrov et al., 1986, 1988, 1989). Properties of α-memory have been investigated for various types of remanence: isothermal (including saturation isothermal), viscous, and also for thermogenetic remanences: total and partial thermoremanences, thermoviscous, transitional (Petrov et al., 1998). At the same time, some experimental results exist that do not fit into the contact particle model (Dimitriev et al., 1991). It was therefore suggested that the stable component of thermoremanence of coarse-grained magnetites from the hypergenesis zone might reside in both contact particles and sub-singledomain regions which also carry their γ-memory (Petrov et al., 2005). However, extensive experimental results are needed to prove (or disprove) this hypothesis. As a first step in this direction, we present determinations of structure-sensitive parameters before and after low- and high-temperature treatments for 11 samples with considerably different structure-sensitive parameters in the virgin state. Certain systematic relationships between different parameters after the two treatments were found, and an attempt was undertaken to relate these to a change of physical defects in the magnetite crystalline lattice produced by the high-temperature treatment. Further work will include an analytical estimation of temperature dependences of critical remagnetization fields up to the Curie temperature of magnetite.

Paleomagnetic record of late Pleistocene loess-soil deposits of Pekla outcrop during 450–300 Ka

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Continental loess-soil sections are interesting, but it is difficult to find long-term, continuous, high resolution paleomagnetic records during long time intervals. A bright example of glacial and interglacial periods is Pekla Cliff which located at the southeast shore of the Sea of Azov on the northern part of the Taman peninsula (45.5 N, 37.9 E). The outcrop was continuously sampled up to 11 m thick Pleistocene sediments. The age ranges between ca. 450 and 50 Ka. A investigation of an environmental variability of Pleistocene deposits from Pekla section was important for recording environmental conditions which took place during accumulation and lithification of the sediments. The loess-soil deposits were carefully examined by rock magnetic and paleomagnetic methods. The variability of the scalar magnetic parameters (such as natural remanent magnetization (NRM), magnetic susceptibility (K), saturation remanent magnetization (SIRM) and anhysteretic remanent magnetization (ARM) against the depth of the Pekla section gave the opportunity to determine diagnostic horizons, related with climatic variations. Using well-developed paleomagnetic methods it was studied the magnetic mineralogy, concentration and grain size of the (NRM) main carriers. The structure of the magnetic grains doesn't vary along the section and the main carrier of the NRM was magnetite in Pekla section. Low frequency (Lf) and High-frequency (Hf) susceptibility and frequency dependency (%) were measured on specimens. The susceptibility in the soil parts is typically 2–3 times higher than in the loess parts. The Pekla collection was demagnetized by the alternating field from 15 to 60 mT. The alternating field demagnetization was fulfilled at a paleomagnetic laboratory of Stockholm and Aarhus Universities. Determination of the angle elements of the geomagnetic field (declination and inclination) gave information about the direction and possible Norwegian - Grinland (∼75 Ka) and Biva-II (∼300–350 Ka) excursions of the geomagnetic field. This research was supported by RFBR grant no. 10-05-00129-a.

New palaeomagnetic data from mafic dykes of the southern siberian craton and applications to the neoproterozoic palaeogeography

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Precambrian dyke swarms, sometimes associated with sills, occur along the western shore of Lake Baikal, at the Sharyzhalgai metamorphic massif, and composite terrane along the Siberian boundary to north-west. There were three major magmatic episodes here. First and second episodes occurred in Late Palaeoproterozoic, but their precise ages are yet unknown. Most of the dykes of the Sharyzhalgai metamorphic massive belong to the third generation. One of these dykes was dated at 758 ± 4 Ma (Ar/Ar) and 743 ± 47 Ma (Sm–Nd) (Sklyarov et al., 2003). These dykes do not cut the Late Neoproterozoic sedimentary cover. Geochemical, petrological, mineralogical similarities, similar trends and dips suggest that they are genetically related and derived from the same mantle source. This was also confirmed by our palaeomagnetic study.

Our new 760 Ma palaeomagnetic pole suggests an equatorial position of the Siberian craton with nearly EW orientation. This pole provides an opportunity to check published Precambrian plate tectonic reconstructions. Some of these models suggest the integrity of Siberia and Laurentia during at least some part of the Proterozoic. However, the exact reconstruction is debated. Our pole together with previously obtained results (see Pisarevsky et al., 2008 for references) demonstrates that any of published reconstructions could not survive the whole period between $\sim$ 1500 Ma and $\sim$ 750 Ma. By our opinion, the most likely scenario is the following. Laurentia and Siberia was parts of the Mesoproterozoic supercontinent since before 1500 Ma until after 1000 Ma. However, they were not in a direct contact, as suggested by some workers, but both had been attached to some other yet unknown continental block between northern Laurentia and southern Siberia. This connection had been broken at some time between $\sim$ 1000 Ma and $\sim$ 760 Ma, which was possible related to the breakup of Rodinia and opening of the Palaeo-Asian Ocean.

Early ordovician magnetic polarity sequence: new results from Northwestern Siberia

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The early Palaeozoic Kulyumbe river section is a matter of the detailed palaeomagnetic investigation during last two decades. However there are still some gaps in the magnetostratigraphic columns constructed by previous investigations. New magnetostratigraphic results for the lower Ordovician sections, exposed along the Kulyumbe river are presented here. Stepwise thermal demagnetisation yields the determination of three magnetic components. Two components of steep positive and negative inclinations are interpreted as a remagnetization acquired during the two phases of the Siberian traps emplacement. The third, dual-polarity high temperature component carried by haematite and sometimes by magnetite, is interpreted as syndepositional or nealy syndepositional magnetization of sedimentary rocks studied. Primary origin of this component have been justified by positive results of the reversal, fold and correlation tests. A sequence of four magnetic polarity intervals is observed between the middle Tremadocian and the top of the Arenigian stages. This result confirms presence of the long reverse polarity Arenigian geomagnetic interval, started at the top of the Tremadocian. This magnetostratigraphic level is presented as a tie – point of a global stratigraphic scale for Lower Palaeozoic, which marks the essentially changes of the geomagnetic polarity history.

On a possibility of using impactites for Thellier paleointensity determinations

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We have studied the natural remanent magnetization (NRM) of suevites from Kara impact structure, together with their magnetic mineralogy, in order to investigate NRM origin and stability. Suevites appear to exhibit a very complex magnetic mineralogy and strongly non-uniform spatial distribution of magnetic mineral phases at all

scales down to few cm. However, it might be hoped that suevites may still carry a very stable thermoremanent magnetization. First attempts have been undertaken to determine the geomagnetic paleointensity on suevites from Kara impact structure using the Thellier-Coe method. Paleointensity estimates expressed as Virtual Dipole Moment (VDM) values are around 4x10(22)Am2, about two times lower than the present geomagnetic field. These preliminary results agree well with existing paleointensity records. Most likely, Kara impact structure has been formed close to the Cretaceous-Tertiary boundary. Fission-track age of the Kara structure is estimated at (64.57±1.56) My and agrees well with K-Ar determinations and biostratigraphy. For the 64-67 My interval there exist about 100 paleointensity determinations mostly from lava flows (World Paleointensity database, http://wwwbrk.adm.yar.ru/palmag/index.html). VDM values are predominantly low ranging from 2 to 6x10(22)Am2 with the mean value of 5.3x10(22)Am2.

Structure and phase transformations in magnetites from the Angaro-Ilim deposit

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Properties of magnetic minerals from the Angaro-Ilim ore deposit are of great interest since the latter exhibit a peculiar phenomenon: high-temperature memory of remanent magnetization (α-memory), which manifests itself as a rebound of a part of initial remanence after cycling a sample up to a high temperature (higher than Curie temperature of magnetite) in a zero magnetic field. Initially, two hypotheses have been proposed to explain the origin of α-memory. One assumes that the effect is caused by stressed 'sub-singledomain' regions within multidomain magnetite grains, while another invokes the heterophase oxidation of large magnetite grains forming magnetite-hematite boundaries. Exchange anisotropy in the latter is believed to be the cause of α-memory. To identify magnetic minerals in Angaro-Ilim samples with α-memory we have measured temperature dependences of initial magnetic susceptibility during multiple cycles from room to progressively higher temperatures up to 700°C using a kappabridge KLY-3 in air. Samples have been also examined under optical and scanning electron microscopes, both in the virgin

state and after cycling to 600°C in a zero magnetic field. Microscopic observations show that in the virgin state magnetic minerals are represented by large relict grains of hematite and by strongly porous magnetite grains with numerous inclusions of maghemite and spinel. Such a structure is common for hypothermal scarn deposits of which the Angaro-Ilim deposit is a representative example. After high-temperature treatment, maghemite transforms into hematite forming lamellae of hematite that cut magnetite grains into separate regions. Most likely it is this process that produces magnetite-hematite boundaries believed to carry α-memory. Susceptibility temperature dependences agree reasonably well with microscopic observations. During the first heating the susceptibility shows two maxima at about 80°C and 300–350°C, respectively. Both these features are non-reproducible, disappearing after heating by some 100° above the temperature of the maximum. This behavior possibly indicates that certain structural changes e.g. a release of mechanical stress occurs during heating to very moderate temperatures, while the transformation of maghemite to hematite takes place at higher temperatures, about 400–500°C.

Microstructure and magnetic properties of suevites from Kara impact structure

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We have studied the magnetic properties of suevites from Kara impact structure with the purpose to identify their magnetic mineralogy. The following techniques have been used: electron and optical microscopy both on polished sections and on the separated magnetic fraction, microprobe analysis, and thermomagnetic analysis of saturation magnetization and initial magnetic susceptibility. Magnetic fractions have been investigated at Borok observatory using an optical microscope Olympus BX 51 and a microprobe Tescan Vega II. Polished sections have been studies at Interdisciplinary Resource Center for Nanotechnologies, St.Petersburg University, using a scanning

electron microscope Zeiss Supra 40VP with X-ray energy dispersion microanalysis system Oxford Instruments INCAx-act and a stereomicroscope Zeiss Axio Imager.

Iron-bearing minerals in suevites appear to be very complex, including sulfides of various genesis, both magnetic and non-magnetic, native iron and nickel and their aggregates with a variety of impurities, fine submicron magnetite grains including spherules, grains with fine exsolution structures produce by exsolution of primary magmatic titanomagnetites and hemoilmenites.

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Paleomagnetism of middle Paleozoic mafic bodies of Togus-Daban three-axial syncline (Siberian Craton)

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

Togus-Daban three-axial syncline is situated in the interfluve of Bolshoi Patom and Lena rivers. Tectonically, this structure belongs to Patom passive margin of Siberia which was heavily deformed in middle and late Paleozoic. In map view the syncline is triangular, thus it has three axial surfaces. The triangle is equilateral, with maximum distances between its sides reaching 60 km. The syncline is composed of Vendian to Ordovician clastic and carbonate rocks. Additionally, the sedimentary rocks host numerous middle Paleolozic mafic sills, belonging to Zharov complex. The mafic rocks were the object of this study. From our earlier geochronological studies of the mafic sills from the syncline we know, that intrusion happened in late Devonian, approximately on Frasnian-Famennian boundary. The core of the syncline is composed of nearly horizontal Ordovician sedimentary rocks. The limbs, on the opposite, are heavily deformed, folded into multiple folds which are sometimes complicated by strike-concordant faults. Mafic rocks of Zharov complex were studied in every outcrop along Lena and Bolshoi Patom rivers (plus their tributaries Turuktakh and Turukta). We collected approximately 300 oriented samples from 25 sites with variable bedding.

Paleomagnetic results. Paleomagnetic interpretation turned out to be a rather untrivial matter. A major part of the samples contains definite paleomagnetic signal; magnetization components from each

site group into tight clusters. At the same time, comparing site averages does not allow us to objectively isolate a paleomagnetic direction. In more or less extent, it is possible to isolate a synfolding (?) component with high negative inclination. Its calculated pole (Plong=128.7; Plat=38.2; A95=9.8 N=8) very well corresponds to the pole of Carboniferous-Permian post-deformational remagnetization (Plong=128.3; Plat=31.4; A95=7.8) which is widely found in late Precambrian rocks to the South of the studied area (Shatsillo and Fedyukin, 2009). The rest of paleomagnetic directions are characterized by quasi chaotic dispersion on a sphere with moderate positive and negative inclinations. At some parts (NW limb of the syncline) the directions also group into tight clusters and are pre-folding (Shatsillo and Powerman, 2007). One of the possible interpretations of the results is a presence of pre-folding paleomagnetic component, characterized by dual polarity, which was deformed by large-scale rotation of the rocks during folding event. After conversion all direction to a single polarity, the fold test (which analyzes inclinations only) suggests a pre-folding magnetization (k max at 110% fold straightening, kg/ks=5.4/26.4, N=14, I at 100% straightening = 34.8+/-5.8). After deleting 3 average directions, characterized by lowest inclinations, the correspondent parameters become: k max at 100% fold straightening, kg/ks=7.2/192.9, I at 100% straightening= 39.1 ± 2.4. Paleolatitude of the studied area, calculated from the average direction, is N 19.2. It is located between paleolatitudes of Silurian (N 10.2) and late Devonian - early Carboniferous (N 35) (Shatsillo et al., 2007; Kravchinsky et al., 2002). This fact supports the physical meaning of the isolated component. At the same time, the proposed scenario involves large scale (up to 180) rotations of the blocks. This needs to be verified by structural geological data. The synfolding timing of the metachronous component is somewhat doubtful and might be induced by partial contamination of pre- and post-folding components alone.

Ordering temperature and space distribution of spontaneous magnetization in ferromagnetic nanoparticles

Shcherbakov, V., Sycheva, N. (Borok Geophysical Observatory, Borok, Russia)

Temperature-space variations in intensity of spontaneous magnetization and the onset of long-range order in a ferromagnetic nanoparticle

are studied by use of Ginzburg-Landau theory. The important feature of such the grains is that the surface ions have only a part of inter-atomic interactions in comparison with those located in the interior of the grain. Due to this, at elevated temperatures the intensity of magnetization of the surface layer is considerably less in comparison with the bulk magnetization value M0 while in the centre of the grain it already may be close to M0. The analytical representation of magnetic structure of thin films with width (1–10) nm is obtained. In rocks, this case is represented by thin lamellae embedded in a paramagnetic environment due to a process of exsolution. Results of numerical calculations for spherical and cubic particles showed a noticeable decrease (up to 200 C degrees in grains of 1 nm size) of the Curie temperature.

The statistics of polarity time scale as a random walk process

Shcherbakov, V. (Borok Geophysical Observatory, Russia), Fabian, K. (Geological Survey of Norway), Sycheva, N. (Borok Geophysical Observatory, Russia)

Recent studies indicate that the lengths of polarity intervals do not follow Poisson statistics. It is shown that first-passage time (FPT) statistics for a one-dimensional random walk provides a good fit to the polarity time scale (PTS) in the range of stable polarity durations between 10 ka and 3000 ka. This fit is achieved by adjusting only a single parameter which can be regarded as the diffusion time T, which comes to lie between 70 ka and 100 ka depending on the PTS chosen. A slightly more sophisticated random-walk model yields an amazingly good global correspondence to the PTS and describes the probability density of the duration of polarity intervals by an inverse gamma distribution with two parameters. A possible physical interpretation suggests that the stability of a polarity chron of the Earth's magnetic field is controlled by a sum of statistically independent, randomly behaving, dynamo processes in the outer core. Another possible interpretation refers to the O/E ratio variability suggested by Coe and Glatzmaier, 2006 where O is the energy stored in odd harmonics and E is the energy stored in even harmonics of the Earth field. The model predicts a weak correlation between the variance of strength of the paleofield and the duration of a chron. A provisional estimation of the probability of the next reversal is presented.

Rock magnetic properties and paleointensity of the Permo-Triassic Siberian trap basalts in the Maimecha-Kotuy region

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Magnetic properties of 65 samples from Permo-Triassic Siberian Trap Basalt collection sampled in 2009 for paleomagnetic and paleointensity studies are investigated. The thermal stability of the ferromagnetic minerals and their Curie points T_c were estimated from thermomagnetic curves of saturation magnetization $M_s(T)$, with incremental heating-cooling cycles to increasing temperatures T_i =200, 300, 400, 500, 600, 700°C. The samples are stable with respect to heating up to 350°C, but significant alterations of ferromagnetic minerals have placed during heating to the higher temperatures. Such the behavior is typical for partially oxidized titanomagnetites. The progressive decrease in the intensity of Ms with increasing of heating temperatures is most likely related to the transformation of maghemite into hematite taking place in some grains (or in part of the grains). The ratios M_{rs}/M_s and H_{cr}/H_c of the investigated samples lie within the SD-PSD region. These findings show that the Thellier paleointensity determinations must be restricted by the low-temperature range. The Thellier-Coe procedure was used in paleointensity determination experiments, and the ancient field was fitted for some lava flows. Preliminary results show that the paleointensities for different lava flows fall in two groups changing from very low to modern one VDM values.

Palaeointensity determinations of Cretaceous rocks from Mongolia

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A complex palaeomagnetic study of Gobi-Altai Cretaceous and Paleocene rocks are carried out. The samples represent volcanic and volcano-sedimentary rocks consisting of two groups. The first group contains sequences of basalts with isotopic (K-Ar) age 134–125 Ma (sections M1 and M2). The second one is presented by volcano-sedimentary rocks (6 extrusions of basanites, 4 lava flows and marl-

stones alternating with the flows) with the age of 110 Ma. The palaeomagnetic directions have been obtained from thermodemagnetization procedure. Palaeointensity determi-nations were obtained by the Thellier-Coe method including the "check-points" procedure. The data obtained from the M1 and M2 sections (130±5 Ma) yielded for each section two different sets of VDMs, conditionally named as "low field" and "high field" sets. Thus, four distinctive values of average palaeointensity were obtained on these two sections: 1) M1 "low field" VDM $= 5.1 \pm 0.5 \times 10^{22} Am^2$ (14 samples); 2) M2 "low field" VDM $= 6.7 \pm 1.7 \times 10^{22} Am^2$ (4 samples); 3) M1 "high field" VDM $= 16.4 \pm 1.1 \times 10^{22} Am^2$ (15 samples); 4) M2 "high field" VDM $= 13.5 \pm 2.0 \times 10^{22} Am^2$ (12 samples). Averaged values of "low field" VDM $= 5.9 \pm 2.5 \times 10^{22}$ which considerably exceed the average "high field" VDM$= 15 \pm 3.5 \times 10^{22} Am^2$. The second group of samples with the age 110 Ma yielded VDM$= 7.8 \pm 0.9 \times 10^{22} Am^2$ (16 samples). The compilation of the Thellier data for the Cretaceous Superchrone available in the world palaeointensity database, with addition of the data reported here, gave the average VDM $= 7.1 \pm 0.7 \times 10^{22} Am^2$ with high range of secular variations VDM$= (2 - 20) \times 10^{22} Am^2$. A comparison of this value with the Miocene (high reversal frequency period) average VDM $= (5.1 \pm 0.7 \times 10^{22} Am^2)$ hints to the existence of a weak correlation between the palaeointensity and reversal frequency.

TCRM properties of rocks

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Recent studies indicate that the remanence stored in oxidized rocks might be a TCRM instead of a TRM. If TRM and TCRM have similar thermal stability they may be undistinguishable from the point of view of Thellier experiments bringing false results. However, no firm experimental or theoretical evidences which support or refute this statement are found. Here we present results of extensive experiments on TCRM created on natural titanomagnetites. The direct Thellier experiments as well (as the Wilson–Burakov express method thermodemagntization curves), performed on these samples, showed a drastic non-similarity of the Arai–Nagata diagrams of these two

remanences. Thus, it is likely that the strong similarity of NRM-TRM plots and the good quality of the Arai–Nagata plots observed on a wide temperature interval, altogether with the lack of significant chemical and structural alterations under thermal treatment, favor of a TRM origin for the NRM of these samples.

Planetary convection and magnetism laws

Starchenko, S.V. (IZMIRAN, Troitsk, Moscow region, Russia)

I prove the known and establish new scaling laws for planetary magneto-convection from the first principles.

A regime with kinetic energy exceeding or comparable with magnetic energy was found. This kinetic regime could lead to relatively lower dynamo efficiency, asymmetric and non-stable magnetic field similar to modern magnetic field of the Mercury, Ganymede Uranus and Neptune or ancient magnetic field of the Mars and Moon.

The other magnetic or MAC regime has efficient magnetic dynamo energy greatly exceeding kinetic energy. Its symmetric and stable magnetic field could be similar to magnetic field of the Earth, Jupiter and Saturn.

The majority of the available numerical planetary type MHD dynamo simulations are closer to kinetic regime than to magnetic regime.

Convection stabilities and magnetic dynamos in thick liquid planetary cores

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For the description of critical stability of almost adiabatic planetary convection we use initial system of PDEs in the rapid rotation limit. For the first time we simplify this system to first-order ODEs for the pressure and vertical component of the velocity. The critical frequencies, modified Rayleigh numbers and distributions of convection are received at various possible Prandtl numbers and in different thick

fluid shells. The choice of physical parameters is based on the possible applications to the hydrodynamics of the deep interiors of the Earth and planets and moons of Terrestrial group.

Our results for the large Prandtl numbers can be interpreted within the frames of compositional or gravitational-chemical planetary convection. The corresponding critical frequencies are almost steady-state, while critical Rayleigh numbers are large justifying the planetary MHD dynamo models with lower supercritical parameters. Thermal convection has small Prandtl numbers that typically leads to high critical frequencies and lower critical Rayleigh numbers with higher supercritical parameters not reachable by the modern numerical dynamo models. Our results for various distributions of convective sources at 'turbulent' Prandtl number unity could be valid for the deep interiors of planets/moons with vigorous enough convection.

For different but sufficiently thick fluid shells we for the first time obtain fully analytical expressions for critical Rayleigh numbers, frequencies and distributions of planetary/moons convection for all possible Prandtl numbers in the approximation of small inner to outer radius aspect ratio. Comparison of this analytic solution with available and our new numerical solutions testify applicability of our general analytic results to a planet/moon with small inner core. Corresponding distribution of thermal and/or compositional convective sources is likely typical for the deep convective interiors of the most part of the planets and moons when it is possible to neglect a homogeneous radioactive heating.

Variations of geomagnetic paleointensity as a result of the protocore evolution

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It is generally accepted that geodynamo is mainly driven by compositional convection due to liquid core crystallization which began about (1.5 ± 0.5) Ga ago. Therefore geomagnetic paleointensity should have a low value until 1 Ga, because it was determined only by an inefficient thermal convection. This is in contradiction with the paleomagnetic records. It can be regarded as a little-known geodynamo

paradox. This paradox could be resolved if we suggest that the sufficient part of the modern Earth's solid core has never been formed due to liquid core crystallization, but represents the small relic of the protocore on which heterogenic accretion has begun. This protocore consists of heavy (Fe, Ni) and light (condrite silicates) components and which is dissolved under influence of the liquid core. We suggest that concentration of the light protocore component is decreased from $\sim$65% up to $\sim$5% towards the protocore's center. The flouting up of the light protocore component in liquid core during protocore dissolution causes the composition convection, which supports geodynamo. According to the model calculations this process could have maximal magnitude at about (2.5 ± 1) Ga and so the geomagnetic intensity could have its present value or larger. When the protocore decreases up to the size at which concentration of the light element is less than 8% than the protocore dissolution stops and the liquid core crystallization can begin. At that transition of about (1.5 ± 1) Ga the estimated geomagnetic intensity should be smaller than the present value. After that period the paleointensity could rise again up to its present value due to another kind of compositional convection which is now determined by the liquid core crystallization.

Paleomagnetism of Holocene formations of Chirchik basin (North-Eastern Uzbekistan)

Stelmakh, A.G. (National University of Uzbekistan, Tashkent, 100174 Uzbekistan)

In this basin Holocene deposits are represented by different lithologic and genetic variants. Terrace sections have been more studied, a slope and watershed sections have been little studied. Nevertheless, we have considered all the genetic and lithological types of rocks suitable for paleomagnetic study.

In laboratory studies to highlight the stable components of the sum vector NRM (natural remanent magnetization) samples were subjected to magnetic cleaning: an alternating magnetic field (h-cleaning) and temperature (t-cleaning). Thermal cleaning was carried out to temperatures $300 \div 700$°C with step $50 \div 100$°C. Destruction of volatile components of NRM in rocks was observed at temperatures of $100 \div 300$°C. Magnetic cleaning by an alternating magnetic field (h-cleaning) was carried out to $100 \div 600$ E with step $50 \div 100$ E.

Destruction of volatile components of NRM often happened in the interval $100 \div 300$ E. By magnetic cleaning it possible to determine stable component of the vector NRM in the investigated rocks. Using this component we have constructed paleomagnetic sections in which we have identified Holocene short-term geomagnetic deflection (two reverse and one abnormal).

In general, it was found that NRM varies widely $(2.0 \div 52.0) \cdot 10^{-6}$ CGS with an average value of NRM equal to $24.0 \cdot 10^{-6}$ CGS, and MS (magnetic susceptibility) varies $(12.0 \div 90.0) \cdot 10^{-6}$ CGS with average value of MS equal to $30.0 \cdot 10^{-6}$ CGS. It is noted that since the early Holocene epoch NRM decreased from $52.0 \cdot 10^{-6}$ CGS to $2.0 \cdot 10^{-6}$ CGS, and MS increased from $12.0 \cdot 10^{-6}$ CGS to $90.0 \cdot 10^{-6}$ CGS. The increase of MS due to enlargement of the faction of ferromagnetic minerals. Low values of NRM correspond to the period of short-term deviations of the geomagnetic field.

New potential of rock magnetism for investigation of Precambrian basement rocks

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Study of the Precambrian basement is a complex task. Considerable variability of the Precambrian basement prevents the effective use of drilling and lithologic stratigraphic methods. In order to understand the geological structure of the Early Precambrian basement used geophysical methods, especially magnetometry. Map of the magnetic field scale 1:25000, 1:50000 gives an indication about the specific geological structure, the virtual sources, such as geological formations or the association. The understanding of geological structure of region with such differentiated basement structure requires detailed studies of small geological bodies. Their size might be to small to be resolved by standard geological survey, but these bodies are magnetic markers of geological structure. For their studying new method was developed — "magnetic scanning". Magnetic scanning is ultradetailed complex petromagnetometric method of studying of the outcrops and adjacent areas. Magnetic scanning includes ultradetailed (fast and work-economic) magnetic survey coupled with measurements of magnetic susceptibility (kappametric) in outcrops, followed by laboratory petromagnetic studies of selected rock sam-

ples. We have shown that magnetic scanning of the Ukrainian shield (US) gives the new structural geological information.

Paleomagnetism of Pleistocene deposits in Uzbekistan

Toychiev, Kh.A., Stelmakh, A.G. (National University of Uzbekistan, Tashkent, 100174 Uzbekistan)

Formation of Pleistocene deposits in Uzbekistan was associated with activation of regional tectonic crustal movements during the Quaternary. As a result of these movements, sections of the Pleistocene formations of the region characterized by cyclical, subordination to local tectonic movements and zonal factors. This considerable thickness of Pleistocene deposits are loess and loess-soil rocks. In general, there is no single complete stratigraphic section of Pleistocene deposits in the region. Sections of orogenic zone in an abbreviated form represent the whole Pleistocene, and in them deposits hold certain levels of complicated structure of cuts. Integrated regional stratigraphic section of Pleistocene sediments consists of various lithologic and genetic types of sediments.

Paleomagnetic study of the characteristics of Pleistocene rocks shows that the natural remanent magnetization (NRM) of these rocks varies $(8.0 \div 22) \cdot 10^{-6}$ CGS with an average value of NRM equal to $12.0 \cdot 10^{-6}$ CGS; its magnetic susceptibility (MS) is in the interval $(32.0 \div 58.2) \cdot 10^{-6}$ CGS with an average value of MS $42.0 \cdot 10^{-6}$ CGS. It is noted that NRM rocks gradually increases from $8.0 \cdot 10^{-6}$ CGS (for early Pleistocene rocks) to $22.0 \cdot 10^{-6}$ CGS (for middle Pleistocene rocks), and one again decreased to $16.0 \cdot 10^{-6}$ CGS for late Pleistocene rocks. However, MS varies unevenly, distinct patterns are not observed. Low values of NRM were observed in samples of Pleistocene deposits, which correspond to periods of short-term deviations and the transitional period of the geomagnetic field, but high values of NRM — to perturbations of the geomagnetic field.

Based on the paleomagnetic study of Pleistocene deposits in Uzbekistan we identified two inverse and the same number of abnormal short-term deviations of the geomagnetic field in the era of direct polarity Brunhes of geomagnetic field.

Paleomagnetism of Eopleistocene deposits in Uzbekistan

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Studied sections of the continental Eopleistocene deposits within orogenic region of Uzbekistan are mainly represented by loess-soil rocks. Natural remanent magnetization (NRM) of Eopleistocene rocks varies within $(0.5 \div 12.8) \cdot 10^{-6}$ CGS with an average of NRM equal to $7.6 \cdot 10^{-6}$ CGS, and the magnetic susceptibility (MS) varies within the $(9.2 \div 26.4) \cdot 10^{-6}$ CGS with an average value of MS equal to $21.6 \cdot 10^{-6}$ CGS. High values of MS of deposits are characterized by relatively high concentrations of ferromagnetic materials. Paleomagnetic properties of paleosoils in Eopleistocene loess deposits weakly manifested and practically do not differ from the paleomagnetic properties of the parent rocks. Here Eopleistocene deposits in complete sections were dissected six back and the same straight magnetized horizons. They was formed in the era of reverse polarity Matuyama.

In the platform region, similar magnetization was found in marine Upper Pliocene sediments of Neogene. In the Early Quaternary, a part of the territory has developed in the platform mode with sea conditions, while others developed in the orogenic mode with continental conditions. Therefore, in the Early Quaternary time it is possible to form both marine and continental deposits. Based on the similarity of the geomagnetic polarity and development of geological and tectonic events, it should assume that Upper Pliocene sediments platform area are the marine equivalent of the continental Quaternary sediments.

Based on the set of five short-term geomagnetic variations of direct polarity in the inverse Matuyama epoch, we have formulated the scheme of regional paleomagnetic correlation of cuts Eopleistocene deposits for different stratigraphic regions of Uzbekistan. Nurata incision was isolated as a regional reference paleomagnetic section of Eopleistocene deposits to compare particular paleomagnetic sections.

Geomagnetic field record of Maeotian deposits of Popov Kameni section

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Rock magnetic and paleomagnetic features of 130 m Maeotian deposits of Popov Kameni section (Krasnodar region) have been investigated. Popov Kameni section is located in a south-west coast of Taman Peninsula on the south from a cape Popov Kameni (450 E, 370 N). Collected samples covered a time interval about 5.9–7.4 Ma. Taman Peninsula is a base region for Neogene sections in Russia. For the first time Maeotian deposits were studied here by M. Pevzner in 1978. With a goal to correlate the base sections of Neogene it was necessary to reveal a detail rock magnetic and paleomagnetic investigations. By means of standard methods of rock magnetism a variability of the scalar magnetic parameters were examined. A composition of the magnetic minerals was determined by thermomagnetic analysis (Ms(T), K(T)) and isothermal remanent magnetization experiments (IRM(T)). Main magnetic minerals of rocks were iron sulfides — pirrhotite and greigite. During heating samples containing pirrhotite exhibited a rapid increase in magnetization above 300 grad C. A common magnetic parameters were measured: NRM, ARM, K, Kfd, AMS. Investigations of an anisotropy of magnetic susceptibility (AMS) showed that deposits had a characteristic for sediments plate anisotropy. Thermo demagnetization of 120 samples were fulfilled in a temperature interval 75–325 grad with 25 grad step. The determination of angle elements of NRM gaves an information about sign of geomagnetic field during Maeotian period. Investigations showed that the low part of Maeotian deposits had a reversed magnetization and the upper part of Maeotian diposits had a today's polarity. There were two horizons of today's polarity in the reversed magnetized low part of the Maeotian deposits. The correlation with magnetostratigrafic scale showed that low Maeotian deposits corresponded to C3Br, C3Bn and C3Ar chrons and the part of the upper Maeotian deposits corresponded to a low part of C3An chron. This research was supported by RFBR grant no. 07-05-00795-a.

Diagnostics of an origin of magnetic microspheres

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Metal particles and microspheres frequently met in meteoric craters and near to them [Grachev, 2008] and in modern deposits [Tselmovich, 2007]. The morphology and structure magnetic particles from sedimentary breeds of Pleshcheevo lake and B. Lozhka lake are investigated. It is shown, that their significant part is submitted by microspheres from magnetite. They have the size from 0.2 for 50 microns. Similar microspheres were observed at hydrothermal processes and in the cast out breeds [Sandimirova, 2003]. Microspheres can be formed and at anthropogenous processes [Anshits, 2010]. The research problem — search of difference of structure and morphology magnetic microspheres a various origin. It is shown, that microspheres of a space origin are background more often. If we find out space balls together with metal iron we can speak about presence of process of accumulation of a space dust and micrometeorites. Features of space balls consist in the following: (1) They have practically ideal spherical form and a characteristic microstructure. (2) Microspheres are found out together with space minerals and native iron. The most widespread indicator of presence of space substance - an alloy of nickel with iron. (3) Space minerals usually do not contain the titan. The titan is a usual element of particles which arise at volcanic processes. Therefore particles, contents the titan, not a space origin. (4) Thin structures of allocation magnetite from a alumosilicate glass can testify to an anthropogenous origin of microspheres.

Giant Barkhausen jumps in basaltic lavas

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Three decades have shown that the magnetic fabric of ferromagnetic minerals present in rocks can preserve, due to their thermal magnetization in a constant field HT, information on the conditions of this magnetization. First of all, this relates to the intensity HT remembered by a rock [Shashkanov and Metallova, 1982; Vechfinskii et al., 1989; Vechfinskii and Tselmovich, 1992]. Induced magnetic

anisotropy (IMA) of diffusion origin arises during thermal magnetization of rock containing multidomain magnetite particles. As an IMA consequence, constrictions of magnetization hysteresis loops are observed in such rocks at magnetizing fields close in intensity to HT. These constrictions are due to the fact that moving domain walls encounter potential energy barriers causing large Barkhausen jumps. The large potential barriers arise as a result of redistribution of lattice defects (impurities, vacancies, microcracks, etc.) in a ferromagnetic species of a rock. Very large constrictions were observed in Quaternary samples of Kamchatka lava (Mutnovskii volcano) containing multidomain grains of low-Ti titanomagnetite (with a Curie point (Te) of 520–570°C). It is found that the energy of these giant barriers should be no less than 100 times higher than the potential barrier energy of magnetic minerals yielding ordinary hysteresis loops and about 10 times higher than the energy of barriers responsible for loop constrictions carrying information on the field value HT. Experiments showed that the magnetic fabric of a rock could record the intensities of a few magnetic fields (differing even in origin) and a few temperatures of thermal magnetization.

Paleoproterozoic APWP of the Siberian Craton

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Well dated Early Proterozoic poles lie on the patterns of the apparent polar wander path Siberia, forming a nonclosed loop. The curve is constructed using a cubic spline using the program GMAP [Torsvik and Smethurst, 1999]. It also added new poles for mafic intrusions of the West Anabar plateau [Veselovskiy, Pavlov, 2009] and Olenek uplift [Wingate at al, 2009]. They are well show the general trend of the apparent motion of the poles of Siberia. At the moment there are two clusters with reliably dated Early Proterozoic poles: 1850–1860 million years and 1750–1670 million years, within these clusters can be observed regular rejuvenation of poles designed in the branches of this loop in opposite directions.

Variations in the Earth's rotation period and virtual dipole moment in geological history

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According to satellite data, the Moon orbit radius increases by about 3.8 cm/year. A small decrease in angular velocity ($d\Omega/dt$) and an increase in Earth's rotation period (ϕ) correspond to the Moon's moving away from the Earth. These global processes probably also took place in the geological past, as shown by studying the number of annual growth rings of different-aged fossils. According to P. Varga, 550 Ma ago ϕ was 3–1 hour shorter, i.e. the angular rotation velocity of the Earth's mantle was about 14% higher, exceeding the modern angular rotation velocity of the inner core. In this case, a geomagnetic field could not have been generated. The mantle retardation energy estimated is commensurable with the output of a modern dynamo, and could be one of the sources of generation of the main geomagnetic field. The increase of ϕ in Phanerozoic time generally shows a near-linear pattern and corresponds to the $d\Omega/dt$ value, but there is a distinct anomaly in the 350–200 Ma interval on T-curve: the Earth's rotation was retarded much faster at that time. The Earth's virtual dipole moment (VDM) decreased in the same interval, as shown by the Global Database on palaeointensity. Furthermore, the beginning of accelerated mantle retardation, corresponding to the age of 400 Ma, that accompanied a "short-time" increase in $\Delta\Omega$ between the mantle and the inner core, is characterized by abnormally high VDM-values. Another similar ϕ- and VDM- anomaly is observed in Precambrian time in the interval 1.0–0.6 Ga. Known VDM-values at the end of this interval were probably also much smaller than at the present level and at the preceding time. However, it seems more essential that both ϕ- anomalies observed began at the time of generation of magmatic activity cycles that mark these events in the crust of all continents and are assumed to have resulted from global geoid restructuring. There were not less than four such cycles in the Earth's Proterozoic history. For the time being it is impossible to trace in detail variations in VDM and ϕ in Precambrian time because reliable data are scarce. We are about to begin solving this problem.

Section S. Seismology

Aftershock process in the channel of Stur-Fiord (Spitsbergen) and hypothesis of seismicity

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Seismicity of the channel of Stur-Fiord became above the background level due to M=6.1 earthquake occurred on 21.02.2008. The channel of Stur-Fiord delimits two the largest islands of Spitsbergen Archipelago – Edge and West Spitsbergen. The channel area is the most active seismic zone of the archipelago. 21.02.2008 at 02.46:17.41 UT Mw= 6.1 earthquake occurred in Stur-Firod. The event is the strongest earthquake for 100 years of seismic monitoring in Barents Sea shelf. After the mainshock more than 3000 $ML1$ aftershocks were registered during 2008 and up to June-2010 the seismic activity is still above background level. The aftershock process intensity reached more than 950 events per day. Catalog used in the study comprises of 29246 aftershocks with $ML \geq -0.2$, including 518 aftershocks with $ML \geq 2$.

To study the seismicity of Stur-Fiord due-to the Mw=6.1 earthquake we applied four models of aftershock decay rate. We used relaxation models and model ETAS-model of triggered seismicity. Relaxation models: modified Omory Law (MOL), Modified Stretched Exponent (MSTREXP), and Limited Power Low (LPL) model. LPL-model takes into account both features MOL and MSTREXP models. The relaxation models were fitted with and without background seismicity. We fitted the four models separately to $ML \geq -0.2$ and $ML \geq 2$ aftershocks sequences. Model selection was carried out using Akaike and Schwarz's information criteria.

For $ML \geq -0.2$ aftershocks sequence the best choice is ETAS-model and for $ML \geq 2$ - relaxation LPL-model with background seismicity. Relaxation features of the aftershock process reveals for $ML \geq 2$ sequence which belongs to exponential type i.e. the forces that initiated the stress still affect. We conclude that aftershocks with $-0.2 \leq ML \leq 2$ don't obey the relaxation models. To explain this we suggest a hypnosis that the process connected with disturbance fluid-dynamic equilibrium and breaking has-hydrates in the sea bottom.

Experience in modern seismicity study

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The distributions of seismic events, based on earthquake catalogues, provide diverse information for studying modern seismicity. The simplicity, flexibility and descriptiveness of statistical modelling make it easier to conduct scientific studies and to pose and solve educational problems. The US National Seismic Service Catalogue, NEIC, with 1973–2006 data, was used in our computing experiments. Columns in the Catalogue corresponded to the year, month, day and time of an event, as well as the longitude, latitude, source depth and magnitude of an earthquake. Modelling in the MATLAB system has shown that the magnitude distribution of events contains at least five constituents, and the depth distribution of events contains the most probable earthquake formation domains that alternate with a ∼50 km step. Variations in magnitude distribution with depth and depth distribution with magnitude and similar distributions in compression zones and continental and oceanic rift zones were observed. The time (date, month and year) distributions of events have shown a nonsteady seismic activity pattern, most clearly exhibited by crustal earthquakes. Analysis of the monthly distribution of seismic events has shown that crustal quakes most often occur in October-November and in April-May and mantle quakes in February and August. The result is interpreted in connection with the tangential Earth's orbital motion acceleration value. The time distribution of events proved to be convenient for obtaining autocorrelation functions and strength spectra and for searching for bifurcation points. An attempt was made to use the above distributions for predicting seismic activity by fuzzy logic methods and singular-spectral analysis of chaotic time series.

The results of seismic monitoring of Russian platform by seismic mini-array

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Mikhnevo small aperture seismic array (MHVAR) consisting of 12 short-period sensors was installed and operated in Moscow region

since 2004. Its main purpose is to study the seismicity of East-European platform (EEP). During 2007-2008 more than 1600 events were located by the array in the central part of EEP. Most of the events are not detected by local seismic network. Detected events form compact clusters around known quarries, where chemical explosions occur. Size of each cluster allows to determine azimuthal error during location. Most clusters have mean square azimuthal error from 2 to 4 degrees. Some clusters from which where strong signals privale provide azimuthal error of less than 1 degree. Estimates of local magnitude ML made by MHVAR data for local events are 0,7 to 3,0 and for regional events in the central part of EEP are 1,1 to 3,6. Analysis of time distibution and waveforms shows that most of detected events are quarry blasts. At the same a few regional events of unknown origin and tectonic earthquakes are located by the array in 2006-2010 including recent event of 14.05.2010 at Ukraine. Further observations at Mikhnevo array and their analysis promise to find out a level of natural seismicity at the platfom.

Velocity structure of the upper lithosphere in the Kirgiz Tyan-Shan from surface wave tomography using distant earth

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A modified method for surface wave tomography (SWT) using records from distant earthquakes recorded at a network of seismological stations was developed earlier (Yanovskaya, 2009). In this method lateral velocity variations of surface waves are estimated jointly with mean velocity corrections at parts of the paths outside the network area. The method was applied to the records of KNET stations from earthquakes in the West Europe, South-eastern Siberia, Japan, India, China, Afghanistan and Pakistan. Dispersion curves of Rayleigh waves are determined by the frequency-time analysis (FTAN). Lateral variations of group velocities at the periods 20–40 sec within a zone covered by the stations were obtained from the dispersion curves by the modified SWT method. S-wave velocity sections along the meridional profile 75°E are reconstructed from locally averaged dispersion curves. It is shown that in the crust of the northern part of the profile there exists a high velocity layer located above a low velocity zone at the depths of 50–70 km. The results are in a good

agreement with previous studies based on the body-wave tomography (Sabitova et al., 2005) and on the receiver function technique (Vinnik et al., 2006).

The traveltime seismic tomography for the archaeology and engineering geophysics: methodological considerations and application for the Solovki island archaeological site

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The ability of the refracted seismic rays to penetrate below the constructed or not accessible areas makes the controlled-source seismic tomography the tool of choice for the investigation of the basements of buildings and other engineering constructions, monitoring the changes in the ground layer, etc. Another area of the tomography application may be the archaeological sites where the positions of the old basements, graves and soil homogeneities are to be reconstructed. We present the results of the methodological studies with the synthetic experiments that imitate the probable position of the old church basement and apply our method to the field data acquired over the Onufrievskaya church ruins in the Solovki island.

BC-method for Lame system

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The paper deals with problems of boundary control and the inverse problems for the dynamical Lame system (isotropic model). Its response operator ("input-output") R plays the role of the inverse data. There are two types of waves (quick (p) and slow (s)), which propagate with different velocities and interact with one another. This approach to inverse problems based on their relations to the boundary control theory (BC-method, Belishev, 1986). Suppose we know operator L which relations components of the boundary control in

order to the front of the wave propagates with slow velocity. It is shown that this data determines slow velocity in this domain.

A new technique for constructing the Gaussian beams with a given width for calculation of synthetic seismograms

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The Gaussian beam summation method is well-known as a very powerful one for calculation of synthetic seismograms, especially when the wave field is irregular. For correct use of this method it is necessary to choose properly the initial parameters for each Gaussian beam that should be summarized. These parameters determine a shape of the Gaussian beams, i.e. width and curvature. In case of incorrect choice of these parameters the Gaussian beams have rather complex form: they may oscillate strongly, and/or decay very slowly that leads both to loss of calculation accuracy and to significant increasing of calculation time. Until now all the known approaches for choosing these parameters were based on the before-calculated iterative guessing or they were too sophisticated to use them in numerical calculation for practical tasks.

In this work the new technique for construction of Gaussian beams with any beforehand given width and simultaneously with minimal number of oscillations for that width is proposed for any media. The initial parameters defined in such a way are individual for each ray, even for the system of incident-reflected/transmitted rays. It is shown that from physical point of view it is quite reasonable to set the width proportional to the wavelength, however it can be specified in any other ways, for example, as related to the geometrical spreading or radius of Fresnel zone.

The construction procedure for such Gaussian beams is universal - it works for any media including the cases with smooth interfaces and allows automatically control/retain the given width at the whole ray. These features together with the fact that the calculation algorithm remains the same at the presence of caustics or critical reflection zones make the Gaussian beam method very convenient one for calculating synthetic seismograms in complex models of the real Earth.

The Gaussian beam summation method on the basis of proposed

technique is implemented in a numerical code. Examples of synthetic seismograms for 2D and 3D structures in inhomogeneous media with smooth interfaces calculated by the suggested approach are presented.

Using neural network for the detection an earthquake in a noise-contaminated records

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We investigate the potential of neural networks (NN) for the detection of an earthquake signal in a noise that is composed of many heterogeneous components. The identification of earthquake phases, especially the first arrival, on a noise-contaminated record is an urgent task for early warning systems based on a single sensor. In that case the sensor is installed by the end user, that is, in places of increased levels of manmade noise and with minimal noise protection. The noise may be very diverse, ranging from stationary to impulsive. We examine the effectiveness of a neural network solution to the problem in hand, discuss various types of NN, the algorithms for network training, the choice of initial weight coefficients. We consider further research goals in the applications of neural networks to the classification of seismic signals. The main goal of our work was to investigate whether it is possible to use neural networks for identification of earthquake signals in noise that comes from heterogeneous sources and has diverse characteristics. Twenty five events recorded at more than 20 stations have been processed to generate the training set. Multiplexing included, we have generated more than 50,000 feature vectors characteristic for the earthquake class. The processing of seismic noise records made it possible to generate a second data set (the noise class) for NN training. One hundred vectors in each class have been reserved for the test data set. The test data set produced a classification accuracy equal to 93%. Since the accuracy attained was sufficiently high, the NN proposed here can be used as the base network for developing an early warning system with a single sensor. The use of neural network technologies, one can deal with problems that are more complex than simple detection of the signal envisaged in this problem, including the identification of earthquake phases, the classification of earthquakes based on characteristics, and so on. An analysis of the weight coefficients of a network makes it possible to

estimate the relative influence of individual variables on the response.

Velocity structure of the mantle lid in the Black Sea basin

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P-wave travel time residuals measured at the coastal stations from earthquakes within and around the Black Sea are used for estimation of lateral velocity variations in the mantle lithosphere of the Black Sea basin. The observed data were corrected for the crust structure that allowed us to get more accurate information on the velocity distribution in the mantle lid. The structure of the crust was assumed in compliance with the model crust2.0. We applied the tomography method in which a 3D region was divided by cells, and velocity correction in each cell were estimated. Due to rather large size of the region, for which sphericity cannot be neglected, the spherical region was preliminary transformed to a rectangular one. A solution was determined at the rectangular grid, then it was transformed back to the spherical coordinates. A resolution matrix was determined jointly with the solution for velocity corrections. The results are displayed in a form of lateral velocity variations in successive depth intervals. Some new features of the mantle lid structure have been found that reflect history of formation and evolution of the Black Sea depression. It is shown that the Black Sea basin is not a single block: it consists of two different depressions distinguishing by the velocity structure and orientation. They are separated by a low-velocity zone, western and eastern parts of which coincide with the Western-Crimean fault and the Trans-Black Sea fault correspondingly.

Tectonostratigraphic model of the Pechengsky geoblock (experience of extrapolation of the Kola superdeep borehole data to the lower boundary of the crust)

Il'chenko, V.L. (Geological Institute of the Kola Science Centre of RAS, Apatity, Murmansk region, Russia)

At studying of Pechengsky area by methods of deep-seismic sounding subhorizontal seismic boundaries have been identified, whose nature

is not quite clear. Two such boundaries have been crossed in the process of drilling of the Kola Superdeep borehole (SD-3). In the paper there is presented a model that takes into account information on physical properties of SD-3 nearhole rocks and on anisotropy of elastic properties of the core.

The model is constructed by extrapolation of the data obtained by SD-3 drilling, to the lower boundary of the crust which is localized here, according to the CDP-92 profile at a depth of about 42 km. Interpretation of deep-seismic sounding results along CDP-92 profile reveals a number of seismic boundaries. These boundaries stipulate rhythmical layering of the crust into intervals of about 6–8 km. Two upper boundaries as it was told above were crossed by SD-3 at deep intervals of ∼5–6 and ∼9–11 km. Both intervals are distinguished by some anomalous features. Namely: appreciable increase in breakout sizes of rocks from the borehole walls and strong anisotropy of the elastic properties and heterogeneity of the core. Such features are characteristic for tectonically active areas of the Earth crust.

Then the section was "build-up", by translating to a depth corresponding to the base of the crust, preserving tendencies of change in the physical properties of rocks along the section revealed by SG-3 and the model itself was constructed. The comparison showed almost perfect coincidence of anomalous zones of the model with depth-intervals of localization of subhorizontal seismic boundaries according to CDP-92 profile.

Thus, we can assume with high probability that the subhorizontal seismic boundaries revealed by CDP-92 profile are tectonic zones, which remain active today. In connection with the above, the subhorizontal seismic boundaries should be distinguished by features (zones of increased electrical conductivity, "waveguides", etc), which characterizes the depth intervals of 5–6 and 9–11 km, revealed by the Kola Superdeep borehole.

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Velocity structure of the upper mantle under the East European Platform from ambient noise surface wave tomography

Koroleva, T.Yu., Yanovskaya, T.B. (St.Petersburg State University, Russia)

Ambient noise surface wave tomography was widely used for studies of the crust and upper crust structure. The method is efficient in case of a dense network of seismological stations as in USA, New Zealand, Japan, China. In this case station-station paths are rather short, and the spectrum of the Green function is short-period. It was helpful to extend this method for long station-station paths and correspondingly for longer periods in order to study deeper stratum, e.g. upper mantle structure. It is important for aseismic regions, which however contain seismological stations, such as the East European Platform (EEP). Testing of the method at examples of pairs of distant stations in Asia showed correctness of this approach. This allowed us to apply the method for determination of group velocity dispersion curves at the station-station paths at EEP and to use them for the upper mantle tomography.

As was mentioned in the other presentation of the authors, sources of the long periods "ambient noise" are actually earthquakes. So if the epicenters are grouped off the great circle arc crossing the two stations the cross-correlation function will be shifted respectively the real Green function, and dispersion curves obtained from such Green function will be incorrect. But such cases could be easily discovered, and they were rejected from the data set. We succeeded to select more than 100 paths for 20 stations at EEP, for which CCF of vertical components (Rayleigh waves) and corresponding group velocity dispersion curves were found to be reliable. For some paths it was possible to construct dispersion curves for periods up to 150 s, but for most of paths the period range was 10–100 s. These curves were used for estimation of 3D S-wave velocity structure in the upper mantle up to depths of 300 km. We applied two procedures of surface wave tomography which differ in sequence of 2D and 1D inversion, and they yield practically the same results. Average structure of the crust is found to be in a good agreement with the model crust2.0. It is shown that upper mantle under the Baltic and Ukrainian shields is characterized by high velocities. Low velocities are observed in the Black Sea depression and in the Dnepr-Don paleorift.

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Comparison of seismic quiescences, revealed by RTL- and Z-techniques

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Some methods of the intermediate-term forecast of strong earthquakes, based on the analysis of low magnitude seismicity and on the revealing of anomalies of seismic quiescences are known. Two techniques of allocation of seismic quiescence (Z and RTL) are used in Kamchatkan Branch of GS RAS for estimation of the current seismic hazard. The Z-technique is based on the method proposed by Wiss and Habermann (1988) and allows to allocate an area of temporary reduction of seismicity rate. RTL- technique is based on predictive parameter RTL, proposed by Sobolev and Tyupkin (1996). According to model of the authors spatial-temporal areas with negative value of RTL-parameter correspond to zones of reduction of seismic activity and formation of seismic quiescence. The reliability of precursor allocated by each of these techniques has been estimated. The Z-technique allows to allocate preceded seismic quiescence before 6 of 10 kamchatkan earthquakes with M6. The RTL-technique allocates preceded seismic anomaly with reliability 0.51 for earthquakes with M6 and with reliability 0.78 for earthquakes with M6.8. The areas of seismic quiescence have linear dimension several times more than source dimension. The strong earthquake occurs in the area of anomalous seismicity decrease or near to it in the interval of a month to 3 years after the finish of quiescence. 25 cases of seismic quiescence have been identified by Z-technique and 18 — by RTL-technique in the Kamchatka seismic zone during the last 30 years. The mutual arrangement in space and time of these seismic quiescences allocated by two different techniques is considered. It was found, that seismic quiescences, allocated by both of considered techniques, were before 8 from 10 earthquakes with M6.8. Usually the revealed areas of abnormal values of considered parameters are either intersected or contacted. Anomalies of seismic quiescences are well coincide in time too.

Some anomalous properties of wave fields generated in the reservoirs of hydrocarbons

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This communication is devoted to the development of ideas about the nature of seismic waves formed in the reservoirs of hydrocarbons. Performing the actual interpretation of the wave fields on the basis of mathematical modeling of reservoir model. Studies address issues: (1) The frequency decomposition of the real wave field. (2) Investigating opportunities to determine the capacity of reservoirs, of water contact and faults. Being explored kinematic features of the interference of waves of different types.

Scattering objects imaging with cross-well data

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Most of conventional imaging techniques are designed to locate the reflecting interfaces in the subsurface. Reflecting interfaces define basic features of geological model of the medium. However, besides reflecting interfaces at medium usually exists scattering objects (diffractors), for example, faults or salt vugs. These objects also may be of great interest for exploration. Scattering objects imaging may be useful for seismic data interpretation, production monitoring and reservoir characterization.

But the scattered wave amplitude may be so weak that it is difficult to see those objects in usual reflection images. The location of scattering objects requires then special data pre-processing and/or imaging. Several methods of pre-processing are based on diffracted wave enhancement (reflection suppressing) in the data: the plane-wave destruction filters, diffraction imaging by focusing-defocusing of reflected waves, filtering of reflected waves in different data domains.

There are also the modifications of migration excluding stacking of reflected waves. It is possible to enhance the diffractions by designing simple weight functions in the angle domain for Kirchhoff migration.

We propose the technique of diffractor location with cross-well data. We use Kirchhoff migration with special weight functions. We have found that it is useful to employ all the components of the data to enhance valid signal, i.e. use the vector Kirchhoff migration instead of the scalar one. We considered several weight functions for both diffraction and reflection enhancement: limitation of the specular reflector dip at the image point and special selection of source and receiver sets. We verify the validity of reflectors and diffractors by building the Common Image Gathers (CIGs).

We have applied these techniques to synthetic data created for a fine-layered model with small diffractors. The diffractors, invisible with the conventional processing, were located with the weighted Kirchhoff migration.

On velocity anomaly in the Earth's outer core

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The paper presents new experimental data on differential travel time t(BC)–t(DF) of seismic waves PKP(DF) and PKP(BC) in the Earth's core. Differential travel time residuals in the narrow range of angles from 20° to 30° between the direction of seismic ray in the core and the Earth's rotation axis reveal the "scoop-shaped" peculiarity not consistent with cylindrical anisotropy. A model with 0.8% P-wave velocity anomaly in the cylindrical region with the radius of 1375 km in the outer core is proposed. The proposed model nicely fits the experimental data.

Dissimilarity of regional characteristics of radiation and propagation of seismic waves in Kamchatka and the Northern Caucasus (Russia)

Pavlenko, O.V. (Institute of Physics of the Earth, Russian Academy of Sciences, Moscow, Russia)

According to Russian construction regulations, calculation of acceleration time histories of scenario earthquakes is necessary when buildings are constructed in high-seismicity areas. These accelerogramms

are used for estimation of various ground-motion parameters; at the same time, they represent input motions for earthquake-resistance testing of the designed buildings. This approach requires knowledge of regional characteristics of radiation and propagation of seismic waves, which are necessary for calculating synthetic accelerogramms.

Kamchatka and the Northern Caucasus are the areas of the highest seismicity in Russia. We estimated regional parameters of radiation and propagation of seismic waves by solving the inverse problems of stochastic finite-fault simulation of earthquake records made in Kamchatka and the Northern Caucasus. Acceleration time histories of Kamchatka earthquakes ($M_w = 6.8 - 7.5$, depths 45–55 km) were simulated at rock and soil stations located at epicentral distances of 67–195 km. In these calculations, we used the source spectra, attenuation $Q(f) \sim 180\, f^{0.7}$, and geometrical spreading obtained earlier for Kamchatka. Parameters of radiation and propagation of seismic waves were obtained, which describe the studied earthquakes rather accurately, and for two of the earthquakes, models of slip distribution over the fault planes were constructed. Station "Petropavlovsk" can be considered as a reference rock station having the minimum site effects. The intensity of seismic oscillations at the other stations is higher due to the soil response or other effects, primarily, topographic ones. At some soil stations, parameters of the soil profiles (homogeneous pyroclastic deposits of $\sim 100 - 200$ m thickness probably wide-spread in Kamchatka) were estimated, and nonlinear models of their behavior in the strong motion were constructed.

Records of local earthquakes ($M_w > 4.0$) made by seismic stations "Sochi" and "Anapa" in the Northern Caucasus were used for estimation of S-wave attenuation $Q(f)$ by the coda-normalization method. Geometrical spreading was estimated based on the decrease of PGA-values with distance. The obtained $Q(f)$: $\sim 55\, f^{0.9}$ for Sochi and $\sim 90\, f^{0.7}$ for Anapa show the difference in attenuation in these areas at low frequencies (indicating different structures of the upper lithosphere) and similarity at high frequencies. Finally, acceleration time histories of the strongest recorded Northern Caucasus earthquakes ($M_w > 5.4$) were simulated.

The performed studies show substantial dissimilarity between Kamchatka and the Northern Caucasus in parameters describing path effects, resulting in drastically different wave forms of the acceleration time histories. Evidently, this is due to the different geological structure in the two regions.

Synchronous observations of the Earth's seismogravitational oscillations and of the variations of rotational velocity

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Synchronous observations of the variations of the Earth's rotational velocity and of its vertical acceleration by the seismogravitational oscillations have been analyzed. The data on rotational velocity of the Earth are obtained using the radiointerferometers with the antennae at a distance of thousand kilometers from each other. The variation of vertical acceleration is registered by superlong-period seismogravimeter in St.Petersburg with the high level of protection from meteorological noise in the 0.5–6.0 h operating band of the equipment. Analyzing the diurnal variation of synchronous observations the similarities are obtained with the significant correlation coefficients. The detected effect is not resistant and takes place only from time to time. In the range of seismogravitational oscillations of 30–300 μHz the significant oscillations have been extracted for each type of oscillations using the representative ensemble of spectrums. The comparison of their distribution on the frequency axis with the statistical spectrum of the Earth's seismogravitational oscillations obtained before (in 1983–98) is revealed the high level of accordance of the data obtained. The statistical spectrum determines the frequency range on which the Earth is excited more often.

In the given investigation the spectral components of only one pair of spectra determined from 15-day synchronous records from the first stage of observation demonstrates the good accordance with statistical spectrum in contrast to the data considered above. It is also revealed that in frequency range 30–115 μHz the spectrum of the variation of rotational Earth velocity obtained from more than 20-year observations by (Titov et al., 2004) is agreed with the statistical spectrum. From 2-week synchronous data the important effect is found, namely there is 2 types of possible connection between the variation of Earth's rotational velocity and seismogravitational oscillations. In the first type of connection it is revealed that the increase of amplitude intensity obtained as the sum of squared amplitude advances of the increase of seismogravitational oscillations intensity for 18 hours. In the second type the possible connection is observed practically simultaneously but the effect is weak. These data require the additional verification.

The analysis of synchronous observations leads to the following conclusions. The correlation between the variations of the Earth's rotational velocity and seismogravitational oscillations exists definitely. In the range of seismogravitational oscillations the spectra of both oscillating processes are agreed with statistical spectrum mentioned above. Taking into account the great distances between radio antennae it can be concluded that the seismogravitational oscillations are characterized by planetary character.

Orientation of the principal stresses of the southern part of the Kuril – Kamchatka zone

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The arrangement of focuses of earthquakes in the Kuril – Kamchatka zone enables to assume direct connection of its seismicity with tectonic structures of the Pacific Ocean. Tectonic processes in the earth's crust and upper mantle result here in creation of the large differences of stresses. In this connection it is interesting to compare the orientation of the principal stresses with an arrangement of tectonic structures of researched area is interesting. We applied the method of cataclastic analysis of earthquake focal mechanism. The reconstruction of the stress state was implemented on the basis of the data of the - decisions for earthquakes taken from the catalogues NEIC. The reconstruction was implemented for different deep shears, before Shikotan earthquake 4.10.1994 and after 1996. Results of reconstruction of a direction of the principal stresses have received in the southern part of the Kuril, submit to the following regularity. The principal axes of deviator compression and stretching for all deep levels almost oriented orthogonal to the strike of the Kuril trench. Axes of deviator compression have gentle plunge under oceanic platform and axes of stretching are steeply plunge under subcontinental platform. The axes of intermediate principal stresses oriented along of the strike of the Kuril trench. Such orientations of the principal stress axis are typical for subduction zones, apparently, connected with the tectonic of region, were stresses accumulate enough frequently. But local parts have deviation from the revealed regularity. The change of orientation of axes is observed both with depth and in time. Such phenomenon probably is caused by redistribution of stresses as a

result of occurring here earthquakes. The direction of compression principal stresses change less. The directions of two other axes change more essential. Such direction of axes of the principal stresses tells that the type of the stress state is horizontal compression.

Deep structure of the Euro-Arctic region

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The Euro-Arctic region includes the Barents Plate, the northern Baltic Shield, the northern Timan-Pechera Plate and the northeastern Russian Plate. In the west, the study region is bounded by the Svalbard Archipelago, in the east by the Novaya Zemlya Archipelago and in the north extends as far as the latitude of the Franz Josef Land Archipelago. In the region, the Kola Superdeep Borehole was drilled to a depth of 12 km and over 450000 linear kilometres of seismic profiles were worked out, about 1/3 of which as a part of regional studies. Deep horizons were mapped, two- and three-dimensional models of geological structures were developed and deep faults were traced using the seismic method. Seismic data provided a basis for interpretation by other geophysical methods. The basic characteristics of the lithospheric structure in the domain of transition from the passive continental margin to the oceanic depression were revealed by integrated interpretation of the data that show the main pattern of the deep structure of the Euro-Arctic region at its different levels. The continental parts of the platforms have an average crustal thickness of 40–50 km, the upper and lower crustal storeys having a commensurate thickness. The plasticity level is at a depth of 20–25 km, and usually corresponds to the lower crust surface. Upper crust heterogeneities are compensated by the mantle, in which either one layer with a velocity of about 8.0–8.2 km/s or two complementary layers with velocities of 8.0–8.1 and 8.4 km/s are distinguished above the compensation level. Locally, in palaeosuture zones the layering of the substrate increases, and lenses with velocities of 7.6 km/s or over 8.5 km/s appear in it. The consolidated crust of the shelf is as thin as 15–25 km, in contrast to oceans, where the maximum thickness of the consolidated crust is not more than 10 km. Another characteristic of the shelf plate is a greater contribution of the lower ("basaltic") layer to the consolidated crust column up to the almost complete disappearance of the

upper crustal ("granitic") layer. Available technical facilities and marine and ground monitoring methods were used to form a system of hodographs of refracted and deep reflected waves to examine the wave field structure over a wide distance range and to study in detail the geological structure of the earth crust and the upper mantle in the transition zone between the Baltic Sea and the Barents Sea depression. At the Baltic Shield-Barents Plate jointing the basement plunges in stepwise manner. The sedimentary cover increases in thickness to 15–20 km, and crustal thickness decreases to 28–30 km. A layer with a velocity of 7.0 km/s was revealed in the thickest sedimentary cover zone in the crystalline basement of the plate. A lower-crustal layer with a velocity of 7.0–7.4 km/s was detected locally on the Baltic Shield in rifting zones. Therefore, its crust-mantle mixture, formed in tectono-magmatic activation zones, can be interpreted. New seismological data on the deep structure of the eastern Baltic Shield have confirmed the correctness of the reconstruction of the deep structure in which the earth crust of the modern continent and shelf was chiefly formed in Archaean time, and Proterozoic structural facies complexes played a minor role. The structure of large Precambrian crustal blocks has largely preserved to the present time, and has only been modified in tectono-magmatic activation zones of limited size.

Variations of the spectrum of propagating ultrasonic waves in the connection with dynamic effect

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A process of destruction of rock massif dependant on the stress state in connection with cracking of rocks was investigated according to the data of ultrasonic monitoring.The data of monitoring were obtained in two objects: (1) In Kyrgyzstan from 1983 to 1993 in the zone of tectonic dislocation of the Karasuisc thrust near the Toctogul HPS. This region is of high seismic activity. Here Susamyr earthequake happened on 19.08.1992 with M= $7,3$. (2) In the region of the Northern Urals from 1986 to 1991 in the North-Peschansk iron mine at the depth of 450 m from the earth surface, where the processes of displacement of boundaries two of collapse zones were investigated in the process of ore extraction. The amplitude of the radiatied pulse and contact between ultrasonic receiver and rock were

constant that made it possible to control the variations of spatial-temporal structure of wave fields in the diapason of comparatively high frequecies. Alongside with natural observations a big cycle of investigations of cracking effect on propagating elastic waves was carried out in the laboratory which was possible as a result of development of the methods of manufacture of solid two-dimensional models with natural cracks. An impulse ultrasonic method was applied during natural and laboratory investigations and applied during natural and laboratory investigations and techniques of sonic test and profiling were used. The range of used operating frequencies was located in diapason of 20–500 kHz.Cracking is one of the most mighty factors effecting physical-mechanical properties of the medium. The value of cracking parameters is closely connected with deformation processes, with characteristics of the stress state. The difficulties in obtaining characteristics of cracking under natural conditions are well known, therefore it was natural to turn to help of laboratory experiment. It was obtained in natural observations that a regular transformation of the spectra of propagating ultrasonigc waves related to a process of rocks destruction was revealed by the time. The experiences on the models with oriented cracks demonstrated that the systems of parallel cracks made seismic parameters of propagating waves anisotropic depending on the angle between direction of the wave propagation and the cracks. The anisotropy is displayed not only in the value of the parameters themselves but in their relation to the stresses as well. Appearance of high frequency components of the spectrum is particularly well observed in three-dimensional models with the cracks. The data of the model tests and theoretical calculations containing reological parameters create such combinations of the cracks orientation, the cracks density, value and direction of the basic stresses and trends of the propagating waves at which the spectrum shift of the propagating waves to the side of high frequencies and distortion of its form occur. The obtained natural data on non-linear transformation of the propagating waves' spectra present tectonic activation of seismically active region and motion of the collapse zone in a mine occurring in rock massifs during variation of their stress strained state.

Seismic noise characteristic in Saint-Petersburg districts with different level of anthropogenic vibration

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The goal of the study is to regionalize anthropogenic vibrations for microzoning of St. Petersburg area. For this purpose it was necessary to assess a level of vibration from anthropogenic sources in order to isolate the anthropogenic components from total seismic noise background. Seismic noise was recorded in some districts in Saint-Petersburg differing by level of anthropogenic noise. The noise was recorded continuously during several days in each site. For observations we used short-period seismometers SM-3V and data acquisition system UGRA with sample rate 200 Hz. Seismographs were installed on the foundation in the building subbasements, the horizontal seismometers being oriented at right angles along the main walls. Daily variations were obtained from twenty-four-hours recordings. Preliminary data processing was performed with the WSG program. Data samples of the same length without perturbations were used to estimate the background noise. Then statistical estimations of noise were obtained for each of three components. It was shown that the level of the background noise depends on the site, and it is strongly different during day and night hours.

Study of influence of lithosphere velocity models and Double Difference method on calculation of seismic events parameters by the KNET network data for the territory of the Tien Shan

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Until the present, the seismic catalogue formed by the KNET network data (characteristics of the network are presented in the work [Sycheva et al., 2005]) was used by Research Station RAS in seismological studies connected with calculations of various statistical characteristics for the territory of the Tien Shan. The accuracy of earthquakes hypocenters parameters estimation met the requirements of conducting such kind of studies. However, some tasks, related to analysis of connection between seismicity and other geophysical fields and geological objects raise the requirements for the accuracy of seismic

foci location determination. To solve such kind of tasks it is advisable to use the catalogue which already has more precise earthquake hypocenters parameters. As it is known, in hypocenters parameters calculation, the greatest errors are connected with inaccuracy of a used velocity model. It is owing to velocity model, the travel time data and the distance between earthquake focus and seismic station are being calculated. Obtaining of more precise absolute solutions of hypocenters parameters is possible using more accurate velocity model of the Earth. The use of Double Difference method which is not so sensitive to velocity model allows obtaining accurate location of earthquakes relative to each other [Waldhauser and Ellworth, 2000, 2001].

There are several velocity models of lithosphere for the Tien Shan territory; the main object of this work is to analyse the known velocity models and to choose the best one for calculation of absolute hypocenter parameters. The second task is to apply Double Difference method in order to obtain more accurate location of earthquakes relative to each other. Application of this method will allow to estimate the quality of earthquake location changes.

The quality of studied models can be estimated in comparison of the earthquake catalogues obtained using each studied model. To calculate the hypocenters parameters there was used the Hypocenter [Barry et al., 1986] program, that used an a priori specified lithosphere velocity model and allowed to determine the hypocenter coordinates, depth, earthquake energy, and additional characteristics as well: RMS (Root Mean Square of arrival time P and S waves to station), ERH (horizontal error), and ERZ (vertical error). For earthquakes catalogues calculation, there were used bulletins of seismic events occurred on the studied territory during 2000–2008 (4095 events). This period was chosen considering that it was characterized by high quality of the KNET network operation. As a result, four earthquake catalogues were obtained. Presence of such characteristics as RMS, ERH, and ERZ in determination of each seismic event allowed estimation of analysed models through these parameters.

It is considered that the use of the Earth's lithosphere velocity model allows accurate estimation of the seismic ray travel time from the seismic source to a certain station. In reality, the Earth's structure is much more complicated than it is described by velocity model. For some seismic station, the errors in calculated seismic wave travel time appear as a result of inaccuracies in a supposed velocity model. Such

deviations can show any time along the motion path of a seismic ray, although, in general case, they are divided into three groups: deviations related to inaccuracy of velocity model close to the seismic focus, deviations near the station, and deviations along the motion path. In order to minimize such kind of deviations, there can be used the method of Double Difference, which idea is presented in works [Waldhauser and Ellsworth, 2000, 2001]. The given method represents an effective technology of high accurate earthquake hypocenters determination.

As a result of the work conducted, four Earth's lithosphere velocity models were analysed for the territory of the Tien Shan. It was determined, that the best-to-use model is the Roeker S.W. model obtained as a result of a tomography research. Double Difference method was applied to the KNET network data catalogue, and estimation was conducted that showed the this method allowed some improvement of the events hypocenters location and allowed obtaining good earthquake location relative to each other. The use of Double Difference method will allow to expand the range of problems being solved by Research Station RAS related to the search of connections with other geophysical fields and geological objects.

Modern parallel computing technologies for the traveltime seismic tomography inversion

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

Modern traveltime seismic tomography experiments, both controlled-source and passive, provide typically very large amount of data (tens of thousands seismic rays) and cover large spatial areas. To achieve the reasonable resolution the inversion model may consists of more than millions of unknowns. At the same time the usefulness of the geophysical inversion methods for the end-user is crucially dependent on their ability to generate a large number of models in a reasonable time to provide the possibility to test the stability of the inversion, test different geological hypothesis, correct the field experiment methodology, etc. Therefore the calculations speed and minimal hardware requirements are essential for the inversion code to be adopted by the community. The power of the modern computers lie in their ability for the parallel computations: even the mid-level

laptops now usually equipped with the two-core CPU's, the high-level desktop systems may use up to 8 or 12 independent threads. Therefore the ability of the algorithm to utilise the power of parallel computing (that was only the point with the super-computing facilities just 10 years ago) became now the important factor of the geophysical software development. We analyse the traveltime inversion algorithm with the adaptive wavelet parameterisation (Tikhotsky, Achauer, 2008) from this point of view and show that it can be re-coded to make use of the parallel computations. Specific attention is paid to the parallel sparse matrix-vector multiplication, which is the key process in the iterative solution of the large linear systems with the irregular sparse matrices that are typical for the traveltime tomography. Recently developed compressed sparse block (CSB) method (Buluc et al., 2009) for the matrix storage and associated parallel multiplication algorithm is suggested to be the most suitable to be utilised together with the LSQR solver. The problem of the memory usage minimisation is also addressed. The improved code allow us to solve large inverse problems that were actually "out of the scope" without the parallel computing algorithms. The speed-up of the software with the increasing number of parallel threads is analysed.

Local traveltime tomography with the adaptive wavelet parameterization: algorithm and its application for the 1991 Racha (M= 7, 0) earthquake source area study

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We develop, test and apply for the real data the local traveltime tomography algorithm that utilise the idea of the adaptive media parameterisation with the sparse Haar wavelet series expansion that is recently suggested for the controlled-source tomography (Tikhotsky, Achauer, 2008). This algorithm allows the irregular parameterisation of the model accordingly to the local resolution power, as estimated by the ray density and angular coverage. The algorithm is tested on the synthetic examples and applied for the 1991 Racha (M= 7, 0) earthquake aftershocks dataset. The stability and uniqueness of the inversion is first tested with the checker-board test that imitate the real field experiment geometry and hypocenters distribution. Then

the series of real data inversions are performed using the different starting 1D velocity model, which is poorly known for the region. All inversions provide a number of common model details that reveal important aspects of the geological structure and fault positions. Specifically, inversion revealed the 8–10 km deep depression-like structure with the along-Caucasus strike direction, gentle SSW and more steep NNE flanks. The hypocenters position are clustered within the low-velocity zone under the SSW and NNE flanks of this depression. This velocity structure and clustering of the earthquakes suggest that the tectonic position of the area is controlled by the thrusting of the Great Caucasus mountain belt in the SSE direction over the Trans-Caucasus plate structures. Majority of the aftershocks are associated with the low-velocity zone with the WNW-ESE strike and NNE deep that flattens with depth. It can be supposed that this zone marks the thrust fault that was roped by the main shock. The obtained results well correspond with the geological and seismological considerations (Beloussov, 2009) as well as with the focal mechanisms of the main shock and major aftershocks (Arefiev, 2003).

Contribution of earthquake signals to cross-correlation function of ambient noise used in surface wave tomography

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Ambient noise surface wave tomography is widely used for studies of the Earth crust structure in the last decade. The method is based on the assumption that the ambient noise consists of surface waves whose sources are distributed almost uniformly over the surface. In such a case the cross-correlation function (CCF) of the ambient noise at a pair of stations is related to the Green function of surface waves. It is difficult to extract "pure" noise from seismic records because it is always overlapped by earthquake signals. To reduce influence of earthquakes the whole record is normalized in one way or another (usually by the running average within some time window). It is assumed that such a procedure eliminates influence of earthquakes because earthquake signals take a minor time span as compared with the "pure" ambient noise generated by oceanic storms and atmospheric perturbations. This is practically true in case of short distances between the stations, and correspondingly of rather short periods of

surface waves. However for upper mantle studies it is necessary to use large periods (up to 100 sec) and consequently large distances between the stations (up to 2000 km). But in such cases the sources of noise should be located at distances of order 6000–10000 km, though it seems rather strange that sources may generate correlated ambient noise at such great distances.

Analysis of CCF at stations located at East European Platform (EEP) averaged for time periods of about one year showed that CCF are strongly asymmetric, the asymmetry being different at short and long periods. For paths oriented approximately EW the pattern of filtered CCF displays strong sources at the East for long periods and, vice versa, stronger high frequency sources at the West. This phenomenon can be explained by the assumption that sources of the "ambient noise" at low frequencies are actually surface waves from earthquakes: the signals from earthquakes are not completely eliminated but only suppressed. Relatively the EEP most epicenters are located at the east — along Pacific belt and in China. More thorough analysis shows that in case of grouping epicenters off the great circle arc crossing the two stations the CCF yields the group velocities greater than expected. Besides, additional maximum appears at filtered CCF that corresponds to correlation of Rayleigh wave at one station and S wave at the other one. Moreover, if the epicenters are concentrated along the line perpendicular to the station-station path, a strong peak is observed at the CCF at zero time. Numerical modeling verifies these peculiarities of CCF.

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Density and velocity model of the Black sea lithosphere

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A back-arc Black Sea Basin is a flat abyssal plain with the sea floor at a depth of 2 km, which overlaps two large sedimentary basins in the western and eastern parts of the sea (the West (WBS) and East Black Sea (EBS) Basins, filled with thick (up to 12-14 km) Cenozoic sediments. Thick sedimentary cover masks poorly investigated

basement and heterogeneous crystalline crust that is most likely represented by a collage of different microplates and terranes of different affinities welded together during accretion. Despite active geological and geophysical exploration of the study region, little is known about the structure of the mantle lid below the Black Sea Basin. This information, together with distribution of recent seismicity, is of crucial importance for understanding the geodynamic situation and governed tectonic processes in the region. In order to investigate the velocity structure of the Black Sea lithosphere we applied seismic tomography using the data from earthquakes occurred inside the study region and recorded by seismic stations located along the coastline of the Black Sea. This velocity model was converted into density model in order to calculate the gravity signal from the mantle lithosphere, which was compared with mantle gravity anomalies derived from 3D gravity analysis using the back-stripping method.

New seismic tomography yielded P-wave velocity distribution in the lithosphere of the Black Sea down to the depth of 100 km. Derived velocity distribution represents the Black Sea Basin not as a single velocity domain, but rather heterogeneous one, where two distinct areas of increased velocities have been distinguished within the western and eastern parts of the Black Sea, which are separated by lower velocities in the central part of the sea. For the purposes of our study the model was represented by horizontal slices of average velocities for the depth of 35–50, 50–70 and 70–90 km. From the density equivalent of this velocity model we calculated the gravity effect. The latter outlines two areas of positive gravity (up to 80 mGal) in western and eastern parts of the Black Sea, separated by non-anomalous zone within the central part of the sea.

Mantle gravity anomalies were derived alternatively by back-stripping gravity analysis whereby gravity effect of constrained layers (seawater, sediments, crystalline crust) are removed from initial gravity field. The crust structure and Moho topography are constrained by new results from seismic refraction study in the EBS and reinterpretation of some old profiles. Gravity calculations were performed on 10 km x 10 km grid. Final residual anomalies of supposed mantle origin distinguish small positive values (to 40 mGal) in the western part of the Blacks Sea, whereas no significant anomalies were revealed in the eastern part – prevailing anomalies here range from zero to 20 mGal. These slight positive mantle anomalies might be indicative of isostatic equilibrium of the Black Sea deep structure, namely

that negative gravity effect of sediments is substantially compensated by strong positive gravity impact of the Moho swallowing. In general these mantle anomalies agree with mantle gravity signal, derived from seismic tomography model (despite amplitude of the latter a bit higher of the former), and both are indicative of lack of the asthenosphere or mantle diapir at the depth less 100 km below the Black Sea. This corresponds also with very low surface heat flow density with prevailing values in the Black Sea of 30–40 mW/m^2 and low deep temperatures estimated to be 500–600 at the depth of 30 km.

Section SEMP. Seismic-ElectroMagnetic Phenomena

Modelling of VLF ionospheric propagation related to earthquake events

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We use a model of subionospheric wave propagation originally developed at Graz University of Technology for VLF propagation predictions of time signals. We develop the model further to include variations in ionospheric parameters related to seismic activity and to describe the wave propagation along long and medium distance ray paths. A description of the model and its parameters of influence will be given along with some preliminary results of simulations along specific propagation paths.

Space observations of whistler VLF emissions before and after l'Aquila earthquake occurrence

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We analyse the ELF/VLF electromagnetic emissions observed by the electric field experiment (ICE) onboard the DEMETER microsatellite. The polar and circular sun-synchronous orbits lead to cover

an invariant latitude range between -65 and +65. The observed dynamic spectrum principally exhibits the classical EM emissions, like the hiss and the chorus, in the frequency range from 20 Hz to 20 kHz. Additionally, transmitter signals in the VLF range, between 10 kHz and 20 kHz, are detected by ICE experiment.

In this study, we consider the dynamic spectra observed by the ICE experiment two weeks before and after the l'Aquila earthquakes (April, 06th, 2009; M=5.6; Lat=42°38 N – Long=13°32 E). We analyse the VLF intensity variations of whistler waves when the satellite was exactly above the l'Aquila region. We show that minima of the VLF intensity levels are occurring before the seismic event. These features are associated with specific spectral features observed in the corresponding dynamic spectra. In the discussion, we emphasise on the electromagnetic precursors, observed onboard the satellite, which appear few days (up to two weeks) before the earthquake occurrence.

A fractal analysis of electroseismic time series prior to the M=6.5, October 24, 1993 earthquake in México

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In the current literature on seismoelectromagnetics has been reported many earthquakes which presented electromagnetic anomalies as probable precursors of their occurrences. Although this methodology remains yet order discussion, it is considered interesting the study of many particular cases. In this work we report a fractal analysis of electroseismic signals recorded in the Acapulco station during 1993. In October 24, 1993 occurred an earthquake (EQ) with M=6.5 an epicenter (16.54°N, 98.98°W), 100 km away the mentioned station. Here, we calculate the so-called Higuchi's fractal dimension and the DFA exponent to signals during one month before the EQ. We dis-

cuss the dynamical meaning of this analysis and its possible relation with the mentioned EQ.

Mathematical simulation of the large scale electric fields and currents in the Earth's atmosphere

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The Earth's atmosphere is studied as the way for the electric field penetration from the Earth's surface into the ionosphere and back. The conductivity of atmosphere is a scalar and the ionosphere has strongly anisotropic tensor conductivity. To simplify the problem, we suppose that such a modification occurs at some height, above which the field aligned conductivity becomes infinite. This approximation corresponds to usual introduction of integral conductance of the ionosphere. Such a model of the ionosphere is equivalent to a special upper boundary condition in the problem for the atmospheric electric field. It can be derived from the charge conservation law. We also suppose vertical geomagnetic field lines.

Setting the electric fields distributions in the ionosphere as typical ones for different geomagnetic conditions we calculate the electric fields in the atmosphere. It is shown that 1-D approach is adequate if horizontal scale exceeds 100 km.

We show that the magnitude of the ionospheric electric field penetrated from the ground is inverse proportional to the value of the ionospheric Pedersen conductance. So its typical value in day-time is about hundred times less than in night-time. Both these values in our model are much smaller than those in some known models, which do not take ionospheric conductivity into account, but much larger than those in the models which are based on infinite Pedersen conductivity above ionosphere or in the upper ionosphere.

ULF-electromagnetic signals induced by seismic activity and their impact on the upper atmosphere

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While searching for electromagnetic effects of the earthquakes, impulse-type signals in the frequency range of 0–5 Hz preceding the earthquake or following it have been detected. The advance or delay time is from 0 to 5 min. The signals are observed as single or pair impulses. It is supposed that the signals make a significant impact on the state of the magnetosphere and ionosphere. As a result, a sharp change in the regime of geomagnetic pulsations is possible. These effects are analyzed using data from the observatories Borok (latitude = 58.06°, longitude = 38.23°) and College (latitude = 64.9°, longitude = 212.0°).

Repeatability of the electromagnetic effects of earthquakes

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While searching for the electromagnetic effects of the earthquakes using data from the observatories Borok ($\varphi = 58.06°$, $\lambda = 38.23°$) and College ($\varphi = 64.9°$, $\lambda = 212.0°$) a remarkable property in the character of the seismoelectromagnetic activity manifestation – repeatability of anticipatory electromagnetic effects of individual earthquakes in a series of the subsequent aftershocks – was revealed. If the main earthquake was preceded by the ULF-electromagnetic impulse then for repeated seismic events in the same region (aftershocks) similar effects are also can be expected.

Earthquake effects in the pulsations of geomagnetic field

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Anomalous changes in the behaviour of Pc1 geomagnetic pulsations and oscillations with the spectrum resonance structure (SRS) occurred several minutes before an earthquake have been found. In all cases the changes happened following the ULF electromagnetic pulse and were observed either as a sudden oscillation stop, or as a sharp intensification of the oscillations. SRS reflects the ionosphere resonance properties that can be sharply modified when an impulsive injection of charged particles from the radiation belt takes place. Changes in the resonance properties can be a reason of the effects in Pc1s as well. It is supposed that the effects in two types of pulsations (Pc1 and SRS oscillations) are the consequence of the united process in the upper atmosphere, precipitation of the charged particles into the ionosphere caused by the interaction of ULF electromagnetic pulse of lithospheric origin with the radiation belt.

Satellite methods of seismic active fault extracting

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The goal of the present paper is construction of the new method of the calculation of space-temporal private differential from magnetic field for the extraction of short-wavelength satellite magnetic anomaly field of the seismic active faults of the Earth's lithosphere in the Pacific region. The second goal is the show of results of the calculation and analysis of the space-deep structure of magnetic heterogeneity in the interior of the Earth's mantle, their correlation with anomaly seismic heterogeneity, as well as with other geophysical parameters. The passes were chosen for the scalar magnetic field and

for three components X, Y, Z of the vector magnetic field. So, 7000 MAGSAT measurement points of the magnetic field were used for each vector component of the field within the limits of these regions under consideration. The magnetic field measured at the altitude of the satellite is a complex function of space and time and is caused by various physical sources, among which are the following: processes within fluid parts of the Earth's core, responsible for more than 90% of value of the measured magnetic field, that has been termed the main magnetic field; current systems near the Earth generating the magnetosphere and ionosphere fields; magnetic induction fields of the Earth's mantle; and, finally, anomaly fields related to magnetization of the Earth's lithosphere seismic active faults. A rather complex problem arises of extraction the fields measured at the satellite. The space-temporal private differential for each of the mentioned vector components the satellite geomagnetic field and they combination were calculated, which were removed from the MAGSAT measured values with the aid of new analytical method. This work was supported by the Russian Foundation Basic Research grant N 10-05-00343-a.

The software package for electromagnetic data analysis from satellite and ground sources

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In the context of Scientific Space System creation project for earthquake precursor's researches was developed software for the complex analysis of the satellite and ground data, including electromagnetic data in the waveform and spectrogram.

The System consists from 3 independent software: TRASSA-OMIR, SOS-OMIR and DeSS.

For the chosen seismic region and time interval the TRASSA-OMIR program allows to predict satellite orbital position (altitude, sub-satellite point latitude and longitudes), and also other parameters for these point - L-shell, satellite light exposure, distance from the satellite to earthquake epicenter, geomagnetic field parameters, etc. As initial conditions for satellite orbit prediction we used classical elements and elements of TLE format (NORAD).

The SOS-OMIR program is intended for complex waveform data

(satellite and ground) processing and analysis in the chosen seismic regions with use of the modern techniques based on methods of the spectral analysis, filtration, statistical and correlation-regression analysis, etc. The special feature of the given system is orientation to processing of ground and satellite data for detecting of anomalies related to seismic events.

The DeSS — it is Software for visualization, analysis and mapping of power spectrum and waveform data from electromagnetic devices ICE and IMSC of DEMETER Satellite. The Software primary goal is to give the researcher friendly tool for the analysis of electromagnetic data from DEMETER Satellite for earthquake precursors and other ionosphere events researches.

The main features and operations of the software is possible:

– the DEMETER format spectrogram data upload and visualization;

– the DEMETER format waveform upload and visualization;

– simultaneous upload of a considerable quantity of files;

– the orbit mapping for the uploading data files with map scale variation;

– various time and frequency filtration;

– spectral density visualization for fixed frequency range as two-dimensional graph;

– spectral density visualization for fixed frequency range in the shape of different scale and color rounds;

– the SNR (signal to noise ratio) calculation for the researching of radio-transmitters influence on the ionosphere.

In the DeSS Software data export in the format SOS-OMIR for the data math analysis and different anomalies detection, including seismic activities, is possible.

Thus, the developed system of the complex analysis is the user's universal tool for work with separate and complex ground and satellite data rows irrespective of the physical nature of signals.

Formation mechanisms of seismo-ionospheric effects and their numerical modeling

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It is presented the review of our researches on modeling of seismo-ionospheric effects and their physical mechanisms carried out for last 3 years. The beginning of these researches was initiated by A.A. Namgaladze who has stated the hypothesis that observable for some days prior to the strong earthquakes the disturbances of Total Electron Content (TEC) and critical frequency of the ionospheric F2-layer located near to forthcoming earthquake, can be caused by zonal electric field of seismogenic origin. This hypothesis has passed the approbation in our model calculations for strong earthquakes in high, middle and low latitudes. We have carried out the analysis of the various possible physical mechanisms of formation of seismo-ionospheric effects above epicenter area prior to the strong earthquakes offered in the literature. On the basis of this analysis the conclusion has been made, that such mechanisms can be only the small-scale internal gravity waves of small amplitude generated in epicenter area and the vertical electric field arising in the atmosphere prior to earthquakes and penetrating into the ionosphere. These mechanisms also have passed the approbation in our model calculations. In our researches we considered the ionospheric disturbances prior to such strong earthquakes as Alaska Earthquake on March 27, 1964 in high latitudes, Greece Earthquake on January 8, 2006, Wenchuan Earthquake on May 12, 2008 in the middle latitudes and Koyna Earthquake on December 11, 1967, Vanimo Earthquake on July 16, 1980; Philippiny Earthquakes on November 22, 1981, January 11, 1982 and January 24, 1982, Sumatra Earthquake on December 26, 2004, and Peru Earthquake on September 25, 2005 at low and equatorial latitudes. The model calculation results are compared to the observation data and conclusions are done about efficiency of each mechanism in researched earthquakes.

Study of local variations of the gradients and phase velocities of geomagnetic disturbances before the strong earthquakes

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Measurements of the ULF (F=0.001–10 Hz) magnetic field variations and telluric currents have been carried out in Japan by means of two groups oh high-sensitive digital three-components torsion magnetic stations MVC-3DS. Each group consist of three magnetic stations located at Izu and Boso peninsulas (south-west and south-east of Tokyo) at the tops of triangles at distances 4–6 km from each other. Such arrangement of the magnetic stations allows determining the gradient and phase velocity vectors along of the Earth's surface using a phase-gradient method. The vectors of the gradients are usually directed to a local source of the ULF EM waves and the vectors of the phase velocity- from the source. The anomalous behavior of gradient and phase velocity vectors of the ULF geomagnetic disturbances was investigated before two strong earthquake (EQ) events in Japan in the years of 2000 (M=6.4) and 2003 (M=5.8). It was found that the gradient and phase velocity values had anomaly changes 1–3 months, 2–3 weeks and 1–5 days before the strongest EQs. New directions of the gradient vectors arose during the same period — the directions just to a forthcoming EQ epicenter. Simultaneously the directions from the forthcoming EQ epicenters arose for the phase velocity vectors. We suppose that new local sources of the ULF magnetic disturbances had appeared in the Earth's lithosphere additionally to the ionosphere sources. The lithospheric sources were situated just in a region of the forthcoming EQ hearth. Circumstantial evidence of the existence of local lithosphere sources was obtained by correlation methods. We found that the correlation coefficient of corresponding magnetic components data of two closely situated magnetic stations had a tendency to increase before the EQs. This effect is most prominent during 1–3 months before the EQ moments in a high frequency region (F=0.1–2 Hz). We offer to use the gradient and phase velocity vectors of the ULF geomagnetic disturbances as one of the important factor for short-term prediction of strong EQs and for determination of the epicenters of the forthcoming EQ.

Magnetic disturbances from the tsunami

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Hydrodynamic processes are considered that are connected with tsunami wave. Tsunami is a source of alternate and quasiconstant magnetic fields. The tsunami most frequently appears due to a vertical displacement of the Earth's crust during strong EQs under the ocean bottom at 50–200 km distance from the coast. It should be efficient to combine different geophysical phenomena monitoring (observations of variations of the ULF and ELF electro-magnetic, acoustic, seismic fields and etc) along a coast line with observations at several sea bottom (buoy) stations. The stations could be installed along two remote profiles (50–200 km length) situated in perpendicular direction to the coast line. In this case coast magnetic gradient stations give an opportunity to detect short-time precursors and position of a forthcoming strong EQ (M$\geq$ 5) under bottom at distance 50–150 km from a coast and to make 5–20 minutes warning about beginning and approaching of the tsunami.

Using the first motion of acoustic signals for localization of fault zone in rock samples during long-term loading

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A nonexplosive destruction mixture was utilized to produce loading acting on a sample from both outside and inside. The samples under investigation were dolomite, diabase, marble, and sunstone. The experimental results obtained permit one to evaluate the destruction nature using the acoustic data from the Aline 32D complex. The oscillograms of the acoustic emission (AE) obtained with the Aline 32D complex strongly differ in amplitude. During $\sim$18 hours of observation, 1300 events were registered. Only 22 of them with the peak amplitudes exceeding the detection threshold (40 μV) by a factor of 30–50 were selected for further analysis. The AE epicenters were determined on the basis of the difference of the moments of the first signals. The difference of the first signal moments of a pair of sensors placed on both the sides relative to the fault zone shows the destruction size (i.e. the range of positions of the epicenters). By the

example of the behavior of a dolomite sample ($v \approx 5 \cdot 10^5$ mm/μs) under loading, a number of regularities have been revealed. Groups of the initial signals due to the faults arose at the stage of gradual rise of deformations. Before the destruction of a sample by the main fracture, the slope of the deformation curves becomes gentle. There was no unique destruction center in such an experiment: the centers of separate events migrated to form the main fracture. The main fracture occurs at the fall of the deformation curves. As this takes place, several AE signals arise with a spacing of a few microseconds. It is possible that this effect is associated with the formation of a fault zone and depends on the crystalline structure of the sample. The nonuniformity of the appearance of AE signals of high intensity has been revealed. It seems that the fact is due to the stepwise character of the deformation of the sample. The first signal moments have allowed not only to estimate the destruction zone but to explain the dynamic process of destruction. Tensometric curves of deformation shift have been obtained as a result of the analysis. These curves showed a multistep character of the deformation process. It is the first time that the tensometric observations near the destruction zone are compared to acoustic emission evolution.

The devastating earthquake in Chile in 2010, geomagnetic variations and solar activity

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It is based on advanced and experimentally confirmed by one of the authors hypothesis of possible influence of geomagnetic variations (substorms and solar-dayly) for the implementation of the strongest earthquakes as one of the links in the chain promoted by the impact of external sources. The catastrophic earthquake was 27/02/2010 at 6.34 h at a depth H = 35 km with a magnitude M = 8,8 and the coordinates of 35.909S; 72.733 W in South America. The results of studying the dynamics of solar-diurnal geomagnetic variation on the low latitude observatories: Huancayo (HUA) (12.06S, 75.21W), Jicamarca (JIC) (11.9S; 76.9W), El Leonito (31.8S; 69.29W) are presented. The characteristic features of the space weather in the interval. of 90 days from December to February, 2010 are selected. It is shown also that the tragedy February,27 broke out in a protracted

(since 1993) of deep recession magnetic activity at the beginning of a weak 24 solar cycle. In contrast to the Chilean disaster (22/05/1960, M = 9,5) taken in the 20th age under the highest magnetic disturbance displaced on two years after the most maximum of 19 solar activity cycle. It is noted that this earthquake was happened at two-sector structure of IMF with the preferential positive direction of magnetic field, from the Sun. At the same time in the interval from 2002 to 2009 were recorded 2-th (2002,4-2004,7yy) or 4-th (2004,6-2007,5yy) sector structure of IMF with 27 day periodicity in spite of the spiral structure of IMF was very unstable before 1976. Characteristically the powerful (M $\sim$ 8) events in Chile were relatively rarely observed (in 1971, 1998, 1985, 2005, 2007) under different IMF directions but mainly at 2-th sector structure in solar wind. It was found that the envelope of the solar-diurnal variations amplitudes (SD) in January-February 2010 shows the maximal values equal of 75 -100nT in depending on the observatory latitude and near of the high solar wind velocity intervals in January,13-20 and in February,16-19. It was found that the amplitude of the SD variations takes the biggest values in February and only closer (El Leonito) to the earthquake epicenter where it is prevalent even during the main phase of magnetic storm February,15 compared with the same moderate (SYM (H) $\sim$ -50nTL) storm in January,20. Another interesting matter is that SD variations become largely negative under the lowest values at the equator (HUA, JIC) in the interval February, 9-14. It was undertake the attempt to understand the abnormal hits of SD variation by the means of its identification with the variation of the geo effective parameters of solar wind (velocity, density, pressure, temperature), Bx, By, Bz IMF components and geomagnetic indexes of global, substorm, polar, storm activities (Kp, PC, AE, AL, AU, SYM).

Fractal analysis of the Earth crust strain observational data made with a laser interferometer

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Data from a laser strainmeter is studied in terms of fractal dimension.

Laser strainmeter (LS) acts as an interferometer, so it is able to record Earth crust microdeformation with great precision. It was found

that crust microstrain field, measured by the LS, reveals variations before moderate and large earthquakes. However, only short-time precursory behavior was investigated.

Now LS data is studied in order to reveal any long-time effects, related to the alteration of the Earth crust in the process of earthquake preparation. It is taken into account that the Earth crust is near to the self-organized criticality (SOC) state. The SOC state main feature is that output parameters have scale-invariant or fractal structure both in space and in time. So fractal methods can be used to study evolution processes in crust before earthquakes.

We have investigated time series representing crust microstrain field, obtained with the LS located on Schults Cape in the south part of Primorsky region. The monofractal analysis method proposed by Higuchi have been applied, daily and hourly variations of fractal dimension have been calculated during seismically calm period and when some moderate earthquakes occurred in the 2000 km circle area around the LS. Peculiarities in the fractal dimension behavior are revealed during the seismically active period.

The orientation portrait of the magnetic field structure according to monitoring on peninsula Boso in 2000

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For the statistical analysis of the magnetic field monitoring data t the cluster analysis method of directions structure of vector geophysical fields was used. Three-component measurements of a magnetic field at two stations located on peninsula Boso were processed. General duration of time supervision made 10 months. At processing approximation of a field by model of a plan wave was used. Transition from time series to spectra was carried out. The direction structure of a spectra vector magnetic field for the several periods was by the day analyzed. The number of clusters was equal 20. The clusters received as a result of the decision were broken into two groups: with vertical a component directed upwards and downwards. In the quiet not indignant day the directions portrait represented vectors with casual image the distributed azimuths. And the sum close to zero. The indignant day were characterized by significant asymmetry of azimuths. With the big size of a total vector and the generalized direction on a southwest. It was observed as for the fields directed

from the top downward, and from below – upwards. Comparison to the data of seismic monitoring has revealed, that activization of the volcanic area located on distance about 140 km from points of registration of a magnetic field, is accompanied by significant asymmetry of the directions azimuths portrait. The common direction of clusters in the indignant day was aside a volcanic zone. It may be treated as reflection in a magnetic field of presence of the external source inducing volcanic activity. It was in parallel carried out the cluster analysis of the data of seismic monitoring. Concurrence of the generalized direction of asymmetry of a direction portrait on spectra of a magnetic field with one of the priority clusters allocated on the seismic data was found out. In a time interval of registration of the magnetic field, anticipating eruption of a volcano (for periods T=4 c, T=6 c), the number of the indignant day was appreciable above, than at recession of volcanic activity.

The new method of geophysical fields processing of may be useful to studying thin direction structure of a magnetic field at monitoring, revealings of connections between various geophysical fields. Changes in a portrait of direction structure of a magnetic field may be used as one of harbingers of strengthening of seismic activity.

Cluster directional analysis of vector geophysical fields in problems of monitoring

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At the analysis of the data of monitoring of geophysical fields of a vector nature there is a problem of creation of the formalized algorithms for research of variations of directions, and not only in sense of the generalized parameter, but with an opportunity in parallel to trace changes on a number of the local spatial directions.

Let there is a set of unit vectors $\{\vec{n}_j\}_{j=1}^{J}$, each of which defines a direction of a geophysical field in a concrete small interval of time. The problem consists in allocation according to set of individual realizations of some the generalized directions (clusters) around of which realizations of ensemble during some time interval of monitoring are grouped. The task is solved by means of iterations. The direction of

a cluster is determined under the formula:

$$\vec{l}_p = \frac{\sum_{j=1}^{J} \vec{n}_j w_{j,p}}{\sum_{j=1}^{J} w_{j,p}},$$

with the subsequent normalization of result.

Weight factors at simultaneous ratings of directions of some clusters are appointed in alternative logic. The formula of definition of weight of individual realization may be given as sedate function of scalar product of a vector of the given realization and a vector of a direction of a cluster

$$w_{j,p} = s_{j,p}^{2^n}, \;\; s_{j,p} = (\vec{n}_j, \vec{l}_p).$$

After stabilization of directions and weights estimations the new direction cluster may be included in system of the generalized estimations. Process comes to an end at achievement of the given number of clusters or at achievement of a sufficient measure of completeness by generalized clusters system of realizations ensemble.

Expressions for definition of such statistical characteristics of clusters as weight capacity, a weight dispersion of a cluster and a measure of completeness for ensemble of realizations by clusters system of directions are given.

In the report mathematical bases of statistical methods of the analysis a geophysical vector fields are stated. The developed approach is tested on the data of monitoring of a magnetic field, and also at the analysis of the seismic data.

Remote sensing of seismic activity by means of natural VLF signals

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Earlier by authors of work it has been established, that in addition to the signals of radio stations for remote sensing areas of the bottom ionosphere above epicentres of earthquakes can be used a natural signals - low-frequency electromagnetic emission of lightning discharges (atmospherics). The effect of earthquake is shown the enhancement

of average amplitude atmospherics in day of event or for 1–2 day after it. Some days before the event (for 3–8 days) increase of amplitude atmospherics which is treated as a precursor of earthquake can be observed also. In present work features of earthquake's precursor in atmospheric characteristics are analyzed.

The analysis of non-deep focus events with magnitude more than 4 has shown that the sizes of area in the bottom ionosphere, forced by lithospheric processes, seldom exceed the sizes of first Fresnel zone on frequencies nearby 10 kHz. At the same time, position of the given areas can shows some dynamics concerning to an epicentre projection. The opportunity of use of the "impedance" characteristic of signals (the ratio of electric and magnetic component of atmospheric's signal) for exception of false precursor is considered also.

For distant event of earthquake the comparison of variations of atmospheric signals and VLF radio station which are being approximately on the middle of a atmospheric path is carry out. It is obtained that variations of atmospheric amplitude have been related by ionospheric changes above an epicentre and, partially, in a storm source.

The comparative analysis of variations of space beams and radiating background of synoptic scale

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In seismically dangerous areas on the existential variations of radiating atmospheric and soil fields connected with change of pressure in lithosphere, "the background" variations caused by meteorological and other reasons, not connected with processes of preparation of earthquakes are imposed. From the point of view of revealing of harbingers of earthquakes these "background" variations represent the hindrances which spectrum and the factors operating them, — are poorly understood. There was a problem with estimation of "background" variations of radiating fields, and with revealing of their communications with meteorological and helio-geophysical sizes in seismically quiet region.

In work preliminary results of the comparative analysis of the data

of monitoring (2006-2010) variations neutron components of cosmic rays (CR) on an observatory"Kluchi" (Novosibirsk region), and also an alpha-beta-gamma radiations, the standard meteovalues are presented, to non-ionising radiation, electric parameters of atmosphere, atmospheric turbulence (experimental complex IMCES-NRTPU, Tomsk). The analysis of the data of monitoring allows to draw a conclusion that contributions an alpha-beta-gamma disintegrations and CR in integrated level of a radioactivity of ground atmosphere and its variation depend on space, meteorological and other factors and, in many cases, do not correlate among themselves.

On time scales from synoptic to annual variations neutron components CR and a gamma background are closely connected among themselves and caused by changes of atmospheric pressure. Reduction of atmospheric pressure on time scales from synoptic to the annual leads to the co-ordinated growth of levels both neutron components of space beams, and a gamma background of a terrestrial origin.

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Space radio method of operative monitoring of conditions of D-region

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he considerable quantity of the data about existence sejsmo-ionosfernyh communications during the periods of preparation of earthquakes is by this time saved up. Basically this data concerns E-region and F-region. On D-region - it is essential the data less.

Estimations of influence of area D and indignations in it on absorption of a radio signal external ionospheric sounding are resulted and are discussed. At external sounding the analysis of the data ionosounde is limited to a strip of frequencies from critical frequency of F-layer to frequencies of plasma resonances. Presence of collisions and a geomagnetic field leads to that: - absorption "X" component at crossing of D-region is more than "O" component; - at increase in frequency of sounding absorption decreases in inverse proportion to a frequency square.

The information on conditions of D-region at double crossing of D-region is concluded in a difference of levels of the registered signals. Equality of both initial amplitudes "O" and "X" component can be reached at generation satellite ionosounde radio impulses with linear polarisation.

On the basis of the modelling analysis of the data ionospheric sounding in a strip of the frequencies exceeding frequency fxF2, perspectivity of use of this strip of frequencies of sounding for the global control of a condition of area D of an ionosphere is shown.

Presence of a reflecting surface does not demand increase in capacity of the onboard transmitter ionosounde, and the equipment arrangement on the companion allows to carry out operative monitoring of area D located over seismoactive regions of a planet.

Use at work onboard ionosounde grids of frequencies allows to choose an optimum range of measurements of integrated absorption, to lower an error of definition of this size and to expand borders of applicability of a method.

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The catalog of the atmospheric electric field anomalies appeared before earthquakes

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The atmospheric electric field anomalies (AEF) which occur before earthquakes are classified as one of the short-time earthquake precursors. However, still now there are no sufficient data described these anomalies due to strong influence of the meteorological and magnetospherical sources which could distort the AEF relationship with the seismic activity. The AEF disturbances with the amplitudes of 100–1000 V/m have been observed in different regions of the world at several hours or days before the earthquakes. But the information of such disturbances was not enough for the statistical study and the construction of a model of the electromagnetic precursor of earthquakes. Thus, it was very important to summarize all existent information of AEF in various areas of the world. Such catalog has

been composed and presented here to support an idea to carry out the atmospheric electric field observations in the seismoactive zones.

Case study of the seismo-induced TEC variations for the Jan. 12, 2010 Haiti earthquake

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We have analyzed the features of the ionosphere TEC (total electron content) deviations relative to the quiet background conditions as seismo-ionospheric precursors possibly associated to the Jan. 12, 2010, 21:53UT Haiti earthquake (18.46°N, 72.5°W; M 7.0).

We treat strong local long-living TEC deviations from the non-disturbed level constantly ground-linked to some position as ionospheric seismo-precursors. We have used running median values for 7 days before the current calculation moment as quiet background conditions. We have calculated and analyzed differential TEC maps for a few days before and after the Haiti earthquake utilizing the NASA IONEX products to recognize such TEC deviations.

The considered TEC variations looked like positive structures existing during Jan. 10, 22UT – Jan. 12, 08UT reaching values up to approx. 40% relative to the background values at the near-epicenter area and more than 50% at the magnetically conjugated region. The deviation's maximum was observed in Jan. 12, 06UT. Those anomalous positive structures had disappeared for about 10 hours before the main shock event release time. No disturbances were observed at the moment of the earthquake. Geomagnetic situation was relatively quiet for the considered period. Therefore, disturbances were not due to the solar and geomagnetic activity. All mentioned above allow us to treat those deviations as ionosphere seismo-precursors.

Recent results of VLF/LF monitoring in the Far East

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During nine years VLF/LF receiver has been successfully operated in Petropavlovsk-Kamchatsky. In April 2009 a new receiver station was installed in Yuzno-Sakhalinsk that considerably increased capability of the Far East observations both in coverage area and in reliability of results.

The results of the monitoring of JJY (40 kHz) signal from Japanese transmitter collected in Petropavlovsk-Kamchatsky and Yuzhno-Sakhalinsk receiving stations are presented. The period of the observation is from May 2009 to April 2010. Several earthquakes with $M = 5.5$–6.5 occurred in the sensitivity zone of Japan–Kamchatka wave path during this time while Japan–Sakhalin path was free from strong earthquakes. Disturbances in the amplitude of LF signal in Japan-Kamchatka path are found to coincide with time of earthquakes with M> 5.5. Taking into account that geomagnetic conditions were quiet in the quoted period we conclude that observed anomalies in the signal are caused by seismic activity.

Fractal approach to search for the earthquake precursory signatures in geophysical time series

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Fractal analysis of various geophysical data obtained in seismic active regions reveals definite dynamics of their scaling characteristics in relation to the violent earthquakes (EQs). As an example, the certain high order fractal dimensions of the seismicity distribution in the Kobe area of Japan were gradually decreasing when approaching the

date of the powerful Kobe earthquake of 17 January 1995. The first order fractal dimension of the ULF electromagnetic time series was increasing before the Guam earthquake of 8 August 1993 as well as before the swarm of Japanese EQs of July–August 2000. That gives us a possibility to consider the corresponding dynamics as the EQ precursory signatures and pay a special attention to fractal approach when develop the EQ forecasting methods. Here we summarize our theoretical and experimental works, which demonstrate fractal properties of geophysical fields in seismic active regions – their spatial distributions and temporal variations. In theoretical aspect, we show how the crack network evolves from the state with random, chaotic behavior to the state with fractal, clustered distributions before the main rupture. Also we show on the example of seismic waves that propagation of the coda waves through the fractally distributed cracks leads to the formation of the monoscaling power law spectrum of the scattered waves. Comparison between theoretically predicted and experimentally observed behaviors of geophysical parameters is drawn. It is shown that fractal approach to geophysical data processing is one of the promising way for monitoring the destruction processes in seismically active areas and thus for development of the earthquake forecasting methods.

Anomalies of LF signal (37.5 kHz) on the radio path Iceland–Bari during magnetic and seismic activity

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We compare variations of the amplitude of LF subionospheric signal from transmitter NRK (37.5 kHz) in Iceland received in Bari station (Italy) during strong magnetic activity and earthquake in L'Aquila (M= 6.3, April 6, 2009). Exceptional strong anomalies in the signal with heavy deformation of normal daily variations were observed during two super strong magnetic storms (Dst∼400 n) on October 2003 and on November 2004. In the case of L'Aquila earthquake NRK signal has been analyzed in three recording stations – Bari, Graz and Moscow. The NRK-Bari radio path was a seismic path, while the NRK-Moscow and NRK-Graz ones were control paths. Strong night-

time anomalies similar to those from magnetic activity have been found 5–6 days before the earthquake and during the aftershocks series in the seismic path. They correspond to anomalies revealed at the same time in VLF/LF signals in several others seismic paths. The effect in LF signal observed during strong magnetic activity in a high latitudes radio path is explicable, but the precise mechanism able to produce the observed variations in the intensity of the radio signals in connection with earthquake cannot be defined at present.

About some features of influence of geomagnetic disturbances on seismic energy realization (according to Ukrainian geophysical observatories data)

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Results of analysis of geomagnetic variations during the long observation period (1988–1996) on the geophysical station Yastrebovka (Crimea) in relation to earthquakes of different energy class from the weak in the Ukrainian Carpathians to the strongest in the Vrancea area are summarized. In connection with the anomalous events on the Sun in October 2003 and November 2004 the geomagnetic storms on Kiev Observatory and their impact on the sequence of strong (M≥7) earthquakes in 2004 and 2005 are analyzed. For each earthquake in the magnetic field the main-storm gradients and near-midnight polar substorm gradients in the immediate vicinity of the thrust have been identified together with their amplitude and duration values. These parameters have been used for the determination of the power (P) of geomagnetic substorms during the main gradient and in close proximity to push. If the power is substorm amplitude multiplied on its duration, the rate of event running – the ratio of the substorm amplitude to its duration. An analysis of geomagnetic conditions in relation to earthquakes for the above periods revealed the following:

1. The main feature of the impact of geomagnetic disturbances on the implementation of the seismic energy is that it does not depend on the degree of disturbance of the field, and develops through specific symptoms in the spectrum of irregular variations. The basic such feature is near-midnight polar substorms with greatest intensity and extent of its middle-latitude manifestations.

2. Length of geomagnetic substorms doesn't depend on the degree of disturbance of the geomagnetic field. The level of geomagnetic disturbance affects only the time interval from maximum gradient of geomagnetic disturbance to push.

3. Substorms before to deep and crustal shocks vary in length. In more than 85% of "trigger" mechanism for deep earthquakes are the long (T$\geq$1.5 hours) near-midnight polar substorms and with considerable amplitude of their middle-latitude manifestation.

4. The time interval (τ, hours) from the peak in the development of polar substorms to push in the general case depends on the hearth depth (h, km). For very large geomagnetic disturbance in particular at the peak of activity in 1991 or in case of anomalies in 2003 and 2004 this link is distorted.

5. Discharge of seismic energy occurs mainly at a reduced level of geomagnetic activity. Probably, it was during quiet geomagnetic field when may be released the internal energy of the hearth zone.

Quasi harmonic pulsations of surface atmospheric electricity parameters

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The nature of atmospheric electricity (AE), with its various forms of manifestations is not well understood as yet. There are a number of theoretical and experimental problems, which have to be solved in relation with AE and with formation of the global Electric Circuit (GEC).

In this report some basic results obtained by the authors with their AE equipment on the basis of the Alibag Geophysical Observatory (AGO), India, during in situ surface monitoring studies of GEC, are presented. The experiment consisted in synchronous logging the values of electric field (**EF**) intensity $\mathbf{E}_z$ and the electric current density $\mathbf{j}_z$ of AE; **D**, **H** and **Z** components of the geomagnetic field, and such meteorological parameters (important in the frame of AE problems) as air temperature $\mathbf{t}^\circ$ C, humidity ν and atmospheric pressure **P**.

Up to present days AE parameters pulsations were considered (if in terms of geomagnetic pulsations) as **irregular** pulsations in wide frequency band, because of unsuccessful searches of AE pulsations like to geomagnetic regular (**quasi harmonic**) pulsations. On the other hand the most familiar situation is accurate and separate observation of AE parameters: $\mathbf{E}_z$ (often) or $\mathbf{j}_z$ (rare). Accurate synchronous continuously measurements of the $\mathbf{E}_z$ and $\mathbf{j}_z$ allowed here to observe new features of AE processes. Thus it is established facts of events of quasi monochromatic oscillations ("wave packets"). During one of events of pulsations its periods varied from about 3 to 9 minutes and continued from 20 to 50 minutes. The pulsations train containing 12 periods of oscillation with fluent increasing amplitudes was observed. In terms of the theory an increment and a decrement of pulsations are the same order. The most important features of these pulsations events are the facts that both $\mathbf{E}_z$ and $\mathbf{j}_z$ of AE have been observed simultaneously and in phase. Other feature is the fact that $\mathbf{E}_z$-pulsations were observed on the background of the bay like $\mathbf{E}_z$-perturbations, but in $\mathbf{j}_z$ — when it is not observed this type of $\mathbf{E}_z$ perturbations. And the last: not all of other pulsations of $\mathbf{E}_z$ variations (including bay type one) were observed in $\mathbf{j}_z$ too.

To interpret origin of AE parameters variations aeroelectric structures (AES) movements are used commonly. It may find an application relatively to pulsations of AE parameters too. But as to this case (particularly as to **regular**, although rare, **quasi harmonic** pulsations) it is remained alternative version about role of atmospheric gravity waves, generated by earthquakes and ocean long periodic waves (AGO situated on sea coast). So it is given two possible mechanisms of generation of the described AE train type pulsations of $\mathbf{E}_z$ and $\mathbf{j}_z$ — **quasi harmonic pulsations** with fluent time **increasing** or **decreasing amplitudes**. As the sources of infrasonic atmospheric gravity upward waves may be earthquakes, tsunami waves (as a result of rapid movement of continental lithospheric and/or ocean floor plates), and atmospheric processes. Sources of downward gravity waves may be ionospheric or/and magnetosphere origin. Besides long periodic ocean waves including tsunami waves as a result of interaction between Earth magnetic field and electrically conducting ocean water masses movements, generate electromagnetic waves propagating upward and playing some its own role in GEC formation as AE $\mathbf{E}_z$ and $\mathbf{j}_z$ pulsations considered. Hence observed types of AE pulsations may be one of precursors of earthquakes and tsunami as nature phenomena that may cause a natural disasters and ecocatastrophes.

Discovery and allocation of electromagnetic signals of lithospheric origin

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The method of registration and allocation of near-by located sources of natural electromagnetic radiation is developed. These sources in seismically active regions with a high probability have the lithospheric origin. A short description of this method is given. It has been executed field experiment in region with small level of technical hindrances and high level of micro-seismical activity (Karimschyna). A number of fragments of the received data are analyzed. The big variety of kinds of the registered signals is shown. It is shown that the most probable source of these signals has the lithospheric origin.

Development of basic physics of man-made electromagnetic action on deformation processes in the Earth crust

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Earthquake triggering by dynamic and static stress change due to an impact of strong distant earthquakes, underground nuclear and chemical explosions, water reservoir filling, fluid injection into the faults, lunar-solar earth tides, etc. is widely discussed in the scientific literature. Relations of electromagnetic phenomena and earthquake occurrence are considered mainly from point of view of possible earthquake prediction based on anomalous variations of electromagnetic signals before the seismic event. Nevertheless, recently an effect of high-power electromagnetic pulses produced by electric power systems on the seismic activity of Northern Tien Shan and Pamir regions has been discovered. An increased number of earthquakes were observed within 3 to 6 days after the switching on the pulsed power systems. It was suggested that electromagnetic pulses result in discharge of energy accumulated in the Earth crust due to tectonic deformation processes. Based on previous field and laboratory study of seismicity triggered by high-power electric pulses injected into the Earth crust the Russian team, which incorporates

researchers from the Joint Institute for High Temperatures, the Institute of Physics of the Earth, Institute of Dynamics of Geospheres (Moscow), Research Station in Bishkek, Kirghizia (Northern Tian Shan) of Russian Academy of Sciences started in 2009 the complex Project "Development of basic physics of man-made electromagnetic action on deformation processes in the Earth crust" for investigation of electromagnetic triggering phenomena. The project is directed to solving the basic problem of stress release in the Earth crust by man-made impacts at the junction of applied seismology, electrodynamics, and rock mechanics. The target of project is development of physical grounds of earthquake hazard mitigation technology by artificial partial discharge of tectonic stresses due to initiation of deformation processes in the earth crust by relatively weak electromagnetic and vibration actions. The project is a continuation of interdisciplinary research of influence of high-power electromagnetic pulses on deformation processes in the Earth crust by methods of statistical analysis of field data, physical laboratory and mathematical simulations. The new basic knowledge is anticipated on mechanisms of interaction of electromagnetic field and vibrations with rocks under stressed conditions in combination with impacts of various natural factors. Preliminary results are discussed obtained to-date from statistical analysis of previous filed experiments with pulsed power systems, laboratory research of dynamics of rock deformation under low-amplitude mechanical and electromagnetic disturbances, physical simulation of seismoelectric and electroseismic phenomena in the rocks, as well as theoretical analysis of possible mechanisms of interaction of stressed rocks with electromagnetic field.

Analysis of seismic data and geomagnetic disturbances. The first results

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In specter of a temporal variable often there is a periodic component. It is possible to separate out this component using harmonious analysis. In result of Discrete Fourier Transform the amplitude and phase spectra for the following variables are obtained: 1) an Ak-index of geomagnetic disturbances and 2) energy of seismic earthquakes (Lg) for the period of 03.01.1996 – 31.12.2008. The most significant sinusoids making the basic contribution to periodicity of the temporal

variables are separated out from the obtained spectra. For the further joint analysis of Ak and E variables the sinusoids of equal periods are sampled. It has been found that the significant harmonics in the specter of E and Ak variables are harmonics of the period about a year. Because for Ak- index of geomagnetic disturbances this periodicity is visually appreciable in the field of low values, Discrete Fourier Transform are carried out for these data separately. The histogram of the Ak values is obtained. The histogram has shown that the bulk of events are concentrated in the field of low values, whereas intensive geomagnetic disturbances are rather rare. According to the histogram the most significant class is the class with the range of 16 – 32 nT of the Ak- index, or in values of the -index the range is 0,6 – 1,7 (for "Lovozero " observatory). All values of the k-index are less than 3 are determined as "weak disturbances" and values exceeding 3–4 — as "disturbances" and "magnetic storms". For "Lovozero" observatory the state of magnetic field is qualified as "disturbances" if Ak values are 90 nT and more, and as "magnetic storms" – if Ak values are more than 288 nT. 1204 "disturbances" and 182 "magnetic storms" are recorded during the period of 1996–2008. It is likely the separated out harmonic of a year period is connected with the annual variations. These variations are concerned with periodical variations and are usually characterized by low values of amplitude, finding confirmation in our data. The interest fact is that the variations of the same period are detected in the seismic data such as the earthquakes of Kola Peninsula and seismic noise.

On TEC anomalies before the Wenchuan earthquake

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The case study of the strong TEC disturbances observed before the Wenchuan earthquake of May 12, 2008, M 7.9, D 19 km, (31.0N;103.4E) as possible seismo-precursors is present.

We defined the TEC disturbances' anomaly as (i) strong local long-living TEC deviations from the non-disturbed level (ii) linked to some geographical position (iii) and possibly with similar effects at the magnetically conjugated region. We calculated the quiet background TEC conditions as running median for 3 days before and 7 days after

the calculation moment. We used Global Ionospheric TEC Maps in IONEX file format provided by the NASA
(ftp://cddisa.gsfc.nasa.gov/pub/gps/products/ionex/)
as input for processing.

The geomagnetic situation was quiet: the Kp index did not exceed 2.5 on May 7–12, 2008, the Ap index was less than 10 units during May 7 13, the Dst index variations did not also have any significant disturbances for the considered period. Therefore, the investigated TEC anomalies could not be triggered by the geomagnetic or solar activity.

From the differential TEC maps analysis we conclude: (i) TEC anomalies were observed 2 days before the Wenchuan earthquake, and looked like TEC increase for more than 60% in magnitude. (ii) They occupied approx. 10° in latitude and approx. 40° in longitude at the near-epicenter region, existed from 06UT till 12UT May 9, 2008. (iii) Similar effects took place at the magnetically conjugated area. (iv) Strong linkage of the anomalies to the near-epicenter area and its morphological features allow us to treat them as seismo-precursors.

About reality of daily and septan variations in the seismic activity

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In this report we analyze the origin of septan (so-called weekend effect, or shortly WEEF) and daily periodicities in the global seismic activity. We propose some statistical criteria which indicate the reality of these phenomena. It is shown that there is a statistically significant difference between the distributions of magnitudes corresponding to the minimum and maximum of daily as well as the septan variations. The observed features of the distributions show that the both periodicities are the real geophysical phenomena. The analysis rejects the null-hypothesis of the origin of these periodicity associated with the weekly and daily variation in the sensitivity of the global seismic network due to the variation of seismic noise. There are the grounds for accepting the alternative hypothesis about the real impact of industrial activities on the seismicity of the Earth. The work was partly supported by the Presidium of the Russian Academy of Sciences (Program 16).

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