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Plenary Talks

Solar cycle evolution of the magnetic activity inferred from the SDO/HMI data

Benevolenskaya, E.E. (Pulkovo Astronomical Observatory, RAS, St. Petersburg, Russia)

There are a lot of discussions about the development of the current solar cycle 24 which follows after a long solar minimum. But, it should be mentioned, that it is observed the deep solar minimum before the cycle 19 and this cycle is the biggest. Yet, weak polar magnetic fields during the cycle 23 should be led to the small cycle 24. The Solar Dynamics Observatory provides us high resolution full disc magnetic images since May 2010 when the solar cycle 24 is started. Using these data it is investigated the evolution of the upcoming magnetic flux on the ascending phase of the solar cycle. Here, it is analyzed the 720 sec cadence of the line-of-sight component of the magnetic field strength. Each image is transformed to the Carrington coordinate system. And, frames of the synoptic maps are obtained with the resolution 0.1 degree in longitude and 0.001 in sine of latitude. It is found that at the beginning of the solar cycle the upcoming and old magnetic fluxes show the unbalanced behavior which leads to strong asymmetry. The old magnetic elements show the longer living time comparing with the upcoming new polarity (positive in the North and negative in the South).

In this presentation it is discussed the transport of the magnetic flux on the sun and the role of the polar magnetic field in the solar cycle development.

Seismic noise as a source of information in some seismological problems

Yanovskaya, T.B. (St. Petersburg University, St. Petersburg, Russia)

Up to the end of the last century seismic noise was regarded as a disturbance, and the main information was extracted from records

of earthquakes and explosions. Therefore the main problem in getting the seismological information of different kind was to suppress the noise and to increase the signal-to-noise ratio. But because of propagation in the upper part of the earth the noise contains some information on its structure. Also it was clear that processes prior to earthquakes should lead to changes in the noise structure due to variations in the stress state and increase of fracturing in the area of future source. Therefore in the end of last century seismologists showed interest to seismic noise and to ways for extracting information from noise characteristics. Appearance of networks of broadband stations with digital recording and the opportunity to get continuous seismic records led to development of the methods for processing of the noise and its interpretation in respect to the earth's structure and source dynamics.

There is a wide spectrum of problems that are solved now on the basis of seismic noise. The sources of the noise are of endogenous and exogenous origin. The exogenous sources are oceanic storms exiting microseisms in the period range of 5–15 s, atmospheric disturbances, wind, and human activity — transport, factories, building. Such a noise is usually referred as the “ambient noise”. Endogenous sources are microearthquakes, fracturing of media prior to earthquakes, and some processes in the medium due to rebuilding of stresses: phase transform, fluidization, etc. Such a noise may be called as “internal noise”. The internal noise is characterized with broad-band spectrum — from very high frequencies specific for microfracturing up to very low frequencies due to slow processes within the earth.

Here we shall consider the main problems that are solved on the basis of the seismic noise.

From the middle of the last century the microseisms were used for microzonation, which is a process of subdividing a seismically dangerous area into zones with respect to some geological and geophysical characteristics of the sites such as ground shaking, landslide and earthquake-related flooding. The microzonation is based on estimate of site effects that may vary in different locations of a city according to the local geology. Microzonation provides a basis for evaluating site-specific risk analysis, which is essential for critical structures like nuclear power plants, subways, bridges, etc. An example of the difference in site effects are damages after 1985 Mexico earthquake, when a part of Mexico City located at soft clay deposits was completely destroyed, while other part situated at consolidated sediments prac-

tically has not suffered from the earthquake.

Microzonation is based on dynamic characteristics of site such as predominant period, amplification factor and shear wave velocity. A popular method for determining the dynamic properties of soil strata is the H/V method (Nakamura, 1989) using the spectral ratio of horizontal-to-vertical components of the ambient vibrations (microseisms). Though the author of the method considered the H/V spectral ratio as a reaction of a low velocity layer to S-wave incident to the base of the layer, a concept accepted at present is that the microtremors consist of Rayleigh waves, and the H/V ratio relates to ellipticity of the fundamental mode. The spectral ratio is characterized by a peak at the so-called resonance frequency, and the value of the peak may be regarded as amplification factor — important characteristics for estimation of the site effect. Another problem for which the microseisms are used is detection of local low-velocity or high-velocity inclusions in near-surface region by the so-called microseismic-sounding method (Gorbatikov, 2008). The method is based on the experimental fact (proved later by numerical modeling) that spectral amplitudes of microseisms increase above low-velocity anomaly, and vice-versa decrease above high-velocity anomaly. Depth of such zones is related to frequency of anomalous amplitudes of the microseisms. This method is used for revealing magma chambers in volcano areas, and for some problems of geophysical prospecting.

During the last decade many tomography studies (mostly crustal studies) are based on the data obtained from the ambient noise. It is based on the fact that the cross-correlation function of random wave field recorded in two points determines the Green's function between these points. On the assumption that the ambient noise contains surface waves generated by sources randomly distributed over the surface, cross-correlation function (CCF) of noise enables to determine the Green's function of the surface wave from a source located at one station and recorded at the other one. The CCF of the ambient noise at pairs of stations are widely used now for determination of dispersion curves at the interstation paths and for following usage of them in surface wave tomography mostly on regional and local scale — for study of lateral variation of the crustal structure.

If the sources are distributed over the surface uniformly, CCF should be symmetric relatively to zero time. In case of relatively short wavelengths (short periods) — and short distances between stations — the 'sources' of surface wave in the noise are exogenous, i.e. they are

storm microseisms and atmospheric disturbances.

But if the method is applied to upper mantle studies it is necessary to use the low-frequency components of the noise and correspondingly to calculate CCF at the remote stations — at distances of about some hundreds or even thousands km. On so large scale the ambient noise is not correlated. Nevertheless the CCF of the low-frequency noise enables to estimate adequately surface wave dispersion curves. It can be shown that in such a case the sources of the noise are endogenous, i.e. it is internal rather than ambient noise. As mentioned above the internal noise is generated by weak earthquakes. In all procedures of CCF determination one or another method for amplitude normalization of the record is used in order to suppress the signals from earthquakes. At high frequencies the ambient noise is rather intensive, and after amplitude normalization the signals from strong though infrequent earthquakes are suppressed, but those from weak frequent events are lower than the noise. However at low frequencies the ambient noise correlated at large distances is sufficiently low — lower than signals from weak earthquakes, so after amplitude normalization the signals from all earthquakes remain. Namely they constitute the noise.

Since the sources of the internal noise — the earthquakes — are distributed over the surface non-uniformly, the CCF at low frequencies cannot be symmetric. Clusters of earthquakes distort the CCF, so that CCF cannot be used for determining the dispersion curve. To reduce the effect of non-uniformity of earthquake distribution we propose the following: in the process of stacking the individual CCFs to eliminate the yearly intervals with earthquake clusters, as well as to sum up the CCFs for several years. Results of surface wave tomography based on ambient and internal noise for upper mantle studies at the territory of the East European Platform are presented.

Internal noise is very important for monitoring of processes in the areas of earthquake sources. Prior to a strong earthquake some characteristics of the internal noise are changing. Intensity of low frequency noise increases before strong earthquakes at stations nearest to the coming earthquake (Sobolev, 2012). High frequency noise (10–50 Hz) is modulated by different deformation processes (Rykunov, 1983) that enables to monitor the endogenous processes prior to strong earthquakes (Saltykov, Kugaenko et al., 2007).

Section C. Conductivity of the Earth

Plate tectonics, anomalies of the lithosphere electrical conductivity and ore minerals

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

Main deposits of the metallogenic minerals are confined to the world's areas showing evidences of recent tectonic activation. The electromagnetic investigations carried out within these regions have revealed a peculiar structure of the lithosphere conductive zones. A narrow conductive zone traced from a depth of a few kilometers and a hundred of kilometers and a conductive layer at a depth of more than 20 km are distinguished within the subduction zones of the lithospheric plates. A transcrustal conductive zone is associated with a region of the Earth's crust material melting and differentiation, where the ore mineral deposits are accumulated. This region appears as a result of the subsidence and melting of the oceanic crust saturated with fluids in the subduction zone. Within stable lithospheric plates there are evidences of ancient palaeotectonic processes. Two-dimensional magnetovariation anomalies are related to palaeotectonic sutures of lithospheric blocks and coincide in space with location of ore mineral deposits. Within the East European Platform west a promising metallogenic zone is associated with a transcontinental system of electrical conduction anomalies stretching from the Black Sea to the Northern Sea.

Construction pseudoreliefs of magnetotelluric and magnetovariational response function on Kyrgyz Tien Shan

Batalev, V.Yu., and Bataleva, E.A. (Research station, Bishkek, Kyrgyzstan)

The method of pseudoreliefs proposed by M.N.Berdichevsky is tested on real magnetotelluric (MT) and magnetovariational (MV) data on Kyrgyz Tien Shan. Smooth surfaces are formed during the construction of pseudoreliefs above the three-dimensional synthetic models with rather big number of cells (3600 in a plan). On these surfaces

we see clear separation of influence of anomalous objects located at different depth levels. In practice we face some difficulties when pseudoreliefs are constructed using field experimental data received for heterogeneous media and when the number of points rarely makes up the first hundreds of soundings. It is quite natural that the density of soundings on real profiles cannot approach the "model" density of data, and so we cannot get the smooth reflection of structures present in the section. Moreover, experimental data are always complicated by some influence of "geological noise". Thereafter, the visualization of presentation of real data by pseudoreliefs method depends on resolution capability of response functions and on intensity of geological noise. For construction of pseudoreliefs we used the MT- and MV-data received by the Research Station RAS for more than 25 years (more than 500 soundings). For each sounding site we calculated and constructed the following invariants in the form of pseudoreliefs for several periods: Berdichevsky impedance, its phase and the matrix norm of Vise-Parkinson. During the analysis of pseudoreliefs on the territory of Kyrgyz Tien Shan we clearly saw the already known crustal anomaly of electroconductivity - the Talas-Fergana fault zone. Besides, there are other heterogeneities in the crustal conducting layer such as the high-resistance Son-Kul block surrounded by conducting zone.

New data on geoelectric structure of Talas-Fergana fault zone

Batalev, V.Yu., and Bataleva, E.A. (Research station, Bishkek, Kyrgyzstan)

The additional magnetotelluric soundings conducted using the new-generation equipment along the Chatkal profile in the western part of Talas-Fergana Fault (TFF), confirmed the earlier assumptions about spatial structure of electroconductivity of the Earth's crust of the TFF zone. Combination of crustal conducting zones on this profile basically has the same nature as everywhere along the whole TFF zone. We focused on the western end of Talas part of electroconductivity anomaly confined to the TFF zone. Here we should note the following: first of all, the near-surface conducting objects through which there is a flow of transversal currents between northeastern (on the side of Naryn depression) and southwestern (on the side of

Fergana depression) parts of crustal conductor, are very powerful (up to 7 km) and therefore they have high total conductivity in consequence of which the transversal curves of magnetotelluric soundings are not ascending. Secondly, the width of high-resistance block which separates the northeastern and the southwestern parts of crustal conductor on Chatkal profile makes up 10 km, while it is estimated as 35-40 km almost everywhere along the TFF zone. Thereby, on the base of results of interpretation of new MT-data received on Chatkal profile (longitude 71.5° east) we can suggest the existence of a tendency towards weakening of electroconductivity anomaly confined to the TFF zone.

Parameters of the Fennoscandian Shield asthenosphere by the experiment BEAR magnetotelluric data

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

In the course of the international experiment BEAR (summer 1998) there were performed synchronous magnetotelluric soundings within the period range from 10 s till own day at 46 sites of Fennoscandian Shield. In present paper we sum up the results of a number of our works performed during 2002–2010 years, in which we managed to form conception of Fennoscandian Shield upper mantle structure and to outline ways for further rising of MT method potentialities for defining thickness of the lithosphere plate and geoelectrical parameters of the asthenosphere. The performed studying of the upper mantle structure by the BEAR MT data made it possible to more confidently speak about the presence of the asthenosphere layer at the depth from 180 to 300 km with the resistivity 20–40 Ohm.m. In order to get more strict estimation it is necessary to perform interpretation of BEAR data using MV data obtained by observatories located directly at the Fennoscandian Shield. May be this approach will made it possible to divide Fennoscandian Shield territory into the regions according to the thickness and bedding depth of the asthenosphere.

On the possibility of using the magnetovariational method for investigation of the upper mantle electroconductivity at the Polar Cape region

Kovtun, A.A., Vagin, S.A., Vardaniants, I.L., Uspenskiy, N.I., and Legen'kova, N.P. (St. Petersburg University, St. Petersburg, Russia)

In our report we consider the principal possibility of using the daily geomagnetic variations generated by the stable current system located within the ionosphere at the Northern Polar Cap for investigation of Earth electroconductivity at these latitudes.

The idea of the presence of this current system was proposed at the middle of the last century by O.V. Burdo. In this work he showed the presence of the stable daily variation of magnetic field components change recorded at the observatories of Dickson island and Tikhaya bay. This variation remained unchanged even during quiet periods of the world magnetic storm. The further works confirmed the existence of two circular current systems over the Polar Cape with the centers at morning and evening side of the Earth. However until the present time the spherical analysis of the magnetic field of this current system was not performed and the possibility of using geomagnetic variations of this current source for deep magnetovariational soundings was not considered. By now we have performed the spherical analysis of the Polar magnetic disturbance and estimated values of mantle apparent resistivity for two first harmonics of polar daily variation.

In this work there were used the published experimental data by M.V. Fiskina, E.B. Fainberg and Ya.I. Feldshtein received on the net of observatories located at the northern hemisphere during summer months in 1965 and 1966 years.

In the report we discuss the problems of the spherical analysis and reliability of the received results.

Analysis of the dimensionality and structure of the strike on magnetotelluric data along a profile MANAS

Kozlova, A.V., Vagin, S.A., and Vardanyants, I.L. (St.Petersburg State University, St.Petersburg, Russia)

In 2005–2008 years within the international program “Geodynamics of Tian-Shan” was carried out the complex geophysical works on the profile of MANAS (Middle AsiaN Active Seismic profiling) by teams of Russian, American (USA), Kirghiz and Chinese organizations. The profile was done along submeridional stretch of longitude 75-76°E from the lake Sonkul in Kyrghizstan toward the Kashgar city in China. Magnetotelluric sounding worked by staff of the Russian Academy of Sciences Scientific station in Bishkek and geophysicists from the Californian university in Riverside under the control of Prof. S.Parka. They used measuring systems MT-24 (EMI, the USA) and MTU-5 (the Phoenix, Canada) in the frequencies range from $0,38 \cdot 10^3$ to $0,11 \cdot 10^{-2}$ for 50 points. The length of average step between points of sounding is $\approx 5-6$ km. The dimensional analysis and the geoelectrical strike structure are provided in this work. We determine the impedance phase and the apparent resistivity by Egers’s method. Using this result we found areas of high resistance (up to 5000 Om·m) at the period from 10^{-2} to 50 sec. and conductivity areas (100–300 Om·m) in the magnetotelluric curves throughout all profile. For each point of sounding we defined the skew parameter of all frequency range for characterize the “geoelectric dimension” environmental. Estimate of “skew” comes to only 0.1–0.5 of the average, but sharply increasing to 2–3 in separate parts of profile. Pseudo-section of apparent resistance was constructed as a result of preliminary interpretation of the received data. Primary analysis of data allow us make conclusion that, the geoelectric structure of field along a regional profile is quasi 2-D, but in some of parts of profile the distribution model of geoelectric properties complicated by existence of powerful fracture, zones heave and tectonic dislocation.

Three-dimensional geoelectric model of Mogilev-Podolsky and Novodnestrovsky earthquake-prone areas

Kushnir, A.N. (Institute of geophysics by S.I. Subbotin name NAS of Ukraine)

Seismic events in the western part of Ukraine took place with strength of shaking above 5 balls. Their magnitude corresponded to the range of values 4.2 - 5.3. The epicenters of earthquakes (1984, 1989 and 2000 with $M = 2,5 - 3,5$ and 2003 $M = 1.0$) coincide geographically with Podolsky deep fault zone, and with Zhmerinka fault that is crossing it. Mogilev-Podolsky and Novodnestrovsky earthquake prone areas spatially correlate with Chernivtsi-Korosten anomaly of high electrical conductivity. Within Mogilev-Podolsky earthquake-prone area, field investigations were carried out by methods of magnetotelluric sounding and geomagnetic-variation profiling. In addition to current data, results from previous studies were used in a 3D model construction. The widespread 3D modeling software, developed by P. Mackie, was applied as a tool for creation and calculation of electric and magnetic components of the magnetotelluric field, tippers and ρk curves. According to the results of 3D geoelectric modeling of Mogilev-Podolsky and Novodnestrovsky earthquake-prone areas, a conductive structure was extracted at depths of 3 - 5 km with the $\rho = 10 \text{ Ohm}\cdot\text{m}$. The structure is oriented northwest to southeast and is limited by Podolsky deep fault from the north. In the south the conductor changes its direction to the sub-latitudinal and contains the intersection node of Podolsky, Belotserkovsky, Zhmerinka deep faults zones and other lower order faults. This structure is extracted on the background of the Chernivtsi-Korosten regional deep anomaly of high conductivity in the crust and upper mantle. Earthquake sources of Mogilev-Podolsky and Novodnestrovsky earthquake-prone areas are realized at a depth above the top edge and the upper part of the selected conductor.

Annual variations of magnetotelluric transfer functions

Moroz, Yu.F., and T.A. Moroz (Institute of Volcanology and Seismology FEB RAS, Petropavlovsk-Kamchatsky, Russia)

The data of multi-year observations of the Earth's electromagnetic field in Kamchatka have been applied for studying temporal vari-

ations of magnetotelluric transfer functions: impedance tensor and magnetic tipper. The observations of the electromagnetic field are performed in the subduction zone along the profile reaching the Pacific coast. The stations are spaced 50–70 km apart. The observation time is 10 years. The resolution in measuring the electromagnetic field components varies from 1 second to 1 minute. The electromagnetic field monitoring data have been processed and analyzed using modern software programs. The following specific features have been revealed in temporal variations of magnetotelluric impedance and magnetic tipper in relation to electric conductivity of the geological medium.

The magnetotelluric impedance behavior shows annual variations. They are more clearly pronounced in impedance module for a period of 500 s where their amplitude is about 30%. The amplitudes of module variations reduce for periods of 1000 and 3000 s. The annual variations are poorly pronounced in behavior of impedance phase. Their amplitude does not exceed the phase measurement accuracy. This indicates that annual variations of impedance are much more due to the variations in electric conductivity of local geoelectric inhomogeneities in the near-surface parts of the Earth's crust. The annual variations are well pronounced in behavior of the imaginary parts of the tipper for periods of 1000–3000 s. The behavior of the real parts of the tipper shows almost no annual variations. This indicates that annual variations of the imaginary parts of the tipper for periods of 1000–3000 s are related to current induction in the deep-seated conductive fault shown in the MTS curves as minimum apparent resistivity for the periods mentioned. Note that the annual variations are also less pronounced for other periods. The annual variations of electrical conductivity of the fault are supposed to be caused by the variations in geodynamic processes induced by the Earth's revolution around the Sun. This is manifested through the variations in electrical conductivity of rocks due to their fracturing and degree of saturation with hydrothermal solutions.

Magnetotelluric Primary Data Analysis Software Utility

Namozov, I.B. (Saint-Petersburg State University, Saint-Petersburg, Russia)

Magnetotelluric Primary Data Analysis Software Utility first public

Alpha release presentation. Graduate student developed a software complex for effective magnetotelluric data processing, using a spectral analysis methods based on assumption of a stationary random process model. Valid directly analyzed MT data were collected in the August of 2012 in the Cape "Kartezh" in Karelia. Discussion will be held on concrete problems solved, results gathered, main features implemented, comprehensive field of investigation analysis, research, testing and detailed technical specification overview.

Long-period variability of impedances for a total conductance reaching middle mantle and their lateral gradients according to the data of European geomagnetic observatories

Petrishchev, M.S. (SPbF IZMIRAN, Russia), Semenov, V.Yu. (Institute of Geophysics, Polish Academy of Sciences, Poland), and Tkachev, A.L. (SPbF IZMIRAN, Russia)

Variations of mid-annual values of impedances for a total conductance reaching middle mantle have been detected by two kinds of magnetovariation sounding methods with fixed periods from several hours till a month. The developed approach of dynamic spectra analysis was tested on the data measured by European geomagnetic observatories. The obtained apparent resistivities on the fixed periods have been averaged over each year where the different types of field source and coherence values were taken into account. The established variations of apparent resistivities are in a good agreement with the solar activity data and have quasi-linear trends. Obtained lateral gradients of impedances are presented as traditional induction vectors. Their regional significant changes are well correlated with the time of geomagnetic jerk registration in Western Europe. A good fit of the variations of apparent resistivity to the cumulative seismicity for some groups of observatories in Western Europe is established too. The reason of established phenomenon is under consideration.

The effective conductivity tensor of the lateral non-uniform anisotropic medium

Plotkin, V.V. (Institute of Petroleum Geology and Geophysics SB RAS, Novosibirsk, Russia)

The results of the simulation for magnetotelluric sounding shown that there are possibilities of the complete recovering the conductivity tensor of the anisotropic medium by using synchronous array data on electromagnetic field components. The domain approach is applicable for the recovering the conductivity tensor of the anisotropic non-uniform medium that smoothly depends on lateral coordinates. It is similar to the approximate description of properties of the limited region by means of the effective conductivity tensor.

By this approach, the magnetovariation sounding data (project IMAGE - International Monitor for Auroral Geomagnetic Effects) and the magnetotelluric sounding data (project BEAR - Baltic Electromagnetic Array Research) are processed. All elements of the effective conductivity tensor are consistently defined for the sliding limited regions of the Baltic Shield. Maps of spatial distributions of eigenvalues and of maximum conductivity azimuths are constructed. For available experimental data, azimuthal angles of 40° – 60° describe best directions of the tensor main axis with the maximal conductivity on Baltic Shield. Comparison of the results obtained on the seismic and electromagnetic data specifies in possible correlation of azimuthal directions of maximal conductivity and the minimal values of seismic speeds, and also similarity of corresponding domain structures of the Baltic Shield.

The study was supported by the Multidisciplinary Integrated Project SB RAS N 96 and by grant 12-05-00014 from the Russian Foundation for Basic Research.

Possibilities of magnetotelluric exploration of geothermal resources in active and stable tectonic regions

Pushkarev, P.Yu., and Ivanova, K.A. (Lomonosov Moscow State University, Moscow, Russia)

Magnetotelluric (MT) method is widely used to study geothermal zones. To evaluate its possibilities and develop an efficient strategy

of MT data interpretation, we constructed a typical 3D resistivity model of a geothermal zone and applied MT data analysis and inversion methods to interpret the appropriate synthetic data set. The model includes two conductive anomalies, near-surface one, corresponding to mineral alteration and/or water saturation zone, and deep one, connected with presence of melt and/or fluid. MT data analysis methods allow delineating the conductive anomaly, but can hardly help to separate the influence of near-surface and deep conductors. 1D inversion clearly imaged the upper conductor, but the deeper structure was distorted. 2D inversion of the most of the data gave better results, providing more correct parameters of the deep conductor. 3D inversion was also successful, but consumed much more computational resources.

Currently the possibilities of exploitation of geothermal resources in stable tectonic areas are evaluated. Here deep (until 5–10 km) drilling is required, and anomalies of physical properties are often also deep and weak. However, any indirect evidence of possible increase of temperature may be useful. MT method provides information about conductivity anomalies in the consolidated crust. Their nature is associated with graphite, sulfides, water saturation and melting of rocks. In many cases such anomalies may correspond to zones of increased crustal permeability, favorable for high heat and mass transfer, or even to tectonic activation zones.

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Investigation of the Kirovograd electrical conductivity anomaly

Rokityansky, I.I., Savchenko, T.S., and Tereshyn, A.V. (Institute of Geophysics, National Academy of Sciences of Ukraine, Kiev, Ukraine)

Kirovograd anomaly was discovered in 1967 and in the next 20 years was studied by the MVP and MTS. The MVP data (Wiese vectors and profile graphs of the eastern magnetic component) show the presence of two-dimensional regional anomaly elongated in the NS. MTS were used mainly for the conducting body depth determination which

turned out be equal 15 ± 8 km. Such error caused by surface inhomogeneities on the Ukrainian shield, and by screening effect of sediments on its slopes. In 2008–2009, we performed new observations near the Black Sea, which conformed early results and showed that the anomaly continues under the Sea.

In recent 30 years, Kirovograd anomaly was modeled with using two-dimensional, three-dimensional and thin film programs. Calculations were conducted for rather complex models and compared practically only with Wiese vector data. Comparison with MTS data gave unacceptably large misfit. So many details of the calculated and published models are not supported by sufficiently descriptive observations.

MTS curves obtained over the cross of Dnieper-Donets Depression (DDD) and Kirovograd anomaly were interpreted as follows: depth of the anomaly is equal to 20 ± 10 km, the total longitudinal conductivity $S_{MTS} 10^4$ Sm. According to the MVP data the value of the integral longitudinal conductivity G of the Kirovograd anomaly was estimated as $G = 2 \cdot 10^8$ Sm·m. Comparison of MTS and MVP results suggest limited length of the anomaly (Rokityanky, 1982), but the regional (within the entire structure of DDD) “S-effect” gives additional reduction of the transverse to DDD strike MTS curve and overestimation of S_{MTS} . The Kirovograd electrical conductivity anomaly was compared with other geophysical results. It have an interesting tendency be located in the zone of maximal gradient from positive to negative anomalies of permanent magnetic field. The same tendency were observed for Ladoga-Ilmen and some other anomalies. The nature of this tendency can be second-order magnetic phase transition near Currie temperature (Szarka, 2010).

Modeling of a magnetotelluric field in the vicinity of Sredny Island and Pezhostrov Island in the White Sea

Saltsberg, A.V. (St. Petersburg State University, St. Petersburg, Russia)

In August 2011 were carried out magnetotelluric sounding on two islands of the White Sea: Sredny and Pezhostrov. Was performed processing of time series obtained from the soundings and made a one-dimensional inversion. Using results of the inversion, data available for this area and geographical maps with indication of depths and heights was built preliminary model of researched region.

For this model was solved 3D-direct task by program Mackie. On map of this area was selected individual points where possible to carry out soundings (i.e. island and adjacent parts of mainland), made 1D-inversion for impedance values obtained in the solution of 3D-direct task and compared with the local cut of model in these points. Proposed a scheme of magnetotelluric investigations for regions with limited opportunities for sounding. Shown that the results of this approach to interpreting in condition of limited information can be used as a starting model for further researches.

Experience of application of the CSRMT method for the engineering tasks solution

Simakov, A.E., Saraev, A.K., and Antashchuk, K.M. (St.Petersburg State University, St.Petersburg, Russia)

New instruments and technologies of the near-surface geophysics are developing very actively. 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 tool and permits us to solve a wide range of near-surface geophysical tasks. It is based on measurement of electromagnetic fields of remote VLF (10–30 kHz), LF (30–300 kHz) and MF (300–1000 kHz) radio transmitters.

In the controlled source RMT modification — CSRMT an own source of signals is used instead or together with measurements of radio transmitter's signals. It can be applied in remote territories where there are not enough LF-MF radio transmitters for soundings fulfillment. The application of the CSRMT method is also necessary for the obtaining of RMT transfer functions in frequency band 1–10 kHz, where there are no radio transmitter's signals. The decreasing of the lowest frequency up to 1 kHz allows us to raise the skin depth approximately in three times compare to one at 10 kHz, therefore one can noticeably increase the investigation depth. Using of 3–4 main controlled source frequencies from the range 1–150 kHz and their several odd harmonics allows us to realize CSRMT soundings in frequency band 1–1000 kHz. Application of such technique does not require the emitting of a big number of frequencies and a measurement at one station takes little time.

Results of application of the CSRMT method for the solution of engineering tasks in several sites are described. In that regions there was a possibility to measure VLF radio transmitter's signals only, which can be used for realization the VLF-R profiling. Application of the CSRMT method allowed us to get full sounding curves for the studying of geological structure. Results of investigations have been confirmed by drilling and by other geophysical methods.

Images of ancient and actual lithospheric plate collisions in resistivity sections of Tien Shan and Western Himalaya

Sokolova, E. (Research Centre Institute of Physics of the Earth, RAS, Troitsk, Moscow region, Russia), Batalev, V. (Research Station of Russian Academy of Sciences Bishkek, Kyrgyzstan), Israil, M. (Indian Institute of Technology Roorkee, India), Rybin, A. (Research Station of Russian Academy of Sciences Bishkek, Kyrgyzstan), Smirnov, M. (St. Petersburg State University, St. Petersburg, Russia), Varentsov, I. (Research Centre Institute of Physics of the Earth, RAS, Troitsk, Moscow region, Russia)

The resistivity sections of Tien Shan and Western Himalaya along the profiles of magnetotelluric and magnetovariational observations of RS RAS ("Naryn" transect: Tarim Basin – Tien Shan – Kazakh plate) and IITR ("Roorkee-Gangotri" profile: Gangetic Plain – Garhwal Himalaya) are considered. Conductivity structure of ongoing subduction areas as well as geoelectrical images of the ancient collisional borders, marked in the present-day lithosphere as major suture zones, are in the focus.

The original results of the data analysis at both profiles were updated with account for new observations and a help of unified processing/interpretation approaches elaborated in GEMRC. The constructed conductivity models reveal differences in the images of Indian plate subduction under Himalaya and Tarim underthrusting under Southern Tien Shan (in dipping angles, character of partial melt zones). While the geoelectric markers of the regional suture under Naryn intramountain valley in Tien Shan (paleo-subduction, related to the closure of the Terskey ocean) are quite similar in morphology to the image of more young Indus-Tsangpo Suture (closure of Tethys) in Tso-Morari dome region of NW Himalaya (discussed on the literature data): both of them are defined as sub-vertical, conduc-

tive structures transforming in Northern direction to sub-horizontal crustal conductors, with more conductive one being associated with ITS.

All the geoelectrical images are discussed in the context of seismic data and regional seismicity. Good correspondence of the anomalous conductivity and low velocity/aseismic structures indicates their common nature, most probably connected with fluidized/partially melted and mechanically weak material. The reliable resolution of the main features of the resistivity cross-sections, which is mostly confirmed by this comparison results, provides objective constraints on the location of partial melt zones, permits to estimate the fluid content and helps to understand the regional seismogeneration patterns and, generally, a balance of the frontal and distant effects of the India-Eurasia continental collision.

Controllable transformation of unsmoothed magnetotelluric data with change of geometry of a section

Vagin, S.A. (St. Petersburg State University, St. Petersburg, Russia)

In 1989 A.A. Zohdy published an article about a simple way to convert the apparent resistivity into a one-dimensional geoelectric section. The key points of this method are rigid adherence to the section layers of the skin layers and one-to-one correspondence apparent resistivity and the resistivity geoelectric section. The algorithm requires that the smoothed apparent resistivity array was presented at a sufficiently complete grid periods. An array of layers according to the algorithm is the same size as the array period. At the same smoothing will be incorrect in terms of magnetotelluric method, if not to take special measures.

In this work the algorithm of controlled transformation of unsmoothed magnetotelluric data within one-dimensional interpretation is considered. Feature of the algorithm is updated at each iteration as the resistivity and the geometry of the geoelectric section. At the final stage the algorithm performs a smoothing of the transformation results by the method of magnetotelluric sounding. Stability is provided by way of correction of the section resistivity. The program was tested on modeling and global magnetovariational data [Semenov, 1998] . A

comparison with the one-dimensional inversion method of Levenberg-Marquardt algorithm with adaptive regularization [Vagin, Saltsberg, 2012] and effective method of linearization [Porokhova, Kharlamov, 1990]. The differences obtained in the transformation and inversion are analysed. For example, program-controlled transformation for the unsmoothed data clearly recorded second asthenosphere at depths ranging from 660 km to 780 km, where the resistivity is almost unchanged.

A new model of the Earth crust structure from results of the control source electromagnetic soundings

Zhamaletdinov, A.A. (St. Petersburg Branch of IZMIRAN, St. Petersburg; Geological Institute of the Kola Science Centre of RAS, Apatity, Russia)

It is suggested to subdivide the Earth's crust into two parts — upper, brittle crust (namely geological) and lower, ductile crust (namely physical). The upper crust of 10–15 km thickness is the most actively involved in geological processes. Its principal peculiarities are: the sharp horizontal heterogeneity of electrical properties, a wide range of variations of specific electrical resistivity from 1 to 10^5 Ohm·m, a high porosity, brittleness, and a presence of fluids that drain the supra structure from the day surface owing to penetrate of meteoric waters to the depths up to 5–10 km. The lower crust (physical) belongs to the depth interval from 10–15 to 35–45 km (up to the Moho boundary). It is remarkable by the horizontal homogeneity of electrical properties and high specific electrical resistivity in the range of 10^5 – 10^6 Ohm·m, by the low porosity and increased ductility. Electrical conductivity of the lower crust, along with geological composition, is determined by the influence of planetary physical–chemical parameters (pressure, temperature, viscosity), phase transitions of substances and geodynamic peculiarities of evolution for different segments of the Earth crust. As an area of physical processes influence, the Low crust is nearer by its origin to the Upper mantle than to the geological Upper Earth crust. Given the marked properties, lower crust should be attributed to the Upper Mantle, limiting the concept of geological crust, only the upper 10–15 km of the lithosphere thickness.

The large-scale anomalies of electrical conductivity in the Earth

Zhamaletdinov, A.A. (Geological Institute of the Kola Science Centre of RAS, Apatity; St. Petersburg Branch of IZMIRAN, St. Petersburg, Russia), and Kulik, S.N.[†] (Institute of Geophysics, National Academy of Sciences, Kiev, Ukraine)

On the background of published and new experimental data the geoelectric parameters, a structure and a geologic-tectonic position of a number of the largest anomalies of the electrical conductivity found on different continents of a planet Earth are analysed. Criteria of division of anomalies on fluid and electronically conducting nature are analysed and their communication with mineral deposits is considered.

Section P. Paleomagnetism and Rock Magnetism

Dependence of hysteresis characteristics of an ensemble of heterophase interacting particles of titanomagnetite on mechanical stresses

Afremov, L.L., and Kirienko, Yu.V. (Far-Eastern Federal University, Vladivostok, Russia)

Using the model of interacting heterophase particles of $\text{Fe}_3\text{O}_4 - \text{Fe}_{3-x}\text{Ti}_x\text{O}_4$ it is possible to show that magnetostatic interaction smoothes the hysteresis loop and lowers the magnetization curve. It leads to decreasing both coercive force H_c and saturation remanence I_{rs} . The reduction of hysteresis characteristics with growth of concentration of magnetic particles associated with disarranging influence of the magnetic interaction on the distribution of magnetic moments.

As expected, the stretching decreases the coercive force and the compression increases it, both in an ensemble of non-interacting nanoparticles and interacting nanoparticles. This can be explained by the fall of the critical fields of magnetization reversal under tension and their growth under compression. The saturation remanence of interacting nanoparticles changes in a similar way, due to the mechanical stresses. At the same time, the saturation remanence I_{rs} of non-interacting nanoparticles is independent on the stresses. Also note that the hysteresis characteristics of an ensemble of interacting nanoparticles under tension vary stronger than in compression. This behavior of H_c and I_{rs} is connected to the fact that the magnetostatic interaction stronger shuffles the magnetic moments of low-coercive nanoparticles, and has a smaller influence on the particles in the high-coercive states.

Effect of mechanical stresses on the coercive force of the system of heterophase non-interacting nanoparticles

Afremov, L.L., and Kirienko, Yu.V. (Far-Eastern Federal University, Vladivostok, Russia)

The effect of mechanical stresses on the magnetic properties was studied in the framework of the model of dual-phase nanoparticles of γ -Fe₂O₃ epitaxially coated with cobalt ferrite CoFe₂O₄. It was found that stretching shifts of the magnetization curves towards the area of lesser magnetic fields H . Compression leads to the opposite effect. In this case the saturation magnetization stays independent on the mechanical stresses and is defined only by the thickness of the cobalt coating.

Coercivity H_c depends not only on stress but also on the magnitude of the exchange interaction through the interface A_{in} and on the relative amount of cobalt coating. Negative exchange interaction leads to a decrease in the coercive force $\sim H_c$ as compared with $A_{in} = 0$, and positive – to its increasing.

These results are determined by the dependence of the critical fields of magnetization reversal on the stresses: stretching decreases the critical fields of magnetization reversal and compression increases it, and the coercivity of the particles changes consequently.

Microscopy and rock magnetism of fine grain-size titanomagnetite from the Jacupiranga Alkaline Complex, Brazil: unearthing Ti-magnesioferrite nanoparticles

Alva-Valdivia, Luis M., and Rivas-Sánchez, María L. (Laboratorio de Paleomagnetismo, Instituto de Geofísica, Universidad Nacional Autónoma de México, Ciudad Universitaria 04510 México DF, Mexico)

Very fine samples from the mineralized zones of the Jacupiranga complex at the Cajatí mine were selected for crystallographic identification of Ti-magnesioferrite (TMf) nanostructures embedded in titanomagnetite (TM) using high-resolution transmission electron microscopy (TEM). A magnetic concentrate obtained of pyroxenite samples (sites 4 to 7) was reduced and divided into fractions of distinct

range sizes: $26 \pm 2 \mu\text{m}$, $19 \pm 1 \mu\text{m}$, $13 \pm 1 \mu\text{m}$, $9 \pm 1 \mu\text{m}$, $6 \pm 1 \mu\text{m}$ and $6-0.1 \mu\text{m}$. The mineralized samples of carbonatite and pyroxenite were characterized by X-ray diffraction, transmitted and reflected light microscope, and scanning electron microscope with multielemental analysis. The finest magnetic concentrate sample (MC₆) was analyzed under high-resolution transmitted electron microscopy (TEM) and high angle annular dark field and Raman spectroscopy.

Magnetic properties were measured for the distinct granulometric fractions, showing drastic changes when grain sizes go beyond the frontier from micro to nanometer sizes. Frequency-dependent magnetic susceptibility percentage ($X_{fd}\%$) report higher values (10.2%) for the finer fractions ($6 \pm 1 \mu\text{m}$ and $6-0.1 \mu\text{m}$) attributed to dominant fractions of superparamagnetic particles. Nanometer and $< 6 \mu\text{m}$ grain size TMf in TM particles require a magnetic field up to 249 mT to reach saturation during the isothermal remanent magnetization experiment. Coercivity and remanent magnetization of these samples increase when the particle size decreases, probably due to parallel coupling effects. Two magnetic susceptibility versus temperature experiments conducted on the same ($< 35 \text{ nm}$) sample showed that the reversibility during the second heating is probably due to the formation of new TMf nanoparticles and growth of those already present during the first heating process.

Anisotropy of magnetic susceptibility (AMS) and features of formation of Lower Cretaceous rocks of the Mountains Crimean

Bagaeva, M.I. (Saratov State University, Saratov, Russia)

Many measurements of the Anisotropy Magnetic Susceptibility (AMS) of the upper Tithonian, Berriasian and Lower Valanginian Mountain Crimea were made in 2009–2012 years by geologists of Petrophysics laboratory of the Saratov State University. It was researched more 2000 samples from 11 key sections (thickness $\sim 650 \text{ m}$): Ordzhonikidze village (J3km2-t1), Dvuyakornaya bay (J3t2 - K1b1), St. Ilya cape (K1b1), Feodosiya cape (K1b1), Zavodskaya balka (K1b3), Sultanovka village (K1b-v1) (Feodosia region), Tonas, Kuchuk-Uzen rivers (J3t2 - K1b1) (East Crimea), Balki, Novoklenovo, Mezgor'e villages (K1b2-3) (Central Crimea). Tithonian and lower Berriasian represent flyshoid alternation clays and limestones, middle Berri-

asian and Valanginian – mainly clays. Stereograms of the magnetic anisotropy conforming of the Tithonian – lower Berriasian, demonstrate a tendency to orientation of the long axes magnetic ellipsoids in NW-SE direction for Feodosia sections and SW-NE for sections of the river Tonas region. This regularity, stronger, develops in the clays. Upper Berriasian have the clear orientation long axes in NW-SE direction for the East Crimea and W-E for the Central Crimea. Research results of the AMS lets receive new information about the conditions of rocks formation. The main factors contributing to these magnetic textures were tectonic deformation and associated plastic deformation under semi-liquid sludge. It is possible that AMS data can be used for paleotectonic reconstructions. This work was supported by RFBR (project 11-05-00405-a)

Paleomagnetism of the late Ediacaran sediments from easternmost Baltica

Bazhenov M.L., Levashova N.M. (Geological Institute RAS, Moscow, Russia), Golovanova I.V., Danukalov K.N., Sergeeva N.D. (Institute of Geology USC RAS, Ufa, Russia), Kuznetsov N.B. (Geological Institute RAS, Moscow, Russia), Meert J.G. (Department of Geological Sciences, Gainesville, USA), Fedorova N.M. (Geological Institute RAS, Moscow, Russia), Kadyrov A.F., Khidiyatov M.M., and Salmanova R. Yu (Institute of Geology USC RAS, Ufa, Russia)

Ediacaran paleomagnetic data are very controversial, especially for Laurentia and Baltica. Ediacaran (~Vendian) rocks have been studied from several localities from Baltica, but the so far published poles may place the craton from the geographic pole to the equator at any orientation. At the same time, it is too important and interesting to understand what the Ediacaran world looked in fact. Therefore, more and more attempts are being made in different countries to obtain reliable paleomagnetic evidences for Ediacaran epoch. In our presentation we'll present the new data from late Ediacaran sediments from the deformed peri-Uralian margin of Baltica, where the rocks of this age are widespread and non-metamorphosed. The uppermost member of Asha series, Zigan Fm was studied. New data obtained recently supplement considerably the preliminary results reported before. The rocks were sampled at four localities spread over more than 100 km. Totally, more than 350 samples were collected. We successfully iso-

lated a dual-polarity high-temperature component from thirty seven sites; the primary origin of this remanence is strongly indicated by the positive reversal test (class B). The corresponding new pole is in close agreement with the coeval results from the Winter Coast of northern Baltica [Popov et al., 2002; 2005; Iglesia Llanos et al., 2005], despite about 1600 km separation between two study areas. These data jointly indicate a very low ($< 10^\circ$, N or S) paleolatitudes of eastern Baltica in Ediacaran time. Several lines of evidence convincingly indicate that no inclination shallowing affected paleomagnetic directions. As deformation of the westernmost tectonic units of the Ural fold belt took place in mid-Permian (Kungurian) time, the late Paleozoic remanence is a useful tool to evaluate rotations between these units and Baltica and to access whether the Ediacaran data from the western Urals can be expanded over the entire craton. Hence a study directed to isolation of such remanence was carried out, and its results will be presented. Paleogeographic implications of the new datum will be discussed too. This study is supported by RFBR grants 11-05-00037 and 11-05-00137.

Genetic algorithms for selection of gravity and magnetic anomalies

Belashev, B.Z. (Institute of Geology, Karelian Research Centre RAS, Petrozavodsk, Russia)

The methods for solving of gravimetry and magnetometry inverse problems are improving in the direction of increasing the reliability of the results and the speed of the computation. In this paper, the anomalies of gravity and magnetic fields were selected using genetic algorithms. Genetic algorithms are referred to stochastic methods of the functions optimization. Global minimum of a function provided by genetic algorithm can often be considered as the unique solution of the inverse problem. The advantages of genetic algorithms are fast convergence and taking into account the constraints of the task. Their flaws are related to the low accuracy of extrema determination and biological terminology impeded for understanding. Computer's mathematics system "MATLAB" and its freeware analogs have the versions of genetic algorithms which can solve various theoretical and applied problems.

The software based on these version had been developed for the di-

vision blurred contours and area distributions on the components of the set of forms and obtain estimates of the spatial distributions of density. Based on these versions of software are developed and implemented algorithms for division blurriness and of the components of the set of forms and obtain the estimates of the density spatial distributions. After testing on simulated examples these algorithms were applied to gravimetric profile Kem-Kalevala and to other published data.

The results of treatment and comparison indicate on the need of detailed testing of this method on the reference data and the development of special high-speed versions of genetic algorithms.

Spin-glass state in nanoparticles with the RKKY interaction

Belokon, V.I., Dyachenko, O.I., and Nefedev, K.V. (Department of theoretical and experimental physics, The School of Natural Sciences, Far Eastern Federal University, Vladivostok, Russia)

In this paper the approximation of the molecular field theory was used with taking into account the Ruderman- Kittel- Kasuya- Yosida (RKKY) interaction. We considered possible magnetic states of the system of the magnetic spherical nanoparticles which ones embedded in a non-ferromagnetic matrix. Estimation of the possibility of establishing the ferromagnetic or the antiferromagnetic ordering, as well as the spin-glass state is based on the relationship between the parameters of the partition function of random exchange fields. Type of ordering depends on the ratio of the mathematical expectation and the dispersion, which ones are in connection and determined by the law of interaction. The RKKY interaction of the magnetic moments of the spherical particles obeys the law of interaction of the spins with the effective magnetic moments depending on the particle radius. The research had shown that:

1. Ferromagnetic or antiferromagnetic spin-glass state can occur as a result of the interaction of individual atoms, randomly distributed in the volume, depending on the concentration of free electrons.
2. Ferromagnetic ordering is possible at very high concentration of free electrons and a high concentration of ferromagnetic atoms.
3. The union of ferromagnetic atoms in the nanoparticles, which is possible due to diffusion at low concentrations, leads to a system of

randomly distributed nanoparticles with the RKKY interaction. It is shown that only the spin-glass state in such system is possible at a temperature which is lower than in the case of randomly distributed atoms.

Magnetic properties of sedimentary greigite

Bol'shakov, V.A. (M.V. Lomonosov Moscow State University, Moscow, Russia), and Dolotov, A.V. (GO "Borok" Institute of the Earth Physics RAS, Borok, Yaroslavl region, Russia)

The authors carried out multidisciplinary magnetic and X-ray phase investigations of five magnetic extracts sampled from different layers of a 60-m sediment core of the Late Pleistocene in the Northern Caspian, which are characterized by increased values of magnetic susceptibility. According to our investigations the Curie temperature (T_c) of natural greigite should not be lower than 463°C , which contradicts the generally accepted concepts about the lower (approximately 330°C) T_c . The saturation magnetization (I_s) of greigite is about half I_s of magnetite.

This work is supported by RFBR, grant N 11-05-00147-a.

Structure of the lowermost mantle and secular variation of the main geomagnetic field

Demina, I.M., and Soldatov, V.A. (SPbF IZMIRAN, St. Petersburg, Russia)

To date, several models of the lowermost mantle structure are compiled down to the boundary with a liquid core. Although these models differ in many ways, it is possible to identify a number of features which are reflected in all models. In particular, this applies to oceanic lithosphere subduction. Under the assumption of structured flows in the liquid core, which determine the non-dipole part of the main geomagnetic field, we constructed a model of its sources. These sources have been continually evolving for the last 110 years. This model allows us to consider the path of each individual source and to identify both the similarities and the peculiarities. First, we examined the movement of the source, which was located at the core-mantle

boundary under the Caribbean. Comparison of the its path to the structure of the core-mantle boundary suggests that the remains of the Farallon plate, which subduction started more than 100 million years ago, not only reach the core-mantle boundary, but also sink into the core to 200–300 km, km disturbing the circulation of the liquid core material. Under this hypothesis, the path of the main dipole is considered.

The shift of Earth's geomagnetic poles and climate variations

Dergachev, V.A., Vasiliev, S.S. (Ioffe Physical-Technical Institute of RAS, St.Petersburg, Russia), and Raspopov, O.M. (SPbF IZMIRAN, St.Petersburg, Russia)

On a basis of palaeomagnetic data the analysis of the shift of the Earth's northern magnetic pole position and change of its shift rate over the last 10 thousand years was carried out. Palaeomagnetic data obtained from sediments in 30 lakes, which contain the information on a direction and intensity of the Earth's geomagnetic field in the past, have been used in this work. The empirical mode decomposition (EMD-method) of the data on the change of geomagnetic pole position was performed. The main purpose of this method is decomposition of the initial data set by orthogonal components. It is shown that both latitude and longitude changed in time not stochastically, but has regular cyclic components. Change of the western drift rate of the geomagnetic pole was investigated. In order to establish a connection between climate change and rate of the geomagnetic pole shift analysis of the correlation between accumulation rate of ice in Greenland and the change of the geomagnetic poles position was performed. Evident correlation between these data was found. The link between changes of geomagnetic pole position and climate variations over the different time scales was investigated.

Paleomagnetism of the Silurian-Devonian sediments of the eastern slope of the Polar Urals

Dvorova, A.V., and Kuznetsov, N.B. (Geological Institute RAS, Moscow, Russia)

We studied Silurian-Devonian sedimentary rocks (80 samples at 12 sites) of the eastern slope of the Polar Urals (66.8°N, 66.5°E). Natural remanent magnetization intensities of the rocks range from 0.3 to 9 mA/m. Thermal demagnetization revealed that the different studied samples retained two different characteristic components. One component stands out mainly in the temperature range $T=300-430^{\circ}$ C ($D= 144.8^{\circ}$, $Inc= 2.4^{\circ}$, $k= 22.9$, $\alpha_{95}= 4.8^{\circ}$ N = 40 samples); the fold test is positive, another - mainly in the temperature range $T=200-380^{\circ}$ C ($D= 225.9^{\circ}$, $Inc= -50.9^{\circ}$, $k= 10.4$, $\alpha_{95}= 12.0^{\circ}$ N = 16 samples); the fold test is negative. This component most likely is the result of the Late Paleozoic remagnetization of the rocks. At present we can conclude with confidence that the studied rocks at the time of acquisition of the prefolding magnetization were in equatorial latitudes.

Paleomagnetic constraints of the geometry of geomagnetic reversals and excursions

Fabian, K., Leonhardt, R., Oda, H. (Geological Survey of Norway, Trondheim, Norway)

Reconstructing the geometry of the geomagnetic field during excursions or reversals from paleomagnetic data is an important aim for understanding the workings of the geodynamo. A simple, stable, and reliable inverse modeling of the higher order spherical harmonic expansion is recommended over the classical representation by virtual geomagnetic poles, which implicitly assumes that a dipolar field is present during the reversal or excursion. The very nature of paleomagnetic data poses a series of problems for the reconstruction task. Paleomagnetic data typically have badly defined intensities, and even worse temporal constraints. Both informations are essential for a good reconstruction quality. Especially difficult is the alignment of records from different regions and recording media. In sediments, the sedimentation rate must be high enough, such that each

paleomagnetic data points represents a sufficiently small time interval. Sedimentary remanence acquisition can also lead to smoothing and delay of the paleomagnetic signal with respect to the true sediment age, which is defined as the time when the sediment layer was deposited at the sea floor. The sedimentary relative paleointensity varies not only with external field, but also with magnetite concentration, grain size and general sediment composition. Volcanic records result from sporadic eruptions and have very irregular temporal distribution, which is difficult to reconstruct by independent dating. Paleointensity determination is a major problem in most igneous rocks. These problems will be discussed, and a new approach for combining these inhomogenous data sources into a realistic inversion method will be proposed.

Magnetostratigraphy of the northern Siberian Traps: Noril'sk and Maymecha-Kotuy provinces

Fetisova, A.M., Veselovskiy, R.V., Latyshev A.V. (Moscow State University, Moscow, Russia), and Pavlov, V.E. (IPE RAS, Moscow, Russia)

The Siberian traps form one of the largest igneous provinces on the Earth. In accordance to the recent studies the large-scale and voluminous volcanic event which formed the Siberian traps, continued for a million year close to the Permian-Triassic boundary (251 Ma) and was essentially coincident with the end-Permian extinction event, which is estimated to have killed 90% of species. Disastrous effects of trap volcanism depend on its duration and volume of erupted material. These characteristics can be obtained from the correlation of most complete trap cross-sections, such as outcrops of Noril'sk and Maymecha-Kotuy provinces of the Siberian traps. But some of existent correlation schemes, based mostly on geochemical, paleomagnetic and modest paleontological data, allow considerable variations of the total traps thickness (from 3.5 km to 6.0 km). It should be noted that paleomagnetic (magnetostratigraphic) studies of the Maymecha-Kotuy region traps were made more than 40 years ago (in contrast to Noril'sk region) and must be confirmed by studies on the modern level. In this work we present the results of magnetostratigraphic researches of the traps cross-section of the Maymecha-Kotuy province. We propose new variant of the correlation scheme of the

Northern Siberian traps which is based on more than 3000 oriented samples.

Vertical variation of testing Thellier paleointensities from a recent lava flow in Japan

Fukuma, K., and Yoshimi, A. (Doshisha University, Kyotanabe, 610-0394 Japan)

During the past decade a number of techniques have been proposed to obtain reliable paleointensities from volcanic rocks. Testing paleointensity measurements on a recent lava flow with a known geomagnetic field intensity are indispensable. We report paleointensity results by applying the Coe-version Thellier paleointensity technique to a vertical section of the Izu-Oshima 1986c lava flow in Japan. Mochizuki et al. (2004) studied at the same site using both the Thellier and LTD-DHT Shaw methods after confirming negligibly small local magnetic anomalies around the site. They claimed that the Thellier method yields higher intensity values but LTD-DHT Shaw method can give correct values.

We collected samples from the 2.7 m thick section constituting an upper clinker, a central vesicular part and a lower clinker in its vertical order. Thermomagnetic analyses revealed that the magnetic phase with high Curie temperature (T_c) above 450 deg.C is ubiquitously present in almost all samples and a low T_c (~ 300 deg.C) phase co-exists in samples from the central part. The hysteresis properties showed that most data fall on the pseudo-single-domain region on a Day plot, whereas the lower clinker samples have single-domain-like characteristics. During Thellier paleointensity experiments with pTRM checks, none of the samples from the central part exhibited linear segments on Arai diagrams. On the other hand, samples from the lower clinker provided linear segments on the Arai diagrams and yielded paleointensities close to the expected value of 45.5 microT at the eruption time.

Our testing paleointensity measurements showed that behaviors during Thellier experiments are variable even in a single lava flow. Lower clinker samples provide reliable paleointensities carried by single-domain-like low-Ti titanomagnetites. We do not necessarily need unconventional new technique any more. Careful sampling and screening are much more important for obtaining reliable paleointensities.

Cosmic iron in sedimentary rocks

Gilmanova, D.M., Nourgaliev, D.K., (Kazan (Volga Region) Federal University, Kazan, Russia), and Pechersky, D.M. (Institute of Physics of the Earth, Russian Academy of Sciences, Moscow, Russia)

The study of an iron content in sedimentary rocks is an actual problem of modern science. In contrast to the numerous works written about the continental deposits, these studies are devoted to the study of ocean sediments. We have done thermomagnetic analysis (TMA) of samples of sediments from the DSDP wells N 386, 387, 391A and 391S (Atlantic Ocean). Samples were selected from four wells' cores drilled in 1977 and 1978 in the northwest Atlantic Ocean. The well N 386 was drilled to a depth of 973.8 m in the central uplift of Bermuda. The Well N 387 was drilled to a depth of 791.6 m in the western Bermuda's uplift. There were selected 61 samples. Well N 391A and N 391C were drilled in the Blake Bahamas' abyssal basin. There were selected 83 and 145 samples respectively. TMA was carried out in the paleomagnetic laboratory of the Institute of Geology and Petroleum Technology, Kazan Federal University with special device called Curie express weighing-machine. This process included the measurement of the samples' specific magnetization (M₂₀) as a function of temperature. The rate of heating was 100%/min. The measurements made in a constant magnetic field — 500 mT. We have got thermomagnetic curves of the first and second heating up to 800°C for all samples, which allow us to determine the Curie point of samples' magnetic minerals. As a result of thermomagnetic analysis all samples with iron were divided into three groups. The first group is a pure iron without admixture. The second group is a native iron with an average nickel content of 5–6% impurities. And the third is a Fe–Ni alloy containing 20% Ni up to pure nickel.

Paleomagnetic characteristic of upper Cretaceous and boundary Cretaceous-Paleogene deposits of borehole 10 Russko-Polyanskii region (South of Western Siberia)

Gnibidenko, Z.N., and Lebedeva, N.K. (Trofimuk Petroleum Institute Geology and Geophysics SB RAS, Novosibirsk, Russia)

The complex paleomagnetic and paleontological investigation of Upper Cretaceous and boundary Cretaceous-Paleogene deposits a bore-

hole 10 on south of Western Siberia has been performed. In 2010 year in the same area authors had been studied the borehole 8. Cretaceous deposits of the borehole 10 are represented by Pokurskaya, Kuznetsovskaya, Ipatovskaya, Slavgorod, and Gan'kinskaya suites. The age of deposits has been determined on dinocysts and palynocomplexes. According to these biostratigraphic data deposits of the borehole 10 were formed in time interval from Cenomanian to Maastrichtian. The upper part of Pokurskaya suite is characterized Cenomanian palynocomplex. The Slavgorod suite according to paleontological data has Campanian, and Gankinskaya – Campanian-Maastrichtian age.

For paleomagnetic researches 186 oriented samples–cubes have been selected. Component analysis of natural remanent magnetization of rocks has allowed choosing the characteristic component of remanent magnetization. On the basis of this component magnetic polarity of all five suites of Cretaceous is defined. Magnetostratigraphic section of these deposits is developed. Pokurskaya, Kuznetsovskaya and Ipatovskaya suites (Cenomanian, Turonian, Coniacian, Santonian) have normal polarity with two horizons of reversal magnetization and form one long magnetozone normal polarity. Slavgorod and Gan'kinskaya suites (Campanian-Maastrichtian) have reversal polarity with one horizon of normal magnetization. Then magnetostratigraphic section of Cretaceous deposits of the borehole 10 is compared with world magnetostratigraphic scale of Gradstein. Comparison magnetostratigraphic sections of the boreholes 8 and 10 shows essentially more longer interruption on boundary Cretaceous-Paleogene in the borehole 10 than in the borehole 8, covering Upper Maastrichtian-Early Selandian – chrons C30, C29, C28, C27, C26 in a time interval of 68,5–66 Ma.

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On the stability of goethite under Earth surface conditions

Gribov, S.K., and Dolotov, A.V. (Borok Geophysical Observatory, Institute of Physics of the Earth RAS, Borok, Yaroslavl region, Russia)

The kinetics of the dehydroxylation reaction of natural goethite fractions was studied in air under isothermal conditions using the thermogravimetric method by measuring the loss in weight of the sample

during the 24-hour exposure at a given temperature in the range of 200 – 270°C (with an interval of 5 – 10°C) and the method of continuous *in situ* measurement of changes in saturation magnetization J_S during 312 hours in a constant magnetic field of 0.65 Tesla in the temperature range of 183 – 273°C (with an interval of 4 – 25°C). The results of the both methods are in good agreement with each other: the calculated values of effective activation energy of the phase transition from goethite (α -FeOOH) to hematite (α -Fe₂O₃) amounted to ~205 and ~201 kJ/mol, respectively. Temporal extrapolation of magnetometric curves to the J_S values, corresponding to the total transition α -FeOOH \rightarrow α -Fe₂O₃, allowed to estimate the time t^* , necessary to complete the phase transformation in the investigated temperature range $T = 198 - 273^\circ\text{C}$. The linearity of the experimentally obtained dependence of $\ln(t^*)$ vs. $1/T$ gives the possibility of its extrapolation to lower temperatures, i.e. allows us to enter the times moments which are not available for laboratory research. As it turned out, in natural conditions the total spontaneous hematization of studied goethite fractions can be implemented for the period of ~1 or ~10 million years only in the case of a regional heating of the rock to temperatures of ~85 and ~73°C, respectively. In paleomagnetic perspective it means that in ancient goethite-bearing sedimentary rocks the fixation of natural remanent magnetization *NRM* may be due to the effects of repeated blocking of the magnetization processes associated with long-term (tens of millions of years) implementation of the dehydration reaction $2\alpha\text{-FeOOH} \rightarrow \alpha\text{-Fe}_2\text{O}_3 + \text{H}_2\text{O}$ in the Earth's surface. In other words, in this case the process of spontaneous dehydration of goethite to hematite may play a definite role in the formation of secondary *NRM* components of different ages in the hypergenesis zone.

Lower Jaramillo reversal and secular variations with characteristic times 3–60 Ky

Gurary, G.Z. (Geological Institute RAS, Moscow, Russia)

Geomagnetic field variations during Matuyama and Jaramillo chrons and the Early Jaramillo reversal were studied by using wavelet analysis. Total duration of the studied interval -180 thousand years. It is shown that the distribution of variations with characteristic times less than 15 thousand years were stochastic; two fluctuations with

characteristic time 18–25 and 50–60 thousand years were confidently present in the field during the all studied interval. The time of the reversal is characterized by strong fluctuations with characteristic times 3–7 thousand years and by significant increase in power of the two low-frequency variations in the interval of the characteristic time 20–25 and 50–55 thousand years.

Geomagnetic field behavior in the past as derived from palaeomagnetic investigations of sediments of archaeological paleolithic sites

Guskova, E.G., Raspopov, O.M. (SPbF IZMIRAN, St.Petersburg, Russia), Dergachev, V.A. (Ioffe Physico-Technical Institute of RAS, St.Petersburg, Russia), Iosifidi, A.G. (All-Russian Petroleum Research Exploration Institute – VNIGRI, St.Petersburg, Russia), and Sinitsyn, A.A. (Institute of History of the Material Culture, St.Petersburg, Russia)

Palaeomagnetic studies of sediments of two paleolithic sites Kostenki 14 (Markina Gora) and Kostenki 16 (Uglyanka) situated at a distance of 500 meters from each other in Voronezhskaya region (Russia) have been carried out. Magnetic characteristics of the samples were measured in the Laboratory for Magnetostratigraphy and Palaeomagnetic Reconstructions of VNIGRI. The palaeomagnetic studies of 53 samples of the Kostenki 14 site (Markina Gora) and 35 samples of the Kostenki 16 site (Uglyanka) have revealed the geomagnetic field Kargopolovo and Mono excursions in both cases, which allows us to date the sediments of each of the paleolithic sites as about 42000–24000 years BP.

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Magnetostratigraphy of Jurassic–Cretaceous boundary of Mountains Crimea

Guzhikov, A.Yu., and Bagaeva, M.I. (Saratov State University, Saratov, Russia)

Magnetostratigraphic characteristic of Jurassic–Cretaceous boundary of Mountains Crimea is based on results of investigations of complete

sequence of Upper Tithonian – Lower Berriasian (Jacobi zone) in summary section “Dvuyakornaya bay – St. Iliya cape – Feodosiya cape” (Feodosiya town). Alternation of seven subzones (four normal and three reverse polarity) characterizes this section. This subzones are correlated with succession of M20r, M19n, M19r, M18b chrons and M18n.1r Subchron (“Brodno”).

Location of Jurassic-Cretaceous boundary in Tethian sections is based on ammonites (base of Jacobi zone) and calpionellids (base of Calpionella zone). By analogy, J/K boundary location in Feodosiya section must be inside lower part of M19n (between top of M19r and base M19n.1r) in accordance with results of magnetostratigraphic correlation. Base of M19n.1r is recommended as a paleomagnetic criterion for determining boundary of the Jurassic-Cretaceous. If “Brodno” will not be detected, then the top of M19r (the closest level to the boundary of Durangites – Jacobi ammonite zones in the key section Puerto Escano) or base of M18r could be used for detecting of J/K boundary.

The Polar Urals and Pay-Khoy in the Late Permian time — palaeomagnetic reconstruction

Iosifidi, A.G., and Khramov, A.N. (All-Russia Petroleum Research Exploration Institute (VNIGRI), St. Petersburg, Russia)

Collection of Palaeozoic rocks sampled from eleven outcrops on the r. Kozim of the Polar Ural have been studied. It is ascertainment that pre-Permian Paleozoic sediments of the r. Kozhim remagnetized during hyperchron Kiama (C_2-P_2) probably due to magnetic viscosity processes blocked when these sediments leaves the relatively high temperature zone during the last stage of the East-European plate — Ural. Thrust faults having place on this stage have conditioned the differences between palaeomagnetic directions on studied structure from that extrapolated from the Russian platform. The available estimations of the age of remagnetization and isotopic rejuvenation has allowed to refer the time of late Paleozoic activations on Ural to boundary of the early and middle Permian [Kuznetsov et al., 2000], i. e. inside the hyperchron Kiama that has provided rock's remagnetization by geomagnetic field of reverse polarity. Hence for comparison new data with data on Russian platform is counted average palaeomagnetic pole for Russian platform on available palaeomag-

netic data for interval 290–260 Ma, which appears $N=12$, $\Phi = 44^\circ N$, $\Lambda = 167^\circ E$, $A_{95} = 2^\circ$. The estimation of horizontal rotation angles for studied structures of r. Kozhim relative the Russian platform was produced using methods, described in (Iosifidi, Khramov, 2002). The interval of horizontal rotation angles for studied structures is $13 - 36^\circ$. Analysis of the inferred and published data on the Pai-Khoi Ridge and Polar Urals showed that horizontal rotation angles of these tectonic structures differ in sign. Early Permian Pai-Khoi structures experienced horizontal counterclockwise rotations through $10-20^\circ$ relative to the Russian platform. Early Permian and Paleozoic (remagnetized) structures of the Polar Urals experienced horizontal clockwise rotations through angles of up to 45° relative to the Russian platform. Analysis available paleomagnetic data for Pai-Khoi and Polar Urals have allowed to estimate the amplitudes of P–T thrusts. They appear at the average 260 and 180 km for structures Pai-Khoi and Polar Urals, accordingly. A reconstruction of the pre thrust fault initial palaeogeographic position of the Pai-Khoi and Polar Urals structures is given.

Cramer-Rao bound in detection of reversals

Ivanov, S.A., and Merkuryev, S.A. (Institute of Terrestrial Magnetism, Ionosphere and Radiowave Propagation RAS, St. Petersburg, Russia)

We use statistical tools, exactly so-called Cramer-Rao bound, to determine ability of detection close magnetic reversal near a spreading ridge.

Magnetic mineralogy of Lower Paleozoic metabasites and granulites from the Orlica-Snieznik Massif (Sudetes, SW Poland)

Kądziałko-Hofmokr, M., Werner, T. (Institute of Geophysics, Polish Academy of Sciences, Poland), Szczepański, J. (Institute of Geological Sciences, University of Wrocław, Wrocław, Poland), Nejbert, K. (Institute of Geochemistry, Mineralogy and Petrology, Warsaw University, Wrocław), Teisseyre-Jeleńska, M., and Gendler, T.S. (Institute of the Physics of the Earth RAS, Moscow, Russia)

The Orlica-Snieznik Dome (OSD), situated at the eastern part of the Bohemian Massif, belongs to the European Variscan Belt. The Dome is divided by the Nysa Kłodzka graben into two parts: eastern Śnieznik Massif (SM) and western Orlica Massif (OBM). Both are built mainly of orthogneisses derived from protholith dated at about 500Ma intercalated by the supracrustal Stronie-Młynowiec formation. The latter comprises metasedimentary sequence composed mainly of paragneisses and micaschists intercalated with lenses of metabasites: amphibolites and eclogites as well as granulites in the SM and amphibolites as well as metagabbros in the OBM. Thermomagnetic investigations shown that in eclogites and majority of studied amphibolites from SM the prevailing mineral is ferrimagnetic pyrrhotite accompanied by small amounts of Fe - oxides (magnetite/maghemite, hematite). Fe-oxides prevail only in amphibolites from one locality and in granulites. In the amphibolites from the OBM ferrimagnetic pyrrhotite is seen only in very small amounts; prevailing magnetic minerals are magnetite and hematite. Hysteresis study presented in the form of the Day diagram showed that observed magnetic minerals occur as SD, PSD and MD grains. This result suggested presence of several generations of magnetic minerals of the same kind. The above idea became proved by microscopic study of ore minerals. The study revealed scheme of succession of growth of these minerals during metamorphic history of the OSD and let to estimate temperatures of the successive alteration stages. These temperatures remain in general agreement with temperatures of documented tectonometamorphic events that took place in the studied area. The succession scheme suggests that amphibolites from the OBM which lack ferrimagnetic pyrrhotite passed through much more intensive low temperature hydrothermal changes than the metabasites from the SM.

To the gravimetric and magnetometric methods of determinations of the landslide bodies' geometric characteristics

Karimov, F.H. (Institute of Geology, Earthquake Engineering and Seismology AS RTajikistan, Tajikistan)

This paper deals with methods of high-precision gravity and magneto prospecting for the quantity determinations of sizes of landslide bodies on the example of the spherical segment shaped body with a given radius and height in a general form. Taking into account the physical properties of the landslide body and embedding rocks for the calculation of gravity and the local geomagnetic fields' anomalies generated by landslide bodies under consideration, the well-known method of fictitious insertion body, having the shape of the landslide body, but with the physical properties of the embedding rocks, has been used. Then the geophysical anomalies can be represented as the fields produced by bodies that make up the field of inserted bodies. Analytical expressions for the gravitational fields produced by a homogeneous spherical segment are well known. The solution of the gravity problem on determination of the landslide body's size is similar to the task of introducing the corrections for the topography accepted in the gravity measurements. Analytical expressions for the magnetic fields of a uniformly magnetized body having the shapes of a spherical segment are also known. Therefore, by measuring the magnetic fields in the vicinity of the landslide body one can apply the inverse geophysical problem's solution to determine the geometrical dimensions of a body. In the most common practical case for the Tajikistan's territory the landslide body is of sedimentary rocks, which are as a rule weakly magnetic ones. If we consider the glaciers located in the shallow holes, then, of course, one can take into account only the magnetization of the embedded rocks. Therefore, if we neglect the magnetization of the landslide body in comparison with the magnetization with the more dense surrounding rocks, then, since the remanent magnetization of rocks and their magnetic susceptibility are usually no more than 10^{-5} and 10^{-4} SGS units, respectively, one can expect the value of magnetic anomalies generated as much as about 0.1 nT up to 10 nT by the order of magnitude. After conducting the magnetic surveys as well as in the case of gravity prospecting methods' applications the geophysical inverse problems are to be solved for determinations of the landslide bodies' geometry.

A possible magnetic source for Siberian loess-soil realm (Pre-Altai plain)

Kazansky, A.Yu., and Matasova, G.G. (Trofimuk Institute of Petroleum Geology and Geophysics SB RAS, Novosibirsk, Russia)

An attempt to determine a possible magnetic source of Siberian loess and paleosols was made on the base of the magnetic study of loess/palaeosol sections of Upper Pleistocene age. Magnetic susceptibility data were obtained for 22 section and hysteretic data for 15 sections. Magnetic susceptibility pattern in all cases corresponds to the "Siberian" mechanism proposed by the authors. The spatial distribution of rock-magnetic parameters are represented as schematic maps showing a definite behavior quite similar for loess and paleosol horizons. The highest ferromagnetic concentration is observed in the eastern part of the study area on the watershed between Ob and Chumysh rivers, comprising stripe along the foothills of Salair mountains (NNW-SSE). This picture is complicated by additional spot of magnetic enhancement on the bank of the Charysh River. It means that the source of Siberian loess is not uniform. However, magnetic mineral composition in all of the sections is very close - predominantly maghemite-magnetite with minor hematite. In general the concentration of ferromagnetic material along with the effective magnetic grain size decreases in SW direction (along linear relief forms) and so testifies the predominant paleowind direction. Decreasing of coercitivity in the same direction probably reflects an oxidation of magnetite grains during aeolian transport. The decrease of magnetic concentration towards the Ob River allows refusing the hypothesis that river channel deposits served as a source of Siberian loess material. The origin of the linear area of magnetic enhancement is not completely understood. Most likely it is represented by distal facies of catastrophic floods from ice-dammed lakes in Chuya and Ust'-Kan depressions. When the water masses poured out over the Pred-Altai plane from narrow valleys of Katun and Charysh rivers the abrupt drop of the flow velocity caused dramatic fall of coarse-grained magnetite grains along the channel of flood current.

The Earth in the Vendian time — an attempt of the World palaeomagnetic data synthesis for 540–580 Ma interval

Khramov, A.N., and Iosifidi, A.G. (All-Russia Petroleum Research Exploration Institute (VNIGRI), St. Petersburg, Russia)

Later Vendian (Ediacaran) time (580–542 Ma ago) is of extreme significance in Earth history due to cardinal changes in biosphere, climate and palaeogeography (Sokolov, 1985, 2012; Dalziel, 1997) caused by widespread rifting and orogenic activity that accompanied the final stage of supercontinent Rodinia breakup, the opening of new oceans and assembly of the supercontinent Gondwana (Evans, 2003; Murphy et al., 2004). All of these changes may have taken place over a relatively short interval of geologic time, giving rise to speculation about cause and connections among these changes. Calculated according known models of the main plate movement velocities during Ediacaran time are much higher than was typical of Phanerozoic time. However the upper mantle convection was not sufficient to drive large plates at velocities excess of 25 cm/yr (Torsvik et al., 2002), which is not enough for existing models explanation of Late Vendian rapid continental drift. Alternative explanation would be that it resulted from an episode of “bulk tumbling of the Earth” (IITPW) (Kirshvink et al., 1997). The set of these geodynamic reconstructions and hypotheses, based mainly on the palaeomagnetic data, are discussed broadly during the last decade (Murphy et al., 2004; Elming et al., 2007; McCausland et al., 2007). Existing reviews of palaeomagnetic data for Baltica, Laurentia and Gondwana indicates, that none of the APW paths approaches the 90° — length, what is necessary for IITPW — model and that apparent motions are non-synchronous (McCausland et al., 2007) and that their age estimations ought to be shifted from proposed 550–525 Ma interval to older ones. Available for (McCausland et al., 2007) palaeomagnetic data permit to these authors to make palaeogeographic reconstruction for the Vendian-Cambrian transition and to propose on the large APW tracks, Ediacaran True Pole Wandering model, giving an Ediacaran palaeogeography that is similar to that, constructed for the V–C boundary. However, at that stage of investigation major ambiguities were remained, arising from minor data used for Baltica and Siberia, choice of polarity and the poor control on the age of remanence for many of palaeomagnetic results. During the last 5–10 years a set of Vendian Paleomagnetic results for Baltica and Siberia have been appeared (Nawrocki et al., 2004; Iosifidi et al., 2005; Pavlov et al., 2004; Ro-

dionov, Gurevich, 2012). These results being obtained using modern techniques have been passed through high reliability criteria ($Q \geq 5$, $DemCode \geq 3$). On the other hand, for some previous results an evidences of the Phanerozoic magnetic overprints have been obtained; these results are excluded. As a result we have 10 to 15 palaeomagnetic poles for Baltica, Siberia and Laurentia more or less uniformly spreaded along the 580–540 Ma interval for each plate. We use also contemporary results for Armorica and west Africa (Pisarevsky, 2005; Murphy et al., 2002). Analysis of these data demonstrate, that the APW path lengths for each tectonic units are of 70° to 100° length, and their shapes are near great circles. This means driving velocity of 25 cm/y, which is critical high for the upper mantle convection, but too low for the “bulk tumbling of the Earth” (IITPW) mechanism. Hence, the best issue is to accept the TPW model and propose more “soft” mantle conditions in Ediacaran time, than in the Phanerozoic ones. Shape and length similarities of APW tracks for main continental plates permit to make the palaeogeographic reconstructions for any times inside the 580–590 Ma, which are different only by pole positions on stable mutual plate positions. This picture is appeared instead of hypothetical supercontinent Pannotia.

There are some problems remained. The main is the rock and its remanence ages for Siberian data. Very broad ranges of rock ages for many results remains possibility to change age order of poles inside track, another problem issues from the presence of two different stable remanence in the contemporary rocks, which may regarded to secondary magnetization or to frequent changes of the geomagnetic field shape (Pavlov et al., 2004). Remanence polarity choice remains too. These problems, may be, in more less volume, still present for other plates. Nevertheless, we demonstrate here two palaeogeographic reconstruction for 580 and 540 Ma times.

Rock magnetic cyclostratigraphy: a new chronostratigraphic tool for rock magnetists

Kodama, K.P. (Dept of EES, Lehigh University, Bethlehem, USA)

Rock magnetic cyclostratigraphy is a new technique that allows rock magnetic measurements to assign high-resolution time to a stratigraphic section. In its simplest application either ARM or IRM measures magnetic mineral concentration variations that record astrono-

mically-driven global climate cycles. This allows time resolution at the precessional scale, better than magnetostratigraphy even at times of high reversal rate. Many samples can be processed rapidly because the samples do not need to be oriented. Remanence measurements are preferred over susceptibility, since they can be targeted at sub-populations of ferromagnetic grains while susceptibility is a more complicated signal making the climate encoding difficult to interpret.

Three examples of rock magnetic cyclostratigraphy will be presented: The first example is the Cretaceous Cupido Formation, Mexico. ARM intensity variations in these platform carbonates show that magnetite concentrations record short eccentricity, obliquity and precession. These cycles become particularly prominent when sequence stratigraphy boundaries are tied to the long eccentricity cycle. Based on the magnetite's grain size and from SEM observations it is sourced from eolian dust.

The Eocene marine marls of the Arguis Formation from the Pyrenees provide the second example. In this study ARM variations record both short and long eccentricity as well as precession. The magnetic mineralogy is depositional magnetite plus secondary iron sulfides, showing that a rock magnetic cyclostratigraphy is possible even if the depositional magnetic minerals have suffered from reduction diagenesis. Coherency analysis shows that ARM maxima are in phase with precessional insolation during the rainy season. Ferromagnetics are encoding run off variations being driven by precession.

Rock magnetic cyclostratigraphy has been pushed into the Precambrian by a study of the Neoproterozoic Johnnie Formation from Death Valley. Using a rock magnetic measure of the goethite:hematite ratio, a strong 5 m cycle is observed with a superimposed 0.6 m cycle. These cycles are interpreted to be short eccentricity and precession. This interpretation is supported by a magnetostratigraphy that shows 4 polarity zones in the 45 m thick section.

New paleomagnetic data from the Bajocian subvolcanic bodies and sandstones of the Crimean Mountains (preliminary results)

Korneyko, A.A., and Veselovskiy, R.V. (Moscow State University, Moscow, Russia)

We present the results of paleomagnetic investigations of the Karadag formation sandstones and intrusive bodies related to Bodrak subvolcanic complex and exposed in the Bodrak river valley (the Crimean mountains). The age of investigated objects is known from the literature and estimated as the Middle Jurassic, Bajocian stage. Two components of NRM were marked out: a low-temperature component has viscous nature and the modern age, and the most stable characteristic component with high blocking temperatures. In nine of ten investigated magmatic bodies the stable component has a normal magnetic polarity. The average direction of the stable component magnetization of the Koronovskiy's sill has a reverse polarity. The bipolar distribution of the magnetization components can be considered as an indication of the primary nature of the stable components of intrusive bodies and sandstones. Paleomagnetic pole corresponding to the average direction of magnetization of the studied objects in a geographic coordinate system, has been calculated ($N = 8$, $platt = 76.3$, $plong = 102.4$, $dp/dm = 11/13$). This pole lies close to the Late Jurassic-Early Cretaceous poles of the Crimea. Because of coincidence of paleomagnetic directions of the Bajocian sandstones and intrusive bodies of the Bodrak river valley in the geographic coordinate system (in the case of a primary nature of the magnetization components) we suggest that all paleomagnetic directions should be considered in the stratigraphic coordinate system. So, we can assume that studied the Bajocian subvolcanic bodies and sandstones were rotated in the post-Bajocian time. Paleomagnetic pole, corresponding to the mean paleomagnetic directions of studied objects in the stratigraphic coordinate system ($N = 8$, $platt = 50.6$, $plong = 232.2$, $dp/dm = 4/8$), lies close to the expected Mid-Late Jurassic pole of the Crimea, that is in agreement with our suggestion.

Magnetism of bottom sediments of Tatarstan's modern lakes

Kosareva, L.R., Nourgaliev, D.K., Gilmanova, D.M. (Kazan (Volga Region) Federal University, Kazan, Russia)

Direct instrumental observations of the magnetic field help us to get the most accurate information about behavior of the geomagnetic field, but the time of these observations is very limited. In recent years the researchers' interest of studying the paleointensity of the magnetic field of oceanic, marine and lacustrine sediments significantly increased. Paleomagnetic information extracted from lake sediments give us basic information about the Earth's magnetism. Investigations conducted at various sites have shown a cyclical, rhythmic nature of the oscillations of the geomagnetic field, which allows for paleomagnetic dating of sediments. Several lakes located in the Bulgarian settlement of Tatarstan was investigated due to the project "Bolgar". Samples were conducted to determine the magnetization, inclination and declination of the magnetization vector. Also we made thermomagnetic analysis of samples. There were analyzed coercitive spectrums and hysteresis parameters. We got some interesting conclusions from obtaining data:

1. The recordings of declination and inclination have unique features that allow carrying out fine-correlation of bottom sediments.
2. Graphs of the magnetization are in good agreement with each other and it makes possible to compare data of different columns.
3. Preliminary analysis of worldwide data and analysis of their results make possible to estimate the time period of sediments' forming (from 800 to 1200 years).

Magnetostratigraphy of Issyk-Kul depression (preliminary results)

Kozyreva, D.A., and Veselovskiy, R.V. (Moscow State University, Moscow, Russia)

The neotectonic stage of evolution of the Tien Shan Paleozoic folded-thrust system, which is part of the Ural-Okhotsk mobile belt, started in the Oligocene and is associated with the collision of the Indian and Eurasian lithospheric plates. Since that time, within the Tien Shan

mountain relief is a revival and the emergence of large intermountain throughs. This work is part of a multidisciplinary study whose primary purpose is to establish the basic stages of neotectonic development of the Tien Shan and adjacent folded systems. At the same time one of the main objectives of the study is to formulate a magnetostratigraphic sections of the Naryn and Issyk-Kul intermountain troughs of the northern Tien Shan. Here we present the first results of magnetostratigraphic studies of the Oligocene-Miocene sediments of the Issyk-Kul depression.

Oriented samples were selected from the 250-meters interval of the section of red sandstones and siltstones belonging to the Sredneissyk-kul suite of the Oligocene-Miocene age, exposed on the southern shore of Issyk-Kul lake.

Most of the studied samples have paleomagnetic record of excellent quality. As part of the NRM released two components of magnetization: low-temperature (20–180°C), which has a viscous nature and the modern age, and high-temperature (180–650°C) bipolar component, characterized by steep positive (negative) inclinations and N (S) declinations. Since the primary nature of magnetization of rocks Sredneissyk-kul suite is confirmed by the positive conglomerate test, it allows us to suppose the primary age of the most stable components of magnetization isolated in studied samples. Preliminary magnetostratigraphic scale of the studied interval of the section has 7 zones of normal (N) and 7 zones of reverse (R) magnetic polarity.

Geomagnetic field behavior in middle Jurassic–Oligocene

Kurazhkovskii, A.Yu., Kurazhkovskaya, N.A., and Klain, B.I. (Borok Geophysical Observatory of Schmidt Institute of Physics of the Earth RAS, Borok, Yaroslavl, Nekouz, Russia)

The behavior of the geomagnetic field in the range (167–23) Ma is explored. It is shown that in the Cretaceous and in the beginning of Paleogene the intensity of geomagnetic field was relatively high; its values (for the geological epoch) averaged (0.7–0.9) H_0 (H_0 is the value of modern geomagnetic field taken as 40 μT). In addition, during that time the bursts of paleointensity (large amplitude variations of 3 H_0 to 4 H_0) took place. In middle to late Jurassic and at the end of Paleogene the average values of paleointensity were about (0.4–0.5) H_0 and the intensity varied with relatively small amplitude. In the

Jurassic the bursts of paleointensity were revealed only at the end of Bathonian and the end of Tithonian. The distribution of paleointensity values corresponding to various intervals of geological time was analyzed. It is shown that depending on the selected interval of geological time the paleointensity data may be approximated either by power (Cretaceous, beginning of Paleogene) or exponential function (Jurassic, end of Paleogene). Distributions of paleointensity values during bursts and intervals between them are approximated by power and exponential functions, respectively. Performed analysis of paleomagnetic data indicates significant role of the turbulent processes for the generation of geomagnetic field.

Paleomagnetic structure of the Upper Cenozoic sediments of the borehole 8 (West Siberian Plate)

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

The paleomagnetic collection is selected from the Upper Cenozoic of the borehole 8 and consists of 174 cubic samples. The borehole is placed in the south of Omsk depression. The Cenozoic deposits are presented by isilcylskaya, novomihailovskaya, zhuravskaya (Oligocene), abrosimovskaya, besheulskaya, tavolzhanskaya, novostanichnaya (Neogene) and krasnodubrovskaya (Quaternary) suits. Magnetic and paleomagnetic parameters such as magnetic susceptibility, the natural remanent magnetization and magnetic inclination of the vector natural remanent magnetization are measured. The main magnetic minerals are presented by magnetite and gematite. Composition of the natural remanent magnetization is determined by components analyses of the natural remanent magnetization. The curves of the thermodemagnetization and demagnetization by alternative magnetic field are interpreted. The characteristic component of magnetization is defined. Magnetobiostratigraphic section of the Upper Cenozoic sediments of the borehole is constructed. It consists of 11 orthozones which are compared with palinological zones and paleocarpological data. The conclusions about incomplete of the geological section and about availability of erosions at the boundary of Eocene and Lower Oligocene (tavdinskaia and isilculskaia suits), Lower and Upper Oligocene (novomihailovskaia and zhuravskaia suits), Oligocene and Neogene (zhuravskaia and abrosimovskaia suits), are made after

comparison section with the regional magnitostratigraphic scale. It indicates reduction of the edge of part of Omsk depression in compare with its central of part.

Rock-magnetic and age of ash-markers in bottom sediments of the Shirshov ridge (Bering sea)

Malakhov, M.I., Malakhova, G.Yu. (Shilo North-East Interdisciplinary Scientific Research Institute FEB RAS, Magadan, Russia); Gorbarenko, S.A., Derkachev, A.N. (Il'ichev Pacific Oceanological Institute FEB RAS, Vladivostok, Russia); Nekrasov, A.N. (Institute of Experimental Mineralogy RAS, Chernogolovka, Russia); Ponomareva, V.V. (Institute of Volcanology and Seismology, Petropavlovsk-Kamchatsky, Russia); Portnyagin, M.V., van den Bogaard, C., Nurnberg, D., Riethdorf, and J.-R. (Leibniz Institute of Marine Sciences, Kiel, Germany)

This study focuses on eight ash layers in the piston cores SO201-2-77KL, -85KL, and -81KL from Shirshov Ridge, western Bering Sea. Cores were recovered along a ~280 km-long north-south transect from intermediate to deep waters during R/V Sonne cruise SO201-KALMAR Leg 2 in 2009 after extensive hydroacoustic sea-floor mapping. Sediments are characterized as monotonous sequences of mainly clay- and silt-sized siliciclastic material, which are repeatedly interrupted by phases of diatomaceous ooze deposition. Age models of all three cores are based on a combination of different tools including high-resolution (non-destructive) core logging procedures (color b*, XRF scanning), benthic oxygen isotope stratigraphy, and magnetostratigraphy. Absolute age control is provided by accelerator mass spectrometry radiocarbon dating (AMS-14C). Each ash layer is given the name of the district works (Shirshov Ridge - SR): ash SR1 (8.6 kyr), SR2 (11.3 kyr), SR3 (40.1 kyr), SR4 (65 kyr), SR5 (164 kyr), SR6 (171 kyr), SR7 (334 kyr), SR8 (369 kyr). The properties of the ash identification were defined by the curves of thermomagnetic analysis of the induced magnetization in strong and weak magnetic fields (thermal hysteresis of the magnetization). Another identification feature is the set of structure-sensitive magnetic characteristics of the parameters of the domain structure. Pseudo- single domain magnetite and low-Ti titanomagnetite are dominating in a magnetically susceptible material. Electron probe microanalysis of both glass

and of mineral phenocrysts were made as a part of the combined research. It was found that the SR1 is from the Plosky volcano, SR2 - Aleutian arc volcanoes, tephra SR4 formed from Klyuchevskaya group of volcanoes. SR6 - Rauchua tephra from the Chukotka Arctic coast.

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Magnetic tephrostratigraphy of quaternary sediments of the Yamato and Pervenets Rises (Japan sea)

Malakhova, G.Yu., Malakhov, M.I. (Shilo North-East Interdisciplinary Scientific Research Institute FEB RAS, Magadan, Russia); Derkachev, A.N., Gorbarenko, S.A. (Il'ichev Pacific Oceanological Institute FEB RAS, Vladivostok, Russia); Shi, X., Liu, Y., Zou, J., and Chen, J. (First Institute of Oceanography SOA, Qingdao, China)

In this report we present the first results of a study of ash layers in the five gravity cores: LV53-19-1, -20-1, -23-1 (Yamato Rises) and LV53-29-1, -33-1 (Pervenets Rises). Cores LV53 was recovered during Russia R/V Akademik Lavrent'ev cruise LV53 in frame of Russia-China project in 2010. Age models of cores are based on a combination of different tools including high-resolution (non-destructive) core investigation of color- and magnetostratigraphy. The age of the sediment cores were constructed by the color and magnetic susceptibility (MS) correlated with color L* and MS of piston core MD01-2407 (Watanabe et al., 2007). All three cores 19-1, 20-1 and 23-1 contain two ash layers of different capacities: A-Tn (Aira-Tanzawa ash, 29.24 kyr, source volcano Aira, S. Kyushu), and U-Ym (Ulreungdo-Yamato ash, 61-62 kyr, volcano Ulreungdo, Korea). Core 19-1 contain DKP-tephra (Daisen-Kurayoshi ash, 58.8 kyr, source volcano Daisen, W. Honshu). Layer of small capacity, which is identified, probably as a Toyamaoki ash (To, 35.9 kyr, source unknown) is between A-Tn and U-Ym layers of core 23-1. Four layers of volcanic ash eruption of Baegdusan and Aira: B-Tm (Baegdusan-Tomakomai ash, 934-969 AD), B-V (Baegdusan-Vladivostok ash, 18-24 kyr), A -Tn and B-J (Baegdusan-Japan Basin, 48-51.5 kyr) were identified in the cores 29-1 and 33-1. Thermomagnetic curves are characterized by low-Ti titanomagnetite. There are non-magnetic sulfides in the ashes. The parameters of the magnetic hysteresis point to mixture of single-

and pseudo-singledomain ferrimagnetic grains and paramagnetic particles. The authors have made great efforts to reduce the influence of the paramagnetic signal in the construction of Day-plot and identification of ash layers of different age.

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Rock-magnetic mapping on iron-smelting sites in Kurma region (Transbaikalia)

Matasova, G.G. (Trofimuk Institute of Petroleum Geology and Geophysics SB RAS, Russia), Kharinsky, A.V., Snopkov, S.V. (Irkutsk State Technical University, Russia)

The end of the first thousand years BC in Transbaikalia is characterized by a wide distribution iron articles. Most of them are of local made that as it supported by remains of ancient iron works in different places of the area. One of localities where a number of bloomery melting furnaces operated at the same time was situated on the western coast of the Maloe More passage of the Baikal Lake, to the southwest from the river of Kurma (53°12' N; 106°57' E). Now, three ironworking centers with remains of bloomery melting furnaces within this area are recognized, but there is an unresolved question about the type and location of iron ore sources used for iron smelting. There are no any signs of iron ore deposits near Kurma ironworking centers as well as remains of raw material pounding. In Near-Olkhon region there are some types of iron ores, however a part of them are not suitable as raw material due to low concentration of the useful component or/and hard rock. Two sources seem to be the most probable as raw material: i) ironstone (hematite) from the weathering layer and ii) rich-iron (magnetite) deluvium and slope deposits of the foothills Primorsky Mountain Ridge. The deluvium formed under the influence of gravitational slipping and slope washout of products of aeration iron-bearing gneiss and crystalline schist. Magnetite distribution in the ground around the ironworking centers has been studied by field measurements of magnetic susceptibility of the ground surface and than proved by laboratory measurements on ground samples. Highly concentrated magnetite sand in a narrow strip spanning along a transition zone from the slope Primorsky Mountain Ridge to the foothill plain has been recognized as the one of potential sources of raw material concentrate. It contains up to 11% of magnetite (low Ti

titanomagnetite with Curie points 540–560 C) with mean magnetic grain size about 60–70 mk. The magnetic sand doesn't require any additional expenses on preparation of the ore (pounding) and can be used directly after sliming.

Remanent magnetic anomalies: The influence of exsolution lamella and other microstructures in oxides on Q values, and the resulting anomaly

McEnroe, S.A., Fabian, K., Robinson, P. (NGU, Trondheim, Norway), and Shcherbakov, V.P. (Geomagnetic Observatory, Borok, Russia)

Magnetic anomalies on Earth are being measured with increasing accuracy over a wide range of length scales and elevations, from near surface to satellites. Crustal anomalies, which are deviations from Earth's planetary field, reflect the magnetic minerals, the geographic locations where these minerals were magnetized, and the intensity of the planetary magnetic field at the time of magnetization. Anomalies are also influenced by the geometry of the geological bodies, their fabric, the magnetic and mineralogical properties of the rocks, and any subsequent change, such as metamorphism or alteration following initial magnetization. Magnetism of the continental crust is commonly described in terms of bulk ferrimagnetism of crustal minerals, and most anomalies are attributed to induced magnetization.

Remanent magnetization proved crucial for dating the ocean floor, yet the contribution of remanence to continental magnetic anomalies is still underestimated. In the study of the mineral sources of continental anomalies, we have explored the nature of different exsolution intergrowths and microstructures, which enhance the remanent component, either by providing additional magnetizations, such as lamellar magnetism, or by enhancing stability due to fine-scale intergrowths. Here we show that lamellar magnetism is responsible for numerous remanent continental magnetic anomalies. Anomalies may differ depending on whether multi-domain magnetite coexists with one or more lamellar magnetic phases, or whether the rock only contains lamellar magnetic phases. Due to its high thermal and magnetic stability, lamellar magnetism can be an important contributor to deep-seated anomalies on Earth, and to anomalies on other planets, like Mars. Understanding of the fundamental nature and stabil-

ity of magnetic minerals in direct relation to their geological setting will continue to expand in importance with the growing demand for mineral exploration by magnetic methods.

Palaeomagnetism of the Buregi beds stratotyps (Frasnian, Main Devonian Field)

Mihailova, V.A. (All-Russia Petroleum Research Exploration Institute (VNIGRI), St. Petersburg, Russia)

Palaeomagnetic investigations of the Devonian sediments on the Russian platform (upper Devonian, Main Devonian Field) researched early by Komissarova et. al [1970] and Pogarskaya [1984] have been include the lower part of Buregi limestone of the sections on Psizha river. It was established that J_n of these rocks is very low (~ 1 mA/m), being arised mostly in the Late Paleozoic. Laboratory equipment used at that times didn't allow to obtain the significant result. That was the reason to repeat investigations now on the modern technical level.

Magnetic parameters — remanence J_n and susceptibility χ of rocks studied have enough lower values. The χ - T dependence obtained propose the minerals of the titanomagnetite series as a magnetic carrier of rocks studied. This also confirm by unblocking temperature range characteristic components of the J_n (320–550 °C), but in some samples were released hematite.

Investigations of the vector behavior during thermodemagnetization allowed to allocate three magnetization components. A-component (100–250 °C) has Cenozoic direction ($n = 43$; $D_g = 342$; $I_g = 82$; $K_g = 4$; $\alpha_{95} = 11$). Bipolar B-component (260–380 °C) has next directions — B_N : $n = 10$; $D_s = 32$; $I_s = 16$; $K_s = 24$; $\alpha_{95} = 9$ and B_R : $n = 10$; $D_s = 204$; $I_s = -14$; $K_s = 32$; $\alpha_{95} = 8$. For B-component reversal test is positive (class C, $\gamma = 7.8^\circ$, $\gamma_c = 12.1^\circ$). Bipolar D-component (430–650 °C) has next directions — D_N : $n = 10$; $D_s = 78$; $I_s = 14$; $K_s = 597$; $\alpha_{95} = 2$ and D_R : $n = 10$; $D_s = 235$; $I_s = -16$; $K_s = 218$; $\alpha_{95} = 3$. Reversal test for D-component is negative, possibly due to significant differences of the ages of rocks or their D_N - and D_R -components. The influence of the non-dipolar members of the ancient Earth field cannot to be excluded also. As a result of allocated two magnetozones: reverse — normal. Magnetic zonation according D-components for Buregi limestones section studied is in

good agreement with available magnetostratigraphic data combining in general magnetostratigraphic scale for Devonian and confirm the Frashian age of the sedimentary section on Psizha river. Boundary between reverse and normal polarity zones is approximately on 375 Ma. Palaeomagnetic poles obtained ($36^{\circ}N$, $176^{\circ}E$ and $19^{\circ}N$, $140^{\circ}E$) are thought to be of the constructed series of the reference Devonian poles for the Russian platform.

Rockmagnetism of Grand Lake sediment, NE Russia

Minyuk, P.S., Lozhkin, A.V., Subbotnikova, T.V. (North-East Interdisciplinary Scientific Research Institute FEB RAS, Magadan, Russia), and Anderson, P.M. (University of Washington, Seattle, USA)

Grand Lake located in Magadan region ($51^{\circ}53'E$, $60^{\circ}44'N$), belong to group of Elikchan Lakes. Maximum depth of the lake is 23.2 m. 12 cores from deep and shallow parts of the lake were taken by Livingston core system. Sediment records from Grand Lake provide continues archive of climate change during stages (MIS) 4–1. Magnetic susceptibility (MS), saturation magnetization, saturation remanence, coercive force, remanence coercivity, temperature dependence of the induced magnetization and susceptibility of sediment and magnetic extract were analyzed. Scanning electron microscopy (SEM) with energy dispersive X-ray spectroscopy (EDX) used for diagnostic of Fe-bearing minerals. MS from cores used for correlation between the core sections. According to complex data there are four main lithologic units of sediment.

Unit 1 (MIS 1), depth 0–320 cm. Upper subunit (0–150 cm) shows negative or very low MS. Sediment has high content of organic matter and SiO_2 (up to 92%) because of biogenic component. Lower subunit (depth 150–320 cm) consist of laminated organic silt. The MS of this subunit ranges from 0 to 295 (95), 10-6 SI. Sediment shows high content of Fe_2O_3 , P_2O_5 , MnO indicating redox boundary.

Unit 2 (MIS 2), depth 320–627 cm. Sediment composed of laminated silt and formed during anoxic condition. Dark thin layers are enriched with P and Mn. Unit is characterized by low MS = 57-500 (170), 10-6, SI. Vivianite and Fe-sulfides including pyrite and greigite are found in this unite. Greigite occur in diatom valves and as fine grained aggregates and has specific TMA curves.

Unit 3 (MIS 3), depth 627–965 cm. Sediment consist of homogeneous silt and were accumulated during oxic condition. Unit has highest MS in the core section: 87–1300 (480), 10-6 SI and is enriched with CaO, Na₂O, K₂O, SiO₂. Unite 4 (MIS 4), depth-965-1015 cm include sand, dense silt and shows high variations of MS values.

According to SEM, EDX, TMA results detrital magnetic minerals are pseudo-single-domain magnetite, titanomagnetite and titanomaghemite. Most titanomagnetites contain impurities of Al, Si and Mn. Chromium-magnetites and Ilmenite are found also. Supported by grants FEB RAS (12-II-SB-08-024), 12-III-A-08-191, 12-III-V-08-191.

Iron-bearing minerals of El'gygytgyn Lake sediment, Chukotka

Minyuk, P.S., Subbotnikova, T.V. (North-East Interdisciplinary Scientific Research Institute FEB RAS, Magadan, Russia), Nowaczyk, N. (Helmholtz-Zentrum Potsdam, GeoForschungsZentrum, Potsdam, Germany), Brown, L., and Murdock, K. (Department of Geosciences University of Massachusetts, Amherst, USA)

Sedimentary sequence recovered from Lake El'gygytgyn (67 grad.30'N, 172 grad.05'E), represents the longest, up to 3.6 My continuous terrestrial climate record available from the Arctic. Magnetic susceptibility (MS) of lake sediments is a direct proxy-parameter for global climatic variations, with low values representing cold and high values representing warm climates. Detrital and authigenic iron-bearing minerals were studied by optical mineralogy, thermomagnetic data including high temperature dependence of MS and induced magnetization, scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDX). There are few group minerals: oxides, sulphides, phosphates, carbonates. Oxides represents predominately by titanomagnetite contained impurities of Al, Si, Mn. Some titanomagnetite are low temperature oxidized and has specific cracks on grains, other titanomagnetite are high-temperature oxidized with lamellae of ilmenite and titanium magnetite. Chromite, Ilmenite, rutile are typical minerals from this group. Sulphides occur rare in sediments and represents by authigenic pyrite and greigite. Pyrite was found in thin sand layers (turbidities) and has framboidal (up to 10 mkm) structure. Greigite as fine grained aggregates was found only in few levels. Sulphides were identified in vivianite nodules also. Phos-

phates represents by authigenic vivianite as nodules and aggregates. Mineral is typical for anoxic condition of sedimentation. MS of nodules are intermediate values between high and low MS of sediments. Among the carbonate was identified siderite by TMA data. In few levels were found ferromanganese aggregates. Magnetite spherules of titanomagnetite, chromium magnetite and iron composition as well as iron straps were found in some magnetic extract suggesting volcanic, impact and anthropogenic origin. SEM images were used for detection of dissolution of detrital magnetic minerals.

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Paleomagnetic methods of investigation of modern sediments of lakes and a new method for the correlation of cores

Nourgaliev, D.K., Gizatullina, Z.M. (Kazan Federal (Volga Region) University, Kazan, Russia)

Natural ferrimagnetics are the most important carriers of natural remanent and inductive magnetization of rocks and ores. Ferrimagnetic minerals have a remarkable feature: "magnetic memory". Their magnetic parameters can provide information about the direction of the ancient geomagnetic field since the formation or alteration of the rock, and the temperatures and pressures acting on the rock. All of this is widely used in the subdivision and correlation of sedimentary and volcanic strata, tectonic reconstructions, and clarifying the conditions of formation and metamorphism. In this project we have studied sediments of Lake Yarovoe in the Altai region, and their lithological parameters, magnetic properties and natural remanent magnetization. This was to clarify the age and reconstruction of the magnetic field changes in the epoch of formation of these sediments. The main objective of the project is the correlation of cores of bottom sediments using lithological methods. There are 5 cores from the Lake Yarovoe. Two cores were drilled in the western part of the lake, and three of them in the central part of the lake. Using the magnetic parameters, we were unable to correlate these cores; the magnetic parameters allow you to correlate well within the column sites, but the correlation between the sites was obscure. So we decided to use the lithological parameters for correlation. We used a microscopic analysis of immersion preparations. The resulting images were sub-

jected to computer analysis. This highlighted dark-colored minerals (the ratio of the area of dark grains to the total area of grains), size and other morphological characteristics of all grains, fragments of organic matter as well as more than 10 other parameters. The information content of all these parameters and their sedimentological significance were estimated. As a result, this work established the presence of a break in the section of sediment caused by a sharp drop in water level in the past.

Middle Paleozoic magmatic complexes of Vyluy region (Siberia): problems of synthesis of paleomag, geochronology and tectonic data

Orlov, S.Yu. (Geological Institute RAS, Moscow, Russia)

Middle Paleozoic magmatic complexes of Vyluy region are considered as one of several promising objects for paleomag investigation which potentially can provide data for construction of corresponding length of Siberian APWP. Accordingly (Kravchinsky et al., 2002) the sought pole was obtained from these complexes already. But another attempts (Orlov, Shatsillo, 2010, 2011; Konstantinov et al., 2010, 2012) of paleomag investigation of the same complexes show some several sharply different mean paleomag directions and some clusters have very unexpected position. All these directions have approximately equal statistical magnitudes. Different results were obtained from basic and ultrabasic magmatic complexes which can be considered either as penecontemporaneous (by isotopic age dating set) or as substantially heterochronous (by position in stratigraphic scheme). Also, different interpretation of rock formation and alteration times can exist there. Which paleomag direction is more close to mean "upper devonian-lower carboniferous" direction? There is a pending question. Modern state of knowledge of geochronology and contrariety of tectonic models don't allow us making univocal decision about this matter now. Time relations of different paleomag direction depend on tectonic model which we will use and voluntaristic selection from age dating set.

Geochronology and paleomagnetism of volcanics of the Ulkan Group, SE Aldan-Stanovoy shield (new evidence)

Peskov, A.Yu., Didenko, A.N., Guryanov, V.A., and Perestoronin, A.N. (Kosygin Institute of Tectonics and Geophysics, FEB RAS, Khabarovsk, Russia)

The study of the Ulkan trough, in particular, the latest investigations have posed the problem of the age of the Aldan-Stanovoy shield and the Angara-Anabar province. There are reliable paleomagnetic and geochronological determinations for the latter, which allows us to judge the latitudinal position of the Angara-Anabar province of the Siberian craton in the Paleoproterozoic. Such determinations are obviously deficient for Paleoproterozoic rocks of the Aldan-Stanovoy shield. The marking object for the Aldan-Stanovoy shield is the Ulkan trough filled in with sedimentary-volcanogenic assemblages and plutonic rock complexes. Our previous geochronological investigations of the Elgetei rocks give the age range 1680–1840 Ma. New U-Pb isotope investigations were conducted at the Institute of Geology and Geochronology of Precambrian for three zircon weight microportions (15–20 grains) from the freshest trachydacites of the Elgetei Formation. The points of zircon isotope composition after acid treatment and aeroabrasive cleaning and with ~60% matter removed are located on the concordia in the interval 1732 ± 4 Ma. The previous and the new additional paleomagnetic investigations of the Elgetei trachydacites give evidence of the primary (ancient) component of magnetization preserved in them. The paleomagnetic pole calculated on the basis of the ancient component has the following coordinates: $Plat = -8.6^\circ$, $Plong = 11.9$. The derived pole does not coincide with the apparent polar wander path of the Siberian craton. However, at 1725–1729 Ma the Aldan-Stanovoy shield became a single whole with the Angara-Anabar province, which is evidenced by coincidence of paleomagnetic poles derived from the evenaged granites of the Ulkan massif and Angara-Kanskiy protrusion. The facts make it possible with a deal of probability to give an answer to the question of the age of junction of the study terranes by constraining it within the interval 1732–1725 Ma.

Thermoviscous remanent magnetization as a remanence belonging to thermogenetic class

Petrov, I.N., Pryadilov, K.A., Sergienko, E.S, and Smirnova, R.V. (St.Petersburg State University, St.Petersburg, Russia)

All varieties of remanent magnetization of rocks can be considered as belonging to two different classes, isothermal and thermogenetic magnetizations. Remanences belonging to the first class, isothermal, are formed at a constant temperature in a constant magnetic field H , with a rock simultaneously exposed to the action of one or more additional factors. Remanences belonging to the thermogenetic class, in particular, the thermoviscous remanence, are acquired in a magnetic field H only when temperature changes. Sometimes the latter term is used to refer to a viscous magnetization occurring at a certain constant elevated temperature. This is fundamentally not correct, and such remanence should be referred as belonging to the isothermal class. True thermoviscous remanent magnetization was discovered by V. A. Shashkanov in 1971 while studying temperature dependences of the total instantaneous magnetization of magnetites from Angara-Ilim region. This study consisted of heating the rock samples in a magnetic field H from $20^{\circ}C$ up to a certain temperature T_1 , as a rule, below blocking temperature T_b . Later on, the phenomenon of α -memory, consisting of a recovery of certain amount of remanence when cycling a sample up to $700^{\circ}C$ in zero magnetic field, was discovered for some magnetite bearing rocks, and in 1986 I. N. Petrov showed that α -memory could be non-negligible for thermoviscous remanence as well. The results of more comprehensive study of thermoviscous remanence and its α -memory were subsequently published in 1996 (Petrov et al.). In the present work, we aim to verify the law of additivity for partial thermoviscous remanent magnetizations formed in the temperature range $[T_1, T_2]$, where $T_1 > 20^{\circ}C$ and $T_1 < T_b$, and their respective α -memories.

Interpretation of results of verification of the law of additivity for partial thermoviscous remanent magnetizations of large-grained natural magnetite

Petrov, I.N, Sergienko, E.S, Smirnova, R.V, and Pryadilov, K.A. (St.Petersburg State University, St.Petersburg, Russia)

To interpret the results of verification of the law of additivity (LA) for partial thermoviscous remanent magnetizations (pTVRM) in large-grained natural magnetite, let us consider the physical processes that accompany the acquisition of partial TRM and TVRM. In the framework of Neels TRM theory, the fact that LA is obeyed for non-interacting singledomain grains appears to be evident. Indeed, remanence acquisition in an external magnetic field H involves only those grains, for which the critical reversal field $H_0(T_b) \leq H$, where T_b is the blocking temperature of a given grain, depending of course on the magnitude and direction of the magnetic field. In the case of non-negligible grains interaction, each of the grains sees its own effective magnetic field $\vec{H}_{eff} = \vec{H} + \vec{H}_i$, where the local interaction field \vec{H}_i is a random variable whose temperature dependence follows that of the spontaneous magnetization. Thus, on cooling from T_2 to T_1 partial TRM is acquired not in an external magnetic field \vec{H} , but in a field \vec{H}_{eff} . Consider now the rocks containing large, and therefore multidomain, ferrimagnetic grains. A typical example would be magnetite-bearing rocks from the hypergenesis zone. Both total and partial TVRM are peculiar in that they are acquired when a sample is being heated in an external field H and cooled in zero field, and so all the processes taking place during cooling are controlled solely by the effective field. One of the reasons why for TVRM of multidomain grains LA is violated could be a difference in temperature dependences of effective fields acting during acquisition of total and partial TVRMs, respectively. This hypothesis is investigated in our study.

Geological and paleomagnetic correlation of Quaternary sections of south of Russia, Ukraine and Azerbaijan

Pilipenko, O.V. (Institute of Physics of the Earth RAS, Moscow, Russia), and Trubikhin, V.M. (Geological Institute RAS, Moscow, Russia)

Geological and paleomagnetic correlation of Quaternary deposits of parallel sections of Ukraine – Roxolany, sections of Taman peninsula – Tuzla, Maliy Kut and Pekla, and Azerbaijan – Karadja have been fulfilled in the same time interval (425–10 kyr) corresponding to Neopleistocene. Previously petromagnetic characteristics allowed us to consider that under investigation deposits are fit to the paleomagnetic investigations. Recorded in the deposits natural remanent magnetization (NRM) directions were compared to each other. The common time intervals of abnormal behavior of the magnetization were distinguished. About six horizons of abnormal NRM behavior were determined. They are pockets of normal, abnormal and intermediate polarity stratums (a duration is about 20–30 kyr). The correlation allow us to suppose that in the sections have been recorded the global geomagnetic field excursions like as Mono Lake, Laschamp, Blake, Biwa-I, Biwa-II, Biwa-III. It was assumed that Mono Lake and Laschamp excursions are the parts of the united paleomagnetic event. This research was supported by RFBR grant no. 10-05-00129-a.

World Palaeomagnetic Database informatively: some aspects and observation

Popov, V.V. (All-Russia Petroleum Research Exploration Institute (VNIGRI), St. Petersburg, Russia)

Analysis of the distributions of palaeomagnetic directions from World Palaeomagnetic Database show sometimes strange output. Thus, for examples, information about bedding cannot give possibility to reconstruct real strata position of different part of fold. We have used more, than 7000 Paleozoic mean directions for this analysis. A lot of these data have not fool information – azimuth and dip angle of strata bedding are unknown. Another part includes only directions in different coordinate system. Calculation of the data absence is possible sometimes, but error in this case can be very huge. As a result we see:

- a. Mean directions in geographic and stratigraphic coordinate system show same declination.
- b. A few declinations for all main plates have values around 90 or 270 degrees. It show absence of this angle rotation.
- c. Biggest part of directions suggested with Permian direction for corresponding plate.

On the Early Paleozoic Apparent Polar Wandering path for Baltica. Data analysis and problems

Popov, V.V., and Khramov, A.N. (All-Russia Petroleum Research Exploration Institute (VNIGRI), St. Petersburg, Russia)

There are many questions, what arouses during interpretation of the Early Paleozoic track of the Apparent Polar Wandering path for Baltica. The first is the presence of two sets of the ChRM-directions for all of rocks of this age. The second question is the absent of dual-polarity ChRM-direction for that ChRM-component which thought to be Cambro-Ordovician, whereas "secondary" NRM-component is often bipolar; moreover, for many results "Ordovician" component is post-folding, whereas "secondary" is pre-folding. The third question is rare data for Middle Ordovician to Early Cambrian interval and the absence of data for early Cambrian-Vendian times, except of data with poles like Mesozoic ones. It is interesting that palaeomagnetic poles, for the palaeofield non-dipolar member as calculated vectorial differences between N- and R-directions of ChRMs for Lower Paleozoic Siberian formations, places on the "C-O track" of the APWP for Baltica. This means the post Baltica-Siberia collision age (i.e. as a minimum post-Permian age) of the "Early Paleozoic" ChRM-directions of Baltica rocks. Depart the origin of that palaeomagnetic directions, it is obvious that we don't know jet real Early Paleozoic track of the APWP for Baltica.

Peculiarities of the magnetic susceptibility anisotropy distribution in different parts of turbidite fan

Popov, V.V., and Zhuravlev, A.V. (All-Russia Petroleum Research Exploration Institute (VNIGRI), St. Petersburg, Russia)

Reconstruction of morphology of the ancient carbonate turbidite fans is a difficult task. The carbonate turbidite cycles as a rule demonstrate unclear Bouma sequence. Thus sedimentological methods are insufficient for correct reconstruction of the fan morphology and flow direction. Different elements number of carbonate Bouma cycles are attending in different parts of the turbidite fan. Study of the magnetic susceptibility anisotropy distribution allows us elaborating three models of main axis ellipsoid distributions. These models match to specific elements of cycles, what gives possibility install these elements and thus define what parts of Bouma cycles we are investigating. Sedimentological data accompanied by information on magnetic susceptibility anisotropy provides correct detection of the elements of the Bouma cycle, and reconstruction of the position in the turbidite fan and also flow direction. The method was tested on the 15 objects from Late Devonian – Early Carboniferous carbonate turbidites of the Cis-Uralian foredeep. It gives possibility assume two source of carbonate material for different time: Western and Eastern.

Palaeomagnetic results for Triassic basalts and Permian sedimentary rocks from river Adz'va, Chernyshov Range

Popov, V.V., Iosifidi, A.G. (All-Russia Petroleum Research Exploration Institute (VNIGRI), St. Petersburg, Russia), and Grebenkina, N.U. (St. Petersburg State University, St. Petersburg, Russia)

In the basin of river Adz'va (Chernyshov Range) 72 samples from 3 Triassic basalts flows — post, pillow and bubbles and 10 samples from Upper Permian sedimentary sequence were investigated by temperature and alternating field cleanings. Isotope age (K-Ar) of basalts lies between 220 and 250 MA. Huge intensity and predominantly single-component of magnetization both of rocks show stable Poles position, which have good correlation with same for Triassic and Permian Polar of Russian Platform. But problem of this result is: in 3 nearest posts of basalt we obtain opposite polarity. In another parts of flows

— only normal polarity. Explanation of this result in this moment cannot be clear.

Geomagnetic field generation as result of the protocore dissolution

Pushkarev, Y.D. (IPGG, St.Petersburg, Russia), Starchenko, S.V. (IZMIRAN, Troitsk, Russia)

There are evidences of early Archean geomagnetic field existence. This contradicts with the generally accepted ideas according to which the geodynamo, is produced by the compositional convection caused due to crystallization of the liquid core. The most probable age of such process is estimated not older than 2 Ga. So, before this time the low geomagnetic field was generated only by inefficient thermal convection. Thus, if the compositional convection is required to generate the Archean geomagnetic field, this convection should have some other nature.

We suggest that the solid core of the Earth didn't crystallize from the liquid one, but represents the small relict of the protocore on which heterogenic accretion has begun. The protocore consists of a mixture of heavy metal iron-nickel alloy and light chondrite silicate component containing primary noble gases. Soon after the end of accretion, the geosphere of the liquid core was formed in an external part of planet. It started to plunge, expanding due to melting of new portions of iron-nickel alloy. Then the expansion rate is decelerated due to decreasing of the temperature difference between liquid geosphere and solid protocore. It leads to the slower conductive transport of the heat necessary to melt the protocore. The rate of this conductive heat transport determines the time needed for the protocore dissolution. If we use thermal conductivity of the liquid core for estimation of this time we will obtain a few billion years as it is required. During protocore dissolution the silicate chondritic component of protocore is liberated. It floats up through metallic melt of liquid core and generates composite convection, which mainly supports geodynamo. This idea is confirmed by presence in mantle derivatives of primary noble gases and isotope Xe-129 which demonstrates contribution of the oldest chondrite component of the protocore into the mantle reservoir.

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Petromagnetic investigations of active submarine volcanoes from western part of Pacific Ocean

Rashidov, V.A. (Institute of Volcanology and Seismology FEB RAS, Petropavlovsk-Kamchatka, Russia), Pilipenko, O.V. (The Schmidt Institute of Physics of the Earth RAS, Moscow, Russia), and Ledygin, V.M. (Lomonosov Moscow State University, Geology faculty, Moscow, Russia)

During the time from 1977 to 1991 years Research Vessel (R/V) "Vulkanolog" was realized considerable volume of a complex geological and geophysical survey of the submarine volcanoes from the Pacific Ocean. The petrophysical and petromagnetic investigations of rocks collection from R/V "Vulkanolog" are continued in modern study. Samples were picked up from five active submarine volcanoes. Results of the investigations are needed for a priori information for interpretations of the petrophysical data and for identifications peculiarities of the magnetization of the rocks during evolutions of the volcanoes. Three volcanoes located in the Northern hemisphere (Esmeralda and Fukujin volcanoes on the Marian Island Arc and Ile Des Cenders volcano in the South Chine Sea) and two situated in the Southern hemisphere (Kavachi and Simbo on the Solomon Island Arc). The petromagnetic investigations of the rocks were fulfilled in the laboratory of Main Geomagnetic Field and Petromagnetism of the Schmidt Institute of Physics of the Earth RAS. Samples of the Esmeralda volcano were presented by aphyric andesite-basalt and porphyritic basalt. Samples of the Fukujin volcano were presented by porphyritic basalt. The Kavachi volcano is characterized by sample of the porphyritic basalt and Simbo is characterized by sample of the porphyritic andesite. An electro-microprobe analyze by "Jeol JSM-6480LV" in the laboratory of Local investigation of the substance in the Geological faculty of the Moscow State University was fulfilled for a confirmation of a composition of the NRM bearer. A comparison of the magnetic characteristics of the active submarine volcanoes, such as Fukujin, Esmeralda, Kavachi, Simbo on the Island Arc and Ile Des Cenders volcano in the marginal sea demonstrated that volcanoes very different by NRM and K values. The aphyric andesete-basalts of the Esmeralda volcano have higher values of NRM and K, the xenoliths of Ile Des Cenders volcanothe have lower values of NRM and K. All studded samples are magnetically isotropic and content relatively low coercitive magnetically minerals of the various domain structure. Magnetic characteristic of the samples of eruptive rocks

from Esmeralda, Fukujin, Ile Des Cendres volcanoes are typical for young oceanic basalts. Main bearer of NRM is titanomagnetite of the various domain structures. At the same time samples from Fukujin volcano with magnetite were found. It was assumed that in these samples oxidation of the primary titanomagnetite was finished in the nature conditions. The data about magnetic characteristics of the dredged rocks can be used for interpretations of the geophysical investigations and for study peculiarities of the magnetization during evolution of the active submarine volcano.

On the eve of the II International Polar Year: magnetic measurements during the arctic flight of the “Graf Zeppelin” Airship in 1931

Raspopov, O.M., Sokolov, S.N., Demina, I.M., and Petrova, A.A. (St. Petersburg Filial of N.V. Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radiowaves Propagation of RAS, St. Petersburg, Russia)

In July of 1931, on the eve of the II International Polar Year, an Arctic flight of the “Graf Zeppelin” rigid airship was organized. This flight was a realization of the idea of F. Nansen who advocated the use of dirigibles for the scientific exploration of the Arctic territories which were poorly studied and hardly accessible at that time. The route of the airship flight was Berlin – Leningrad – Arkhangelsk – Frantz Josef Land – Severnaya Zemlya – Taimyr Peninsula – Novaya Zemlya – Arkhangelsk – Berlin. One of scientific goals of the expedition was to measure the H and D geomagnetic field components. Actually, the first aeromagnetic survey was carried out in the Arctic during the flight. After the expedition, only preliminary results of the geomagnetic measurements, in which an anomalous behavior of magnetic declination at the high-latitude part of the route was noted, were published. Our report is concerned with the results of the first aeromagnetic measurements in the Arctic and their analysis based on archival and modern data on the magnetic field in the Barents and Kara sea region. It is shown that the magnetic field along the flight route had a complicated structure that was not reflected in the magnetic maps of those times. The data on magnetic declination and horizontal geomagnetic field component obtained during the expedition are still of great importance because almost no new information

on the thin structure of the geomagnetic field components for this region has appeared so far.

Palaeomagnetism of the South Uralian Asha Series — old data and new results

Sal'naya, N.V., Mihailova, V.A., and Iosifidi, A.G. (All-Russia Petroleum Research Exploration Institute (VNIGRI), St. Petersburg, Russia)

Recent palaeomagnetic results for Vendian formations of the Winter Coast and Podolia regions of the EEP are of great stimula to appeal to palaeomagnetism of the Upper Vendian formations on the South Urals. First results for these formations have been obtained as soon as 30–40 years ago (Komissarova, 1970, 1984). These investigations yields poles at $08^{\circ}N$, $189^{\circ}E$ for Basa series and at $29^{\circ}N$, $166^{\circ}E$ for overlying Kuk-Karauk series. The last, newest results being obtained using modern techniques (Golovanova et al., 2011) can't change old results and yields poles at $01^{\circ}N$, $187^{\circ}E$ for Basa series. All these poles are discordant to above mentioned poles for EEP, being placed on the Devonian to Late Ordovician track of the APWP for Baltica (Torsvik, Cooks, 2001). There is a reason, why we have started to reinvestigate our rich collection (up to 1000 samples) using modern technique. First results of this big work were published many years ago (Pisarevsky et al., 1999; Komissarova, Iosifidi, 2000), but have been ignored by other authors. Here we present the to-day stage palaeomagnetic results of this work, based on the subcollection of 100 samples were, which collected from outcrops along r. Inzer, r. Basa ($53.5^{\circ}N$, $56.8^{\circ}E$), r. Kuk-Karauk ($54.2^{\circ}N$, $56.3^{\circ}E$) and r. Zilim ($53.4^{\circ}N$, $56.4^{\circ}E$). The sedimentary rocks are represented by silty claystones, sandstones and shales of the Kuk-Karauk and Basa series. For 25 samples of Basa series and 27 samples of Kuk-Karauk series useful results have been obtained by now. The NRM of samples is complex. As a rule each rock specimen contain 2 or 3 components. Thermomagnetic experiments (J_{rs} -T) indicate that hematite is the main magnetic carrier. Finally 4 magnetic components were isolated by thermal demagnetisation up to 500–680 °C. First A-component has a mean direction of $D_g = 337^{\circ}$; $I_g = 75^{\circ}$; $n = 39$; $K_g = 9$; $\alpha_{95} = 8$ and pole position at $76^{\circ}N$, $8^{\circ}E$. This component is probably of recent origin and acquired in the Earth's present field, it was removed at tempera-

tures below 250° . All of the intermediate and high-temperature components are of bipolar and prefolding ones. There are B-component ($D_s = 52^\circ$; $I_s = -30^\circ$; $n = 17$; $K_s = 43$; $\alpha_{95} = 5$) yields pole at $7^\circ N$, $186^\circ E$ for Basa series and $D_s = 71^\circ$; $I_s = -16^\circ$; $n = 21$; $K_s = 21$; $\alpha_{95} = 5$ and pole position at $4^\circ N$, $166^\circ E$ for Kuk-Karauk series, close to the pole for Basa series, obtained earlier (Komissarova, 1984; Golovanova et al., 2011). Third component ($D_s = 349^\circ$; $I_s = 0^\circ$; $n = 12$; $K_s = 10$; $\alpha_{95} = 15$) yields pole at $35^\circ N$, $250^\circ E$ for Basa series and $D_s = 348^\circ$; $I_s = -2^\circ$; $n = 27$; $K_s = 13$; $\alpha_{95} = 7$ and pole position at $34^\circ N$, $251^\circ E$ for Kuk-Karauk series, both close to poles for Vendian basalts from Podolia ($45^\circ N$, $242^\circ E$, Iosifidi et al., 2000, 2001) and for Lower Cambrian – Upper Vendian sandstones from Bornholm, Denmark ($43^\circ N$, $230^\circ E$, Lewandowski et al., 1999). Kuk-Karauk samples holds, also Kiaman-age magnetic overprint components with $D_s = 259^\circ$; $I_s = -31^\circ$; $n = 22$; $K_s = 15$; $\alpha_{95} = 8$ and $D_s = 231^\circ$; $I_s = -36^\circ$; $n = 17$; $K_s = 79$; $\alpha_{95} = 4$. The study of the next parts of samples from our collections must give us more results, which will appear to be useful for palaeogeographic and palaeotectonic reconstructions.

Is there a chance for alternating-field remagnetization method to be used in palaeointensity estimation?

Sapozhnikov, A.V. (St.Petersburg State University, St.Petersburg, Russia; VNIGRI, St.Petersburg, Russia), Popov, V.V. (VNIGRI, St.Petersburg, Russia), Sergienko, E.S., Smirnova, R.V. (St.Petersburg State University, St.Petersburg, Russia)

In 1975 V. A. Shashkanov proposed a method of alternating-field remagnetization which could be applied to rocks with thermoremanent (TRM) and detrital (DRM) remanent magnetizations. It uses anhysteretic magnetization to find specific magnetic structure (magnetic phase distribution anisotropy) inhomogenities due to ancient Earth's magnetic field influence. However after being criticized in 1989 it was concluded that the method cannot be used at least in case of TRM. In spite of the fact that in 2006 the explanation of failure was given, method development practically stopped.

The idea is to understand if there is a possibility to allocate magnetic texture inhomogenities which indicate palaeointensity. For this purpose we constructed an alternating-field remagnetization device using

modern equipment. Experimental data obtained from several naturally and artificially thermomagnetized samples leads to a conclusion that such an allocation is possible and, moreover, can point on two inhomogenities.

Carrying out the remagnetization in a wide range of constant fields we studied how do the inhomogenities manifestations behave depending on the constant field value. The repeatability of the results of remagnetization in the same constant field on the single sample was also checked. It showed less dispersion in the subsequent experiments. An explanation of the observed phenomena was suggested.

A statistical analysis was used to estimate palaeointensity. The results obtained from modern naturally and artificially magnetized samples show quite a good agreement with modern Earth's magnetic field value and previous palaeointensity estimates.

Preisach-Neel model, diagram and alternating-field remagnetization method in simple terms

Sapozhnikov, A.V. (St.Petersburg State University, St.Petersburg, Russia; VNIGRI, St.Petersburg, Russia), Popov, V.V. (VNIGRI, St.Petersburg, Russia), Sergienko, E.S., Smirnova, R.V. (St.Petersburg State University, St.Petersburg, Russia)

Natural remanent magnetization (NRM) seems to be the most convenient source of information for estimating palaeointensity. However secondary influences, which act upon rocks during its time of existence, can partially or completely destroy primary NRM component. This fact leads to a pretty limited circle of suitable rocks for palaeointensity determination.

Another way is to study magnetic texture (magnetic phase distribution anisotropy). Being interconnected with energy minima positions it must be less affected by negative factors such as heating or applying external magnetic field than remanent magnetization. We can study magnetic texture by looking at magnetic rock behavior in external magnetic field.

One of the most convenient ways to consider magnetic texture is using the Preisach-Neel model and corresponding diagram. In their terms V. A. Shashkanov proposed a method of alternating-field remagnetization 1975 to study magnetic structure in rocks with thermorema-

nent (TRM) and detrital (DRM) remanent magnetizations. In 1989 the method has been criticized and practically forgotten. Nowadays we are facing the necessity to consider magnetic texture and Preisach-Neel diagram again. due is lack of objects which can be studied by methods used today.

Our mission is to describe the Preisach-Neel model and its application to palaeointensity estimation using simple terms. We want to explain the sense of the model, the ideology of using alternating magnetic field and, in particular, the main ideas of alternate-remagnetization method to as wide audience as possible.

Paleomagnetic research of Vyatkino section (Priobsky steppe plateau)

Shcheglova, S.N., Smolyaninova, L.G., and Zykina, V.S. (Sobolev Institute of Geology and Mineralogy, SB RAS, Novosibirsk)

Paleomagnetic researches of Vyatkino (Priobsky steppe plateau) are carried out. Soils of berdsky, shadrikhinsky, charyshsky, volodarsky, belovsky and evsinsky pedocomplexes are tracked and studied. Magnetic characteristics of sediments and results of magnetic cleaning of samples are received by a variation field and temperature. Transition from negative orthozone to positive in loam between soils of evsinsky pedocomplex is fixed. We interpret it as border Matuyama-Bryunes. The abnormal zone at brink of water which can be compared with Jaramillo's episode is also allocated. It proves results of researches remains of rodents, carried out by V. S. Zazhigin. Besides, thermomagnetic cleaning allowed to allocate positive orthozone below evsinsky pedocomplex at the highest levels of the talmensky loess which probably is Kamikatsur's episode.

The geodynamo as a random walker: a view on reversal statistics

Shcherbakov, V. (Borok Geophysical Observatory of Schmidt Institute of Physics of the Earth RAS, Borok, Russia), and Fabian, K. (Geological Survey of Norway, Trondheim, Norway)

The sequence of durations of the geomagnetic polarity intervals is often described in terms of a non-homogenous Poisson process with time dependent reversal rate, reflecting the non-stationarity of the underlying geodynamo process. This view has recently been challenged, and here we show that the first-passage time statistics of random walks taking place on a flat potential relief yields a much more consistent interpretation of the distribution of geomagnetic polarity intervals. A possible physical explanation 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. The random-walk hypothesis naturally includes the observed occurrences of very long superchrons, and it provides a new, considerably longer statistical estimate for the total duration of the present Brunhes chron predicting that the probability for a geomagnetic field reversal within the next 30 Ka is $\sim 5\%$ and the probability that we live in a chron longer than 2 Ma is about 30%.

On the relationship between reversal frequency and average paleofield intensity

Shcherbakov, V., and Sycheva, N. (Borok Geophysical Observatory of Schmidt Institute of Physics of the Earth RAS, Borok, Russia)

A new statistical analysis of the global database on the paleointensity, containing determinations of the virtual dipole moment (VDM) for a stable (normal) regime of the geomagnetic field in a time interval of up to 3.5 Ga, is performed. By reason of great paucity of the determinations VDM in the past, the analysis was restricted by performing only the last 200 Myr. The temporal dependencies of the average VDM values are compared to the reversal rate calculated within a window of 1, 5 or 15 Myr. As occurred, the correlation between these sets of data is statistically insignificant (the correlation coefficient $k \sim 0.1$). Thus, our results does not support the hypothesis

by Cox, 1968 that the average VDM values are linked to the reversal frequency. Altogether with it, a substantial correlation between the standard deviations and average VDM values ($k \sim 0.51-0.88$). In order to see if the field behavior depends on the geomagnetic polarity length, statistical characteristics of the paleointensity data inside some stable polarity intervals have been studied. Due to paucity of the data, only about 10 from 500 intervals by duration over 100 Ky proved to be suitable for statistical analysis. Again, both standard deviations and average values of VDMs, calculated within each polarity interval, did not show a significant link with the length of the geomagnetic polarity interval. Instead, another relation is assumed: the more is the variance, the more is the average intensity which suggests that the distribution of VDMs inside a stable polarity interval is non-Gaussian. As alternative candidates gamma and log-normal distributions are considered. The only exception to the results obtained is the Brunhes epoch, where the VDM distribution seems to be rather normal.

Palaeointensity and palaeodirection determinations of palaeoproterozoic dykes in the Kaapvaal Craton (South Africa)

Shcherbakova, V.V. (Geophysical observatory "Borok", Russia), Lubnina, N.V. (Lomonosov Moscow State University, Moscow, Russia), Shcherbakov, V.P., and Zhidkov, G.V. (Geophysical observatory "Borok", Russia)

A combined palaeodirectional and palaeointensity study of a representative collection from the Bushveld Igneous Complex from 27 dolerite dykes from the 2.9, 2.7, and 1.8 Ga age swarms radiating SE, E and NE, respectively was carried out. Conventional progressive thermal or AF demagnetization was applied to all specimens. The paleopole calculated for some NE-trending dykes of the Black Ridge swarm in the NE region is close to the 1.87 Ga pole of the Kaapvaal Craton. Curie temperatures, the thermal stability of magnetic minerals, their magnetic hardness, a domain structure were performed. The Thellier-Coe procedure with the "check-points" as basic and the Wilson's method were used for palaeointensity determination. Reliable palaeointensity determinations were obtained on only the site N28 of the age 1.85 Ga. The rocks are very stable for heating, Curie points are closed to magnetite T_c , thermodemagnetization curves NRM(T)

and TRM(T) are very similar. Seven samples (12 sister cubes) showed very similar intensities of paleofield H_{anc} 15-23 μT , the mean VDM = $2.85 \times 10^{22} \text{ Am}^2$. This result agrees with the widespread opinion that the field in the Paleoproterozoic was considerably less of the modern magnetic field.

The analysis of the data available for the Precambrian showed that:

- the VDM distribution for the precambrian is bi-modal most likely due to great shortage of data;
- average VDM intensity oscillates with time, so there is no clear indication of the onset of the inner core start;
- the validity of the hypothesis of the geocentric axial dipole is debatable.

Magnetic field reversals in a simple model of geodynamo

Sokoloff, D.D. (Moscow State University, Moscow, Russia)

A relatively simple dynamical system for geomagnetic field excitation and evolution is obtained from general mean-field dynamo equations. It is shown that the model produces a sequence of abrupt reversals of magnetic field generation. Statistics of the reversals occurs to be very similar to that one known from paleomagnetic studies.

Determination of the magnetic state of marine sediments particles with high content of the paramagnetic material

Solyanikov, Ya.L., and Malakhov, M.I. (Shilo North-East Interdisciplinary Scientific Research Institute FEB RAS, Magadan, Russia)

The magnetic hysteresis parameters of diagenetically altered magnetic fraction of sediments from Sea of Japan are investigated. The concentration and the domain structure of the parent ferrimagnetic grains significantly decreased due to the formation of a large number of paramagnetic substances during post-sedimentation phase. Diagenetic transformations negatively impacted on the ratio of signals from the ferrimagnetic and paramagnetic components on the hysteresis curves [Jasonov et al., 1998]. The authors correctly identified the

parameters of the magnetic hysteresis (used to build Day plots) — especially the coercive force B_c of saturation induced magnetization of ferrimagnetic component. The macro, written in the graphical editor Corel Draw, finds the linear part of the full induced magnetization curve by the least squares method [Solyanikov, 2011]. This allows to separate reliably enough the weak ferrimagnetic and the dominant paramagnetic signals in the magnetic hysteresis curves. Thus, the value of B_c with an error less than 1 mT is found.

Energetically determined geomagnetic intensities, scales and periods

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

From the first principles the typical geomagnetic field B is found to be proportional to the third root of the buoyancy flux F driving the convection, while B is independent on conductivity σ and angular rotation rate Ω . The same scaling law was previously obtained only via extrapolation of all the available numerical dynamo simulations. Besides, I obtained scaling laws for typical hydrodynamic scale h , velocity V , Archimedean acceleration A , electromagnetic scale d and sinus of the angle between magnetic and velocity vector s . The nature of the known geomagnetic periods and intensities are outlined.

Heat-mass-transfer gives $AV = F$. The curl of momentum equation relates magnetic to kinetic energy as $(B/V)^2/\rho\mu = (d/h)^2$ also giving $\Omega V/H = (V/h)^2 = A/h$, where H is thickness of the Earth's liquid core. This gives laws: $V^5 = F^2 H/\Omega$, $h^5 = FH^3/\Omega^3$, $A^5 = F^3\Omega/H$. Faraday law with typical electric field E and Ohm law give $BV/H = E/d$ and $E = sBV$, while the inverse time of magnetic field change is $sV/h = Vd/Hh$. Change of magnetic energy by Archimedean force results in $B^2Vd/Hh = \rho\mu AV$. Finally the first principles' scaling law is $B = (\rho\mu)^{1/2}(FH)^{1/3}$. Thus, typical geodynamo values ($B=2\text{mT}$, $h=6\text{km}$, $d=90\text{km}$, $V=1\text{mm/s}$, $s=0.04$) are now fully determined by the energy driving convection $F \approx 2 \cdot 10^{-13}\text{W/kg}$ and known $\Omega = 7.3 \cdot 10^{-5}/\text{s}$, $\rho = 11\text{Mg/m}^3$, $H = 2.3\text{Mm}$.

Turbulent transport gives $h/V = 0.2\text{yrs}$, $d/V = 3\text{yrs}$ and $H/V = 75\text{yrs}$ periods related with jerks and secular variations. Magnetic diffusivity in $\mu\sigma h^2 = 2\text{yrs}$, $\mu\sigma d^2 = 500\text{yrs}$ and $\mu\sigma H^2 = 0.3\text{Ma}$ adds time t between inversions. Thermal diffusivity k gives $h^2/k = 0.1\text{Ma}$,

$d^2/k = 20\text{Ma}$ and $H^2/k = 10\text{Ga}$. So, the shortest t could increase with growing B $F^{1/3}$ because $h \sim F^{1/5}$.

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Geodynamic model Kiselevka–Manoma terrane on the basis of paleomagnetic data

Stupina, A.I., and Didenko, A.N. (RAS FEB Institute of Tectonics and Geophysics named after Yu. A. Kosygin, Khabarovsk, Russia)

The paper presents the results of paleo- and petromagnetic investigations of Jurassic-Cretaceous rocks of the Kiselevka block, Kiselevka-Manoma terrane, which is part of the structure of the Sikhote-Alin fold belt. The investigations resulted in the following: (1) based on the analysis of petromagnetic and paleomagnetic characteristics, ancient prefold remnant magnetization has been distinguished, close in time to the age of formation of the rocks (J3–K1); (2) the allochthonous nature of the Kiselevka block has been proved; (3) the paleolatitude ($18 \pm 5^\circ\text{N}$) has first been defined, in which the rocks of the terrane formed; (4) a kinematic model has been developed, according to which the Kiselevka block was shifting on the Izanagi Plate north-east at an average rate of 16–17 cm/year, beginning from 140 Ma before the attachment to the North Asian paleocontinent 110–105 mln years ago ($45 \pm 5^\circ$); later the block was translated along continental margin to the north in the regime of strike-slip fault. The block was completely accreted to the North Asian paleocontinent at 90 Ma in the paleolatitude $55 \pm 5^\circ\text{N}$.

Native metals in objects for paleomagnetic studies

Tselmovich, V.A. (Geophysical Observatory “Borok” IPE RAS, Borok, Russia)

We studied the morphology and composition of magnetic minerals in the 6 samples, which were intended for paleomagnetic studies. Microprobe Tescan Vega II was used for research. Samples of magnetism attracted interest because they have unusual magnetic properties. Their magnetic properties were very different from the properties of the samples, which were found above and below the sampling sites

with anomalous characteristics. The investigated samples contained minerals of cosmic origin, including native metals. We studied samples of the following points:

- 1 Gabbro-dolerites (r.Uda, Sayan region), 740 Ma.
2. Amuria, Devon, silty sandstone, clastic complexes.
3. Far East, the volcanic rocks of South Sinegorsk Diva.
4. Armenia, Kafan section, 158 Ma, baked tuffs.
5. Silurian-Lower Devonian section of Podolia - part of the section of the Lower Paleozoic of the Dniester River. Ukraine.
6. Lake B.Lozhka, Novosibirsk Region.

They were discovered minerals that can be attributed to the minerals of cosmic origin. Among them are found native metals: pure native metals Fe, Ni, W, Cr, Co, intermetallic compounds of different composition FeCr, FeNi, FeCrNi, FeCo, FeWCo, FeCuZn, FeNiSnCu. Thus, the indirect result of paleomagnetic studies was the detection of impact events (meteoroid or asteroid). The scale of such events can be established with additional studies with sampling of the plane in which the minerals are found space. The same plane can be microstratigraphical horizon. The study found native metals will clarify the details of cosmochemical processes. Interpretation of paleomagnetic data on such samples should be made taking into account the findings. However, the occurrence of native metals may be associated with other processes. For example with the fallout of ash. Therefore, final conclusions should be done with caution, taking into account other recovery processes.

Magnetic minerals of the Kara astrobleme

Tselmovich, V.A., Sergienko, E.S., Smirnova, R.V., Popov, V.V., Sapozhnikov, A.V. (St. Petersburg State University, St. Petersburg, Russia), Dolotov, A.V. (Geophysical observatory "Borok", Borok, Yaroslavl, Russia)

Kara astrobleme — one of the largest astroblems known on land. The study of magnetic properties and composition of the zyuivites of the Kara astrobleme is of interest to paleomagnetism. Impacted species do not often get in their field of vision. That such species are zyuivites and tagamites. The impact of shock metamorphism, it is important

to the paleomagnetic point of view, should ensure the acquisition of natural remanent magnetization of rocks of the same age as the impact events, but also leads to changes in the mineral composition of rocks. Therefore necessary to carefully study the chemical and phase composition of magnetic fraction of the samples. Expedition of St. Petersburg State University in 2011, studied sections of the complex and koptogen Show "target" on p. Kara and its tributaries. The magnetic fraction was isolated from these samples by the original method and studied by microprobe "Tescan Vega II" in the Geophysical Observatory "Borok". Found various forms of occurrence of native metals (Fe, Ni, W, Al, Ag, Cu, Sn), complex and diverse composition of intermetallic compounds (FeCr, FeNiCr, FeNiCo, FeSn, FeCuNiSn, FeNd, LaCeNiFe, NiAl, and others) sulfides Fe, magnetite debris, magnetite cosmic spheres, titanomagnetites. Of particular interest are the compositions of the drummer for the first time detected the target, which serves as the target mineral is of terrestrial origin, as well as a drummer visible particles of native metals. Such compositions take off the question of the origin of terrestrial metal particles, since the introduction of a mineral in the target they were supposed to have a space velocity. It is interesting to identify other buried impact craters. This is due to the possibility of detection of hydrocarbons in lithologic traps associated with these structures, as proposed in the study of Kara astroblems diagnostic features can be used in practical work for exploration.

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Geological Dictionary. Section "Geophysics" – Entries and Authors

Tsirel, V.S. (Enterprise "Geologorazvedka", St.Petersburg, Russia)

1. Publication of the three volume "Geological Dictionary" in 2011–2012 is the culmination of the more than 10 year long period of its publication. The "Dictionary" at the compilation of which have been working more than 250 scientists, covers more than 30 subdivisions, i.e. the whole complex of branches of geology.

2. The main difference between the present edition and the preceding ones (1st edition of 1955 and 2nd edition of 1973) is not in the increased amount of terms (which is easily explained by the appearance

of new terms), but rather in the new, up-to-date definitions reflecting modern ideas in geological sciences.

3. The section "Geophysics" is very well represented. It comprises more than 1350 terms out of the total of 24.500.

4. The section is divided into 16 subsections. The amount of terms varies from a few in the subdivision "Ecological Geophysics" to several hundreds in the "Physics of the Earth".

5. The section exceeds by far all the other sections in the number of authors -99 of them! The explanation is as follows: terms belonging to highly specialized branches of geophysics were dealt with by specialists in those very branches.

6. The majority of authors work either in St. Petersburg or Moscow. However, some of them are from Novosibirsk, Yekaterinburg or other cities. They represent the leading establishments of education such as Petersburg University and Mining Institute, institutes of the Russian Academy of Sciences, especially the Institute of the Physics of the Earth, centers of the geological service of Russia such as VCEGEI, VNIGRI, "GEOLOGORAZVEDKA" and others. The authors include several academicians of RAN, well-known scientists holders of scientific degrees (Doct. of Sc. or Ph.D.), as well as specialists in exploration geophysics.

7. Unfortunately, during the long period of compiling the dictionary the team of authors suffered irreparable losses. So the Dictionary is, in kind, a real memorial to those who are no more.

8. The huge amount of random and sometimes questionable information pertaining to geophysics in the internet makes it necessary to publish a separate "Geophysical Dictionary" on the basis of the section "Geophysics" in the above discussed "Geological Dictionary" by the still functioning team of authors.

Paleomagnetism and geochronology of the Devonian dikes of the Kola Peninsula

*Veselovskiy, R.V. (Moscow State University, Moscow, Russia), and
Arzamastsev, A.A. (Institute of Precambrian geology and geochronology, St. Petersburg, Russia)*

In this report we present the results of detailed paleomagnetic stud-

ies of the Devonian dikes of the Kola Peninsula (NE Fennoscandian Shield). Obtained data suggest the presence of regional remagnetization of metamorphic and igneous complexes of the NE Fennoscandian Shield in the Middle Jurassic. The main feature of this remagnetization event is its selectivity — it is widely spread in the Devonian dikes mostly, but among them the degree of remagnetization can vary significantly even in the adjacent dikes. In addition to the paleomagnetic data we present the results of isotopic dating of the Devonian dykes by Ar/Ar method (step heating). We conclude that K–Ar isotope system was closed after the Devonian time, so the remagnetization factor had low-temperature origin: the rocks of the Devonian dikes were not heated more than 200–250 degrees of Celsius since their formation.

Microprobe studies revealed the presence of several generations of magnetic minerals, as well as significant changes of the primary magmatic minerals, that could be caused by the magmatic fluid of basic composition. So we suggest that the source of Mesozoic remagnetization was linked with basaltic magmatism, which became in the Jurassic-Cretaceous time on the Franz Josef Land, Spitsbergen and shelf of the Barents Sea.

Our studies allow us to obtain the new Devonian paleomagnetic pole for Baltica, as well as some isolated paleomagnetic determinations on the Proterozoic dikes.

Paleomagnetic investigations of Crimean mezozoids in the context of plate tectonics

Yudin, S.V. (St.Petersburg State University, St. Petersburg, Russia)

To study the dynamics of movement of Crimean mountain terrane in the Mesozoic were investigated volcanoclastic and sedimentary strata, and intrusive bodies. In the central part of the Kachinsky uplift of Mountain Crimea sub volcanic bodies, intrusive formations and containing them volkanoklastic strata of middle Jurassic age are investigated. Magmatic bodies middle-upper Jurassic age and also sediments of Cretaceous age from the Second ridge of mountain Crimea are tested. Clockwise rotations of middle Jurassic volcanites, shown in previous works, were confirmed in the present research. They vary in the range from 35 to 165 degrees. These rotations could be a

consequence of modern movements on the right-hand normal faults shown on geological area of researches. Besides, primary directions of a volcanic chain of an island arch, most likely, did not answer modern position of its fragments opened now. Position of an Euler pole of blocks, located within their boundaries, or in immediate proximity of them. The paleolatitude of origin of middle Jurassic strata is calculated to 26–28 degrees. The distance on a meridian, corresponding to size of open oceanic basin, concerning edge of Eurasia (settling down at width 42 degrees) in middle Jurassic time, was 1500–1800 km. Geological data (conglomerates of mountain Demerdzhi with fragments of ofiolites) determines reduction and the subsequent shortening of this basin with oceanic type of a core. The uplift formed on a place of a collision with central Pontides, were source for accumulation of molasses strata. The subduction zone was on 100–300 km to the south. Thus, subduction of oceanic core under Evrasia was accompanied by the general movement of Island arch terrains of Mezotetis ocean to the north. In our study paleolatitudes of Lower Cretaceous sediments of the Crimean Mountains are 35 degrees, equal to those of the Early Cretaceous of the southern margin of Eurasia. Thus, to the Late Cretaceous oceanic basin Mezotetis has been reduced and volcanic arc collided to southern margin of Eurasia.

Anomalies in the rotation period and magnetic moment of the Earth in the geological past

Zemtsov, V. (Institute of Geology, Karelian Research Centre, RAS, Petrozavodsk)

The rotation anomalies and energies of 1st- and 2nd-order tectono-dynamic structures of the Earth were analyzed theoretically on the basis of the modern structure of the Earth and its rotation over geological time. Long-term anomalies in the Earth's rotation period in Palaeozoic and Precambrian time that lasted for at least 100 Ma were shown to correlate with considerable variations in the Earth's magnetic moment values known from the updated IAGA palaeointensity database and from the Earth's magmatic activity cycles. Known global glaciation (Upper Carboniferous-Lower Permian time) and "The Great Dying" have begun in the end of the last anomaly interval (251.4 Ma ago). These global processes undoubtedly took place in the geological past and will be in the future. Of practical importance

is the fact that even small-scale "retardation" periods in the Earth's rotation, recorded over the past century, correspond to its highest seismic activity. The secular retardation of the mantle rotation was chiefly due to the well-known tidal friction of oceanic N-S wave M2, which rolls over continent and island shores from east to west about twice a day.

Late pleistocene variations of Earth's magnetic field recorded in cover sandy loams from Central Kamchatkan depression

Zubov, A.G. (Institute of Volcanology and Seismology FED RAS, Petropavlovsk-Kamchatsky, Russia); Kochegura, V.V.[†] (VSEGEI, St. Petersburg, Russia)

Cover sandy loams or loess-like deposits were paleomagnetically studied in Central Kamchatkan depression. Sampling took place in Kamchatka-river erosion of Polovinka dene ($158^{\circ}55'40''\text{E}$, $54^{\circ}54'40''\text{N}$). Due to radiocarbon dating age of deposits was determined in 30–50 kyr and an average sedimentation rate was calculated in ≈ 2 mm/yr. 457 orientated samples were collected across the section after 10 cm. Resultant paleomagnetic angular records were compared with ones from well-known Kargapolovo section, located on the same latitude and trough 77° wester. Shapes of D and I curves were like to each other on the considerable part of records. The same were for shapes of loops on the stereograms. Such result is in good agreement with the hypothesis of drifting nondipole sources as a cause of PSV. No geomagnetic excursions was indicated on Polovinka records.

The reliability of geomagnetic dip poles in the modern, historical and ancient models

Zvereva, T.I., and Starchenko, S.V. (Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation RAS (IZMIRAN), Troitsk, Russia)

Based on vector magnetic data from the CHAMP satellite, average daily spherical harmonic models of the main geomagnetic field to $n=m=10$ have been constructed for the period from May 2001 to the end of 2009 at an interval of 4 days. The geomagnetic dip poles (the

points where magnetic field lines are vertical) were modelled on the Earth's surface for each half year average with Gaussian decomposition degree n from 1 till 10. Final result is that models with $n = 6$ are virtually indistinguishable with $n=7, 8, 9, 10$ models. Therefore, the historical spherical harmonic models for the calculation of the virtual magnetic poles should be build at least up to $n=6$. For this reason the majority of the available ancient (archeo/paleo) magnetic reconstructions are not suitable for dip pole modeling, while the historical models (e.g. *gufm1*) are suitable for that because they are based on real measurements allowing modeling with $n=6$ and more.

Section S. Seismology

On the relation between GPS strain field and active faults in the eastern Baltic region

Assinovskaya, B.A., Panas, N.M. (GS RAS St. Pulkovo, Russia), Gorshkov, V.L., and Shcherbakova, N.V. (GAO RAS, Russia)

The strain field of Lake Ladoga — Eastern Gulf of Finland region has been previously studied (Assinovskaya et al. 2012) using specially processed GPS data. The GPS station velocities on long term observation by GIPSY 5.0 were estimated. Analyzing the strain field it was supposed that the borders between areas of different strain-stress state point to the regional active faults position. The data obtained were compared with regional tectonics and earthquake focal mechanisms. The specified consistency between them was revealed. This work extends the study further to the west, covering the area of Gulf of Bothnia and Gulf of Finland joint where significant seismic activity was observed and known Osmussaar earthquake ($M=4.6$) occurred in 1976. The seismotectonic parameters of this earthquake are very important for seismic hazard assessment of the Baltic shore as a whole but its tectonic position and dynamics were not identically defined. In this study we used GPS data of Finnish, Sweden, Estonian and Latvian stations which were prepared by GIPSY 6.2.1 with adding all loading correction (atmospheric, ocean and hydrology). Then the regional strain field was mapped and analyzed by GRID-STRAIN (Teza et al., 2007) and 1976 earthquake source zone was studied by COULOMB 3.1 (Toda et al. 2005, Lin, Stein 2004) soft in 3D. The stress-strain condition results were compared between and with other regional geological and geophysical data. In the result, the active fault zone parameters were specified more exactly. Besides, it was supposed that this earthquake source had a non-double couple focal mechanisms. The strain field of Lake Ladoga — Eastern Gulf of Finland region has been previously studied (Assinovskaya et al. 2012) using specially processed GPS data. The GPS station velocities on long term observation by GIPSY 5.0 were estimated. Analyzing the strain field it was supposed that the borders between areas of different strain-stress state point to the regional active faults position. The data obtained were compared with regional tectonics and earthquake focal mechanisms. The specified consistency between

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3D cross-well travelttime tomography in the thin-layered media

Fokin, I., Grigoriev, A., Oshkin D., Vladov M., and Tikhotskiy, S. (Institute of Physics of the Earth RAS, Moscow, Russia)

We present the experience of the seismic tomography application for the 3D cross-well engineering study. The background model consists of the thick (5–10 m) low-velocity rotten sandstone layers with some thin (2–3 m) high-velocity limestone layers. Limestone contains cavities filled by low-velocity sand and clay mixture. The central frequency of the seismic source is about 750 Hz, which implies the wavelength of 2–3 meters, i.e. of the order of the limestone layers thickness. This velocity pattern poses specific questions regarding the possibility of the adequate model reconstruction, limits of resolution, non-uniqueness of the inversion and role of the acoustic logging information. We investigate these problems using synthetic tests and field data.

On the pole tide excitation of seismicity

Gorshkov, V.L., and Vorotkov, M.V. (Central (Pulkovo's) astronomical observatory of RAS, St. Petersburg, Russia)

The NEIC seismic database up to 2011.0 was used for search of pole tide influence on the intensity of seismic process. The pole tide is generated by the centrifugal effect of polar motion on the Chandler and annual frequencies (0.84 – 1.0 cpy) with the radial displacement up to 2 cm. Their beat frequency is equal to 0.16 cpy. These frequencies (for Chandler wobble in doubled frequency) were revealed in series of seismic intensity calculated for the 0.05 year time span. These long-period components in seismic intensity are robust to the change of interval (up to 0.2 year) and to minimal used magnitude (from 3.0 to 4.5).

It is known that seismic failure time (the mean preparation time of earthquake t) in any region is depend on energy of seismic event E as $t \sim E^{1/3}$ and hence on seismic magnitude. For magnitude up to 5.5 t is usually equal from one to some years. This failure time correlates with the oscillating stress. The degree of correlation between failure time and the phase of the driving stress depends on the amplitude and frequency of the stress oscillation and on the stressing rate. So pole tide influence on the intensity of seismic process could be revealed in the small regions where its amplitude is maximal (latitudes 30° – 60° in both hemispheres) and spatially uniform (1000–2000 km). The response of seismic intensity on the value of pole tide radial displacement was researched for various zone of seismic activity. It was revealed that pole tide influence on seismicity is approximately the same for various seismic zone and begins to show for radial displacement more than 1cm. The dependence on minimal used magnitude and depth of seismic event was not found.

Identification of a useful signal and his low-frequency component in a non-stationary seismic signal with high noise level

Gravirov, V.V., Kislov, K.V., Vinberg, F.E. (Institute of Earthquake Prediction Theory and Mathematical Geophysics, Moscow, Russia), and Ovchinnikova, T.V. (Federal Institute of Aviation Systems, Moscow, Russia)

The method for identification of the low frequency component in a non-stationary seismic signal with high noise level is based on advanced computer technology using the wavelet analysis of observed data. The main goal of this data processing system is finding the optimal fitting relation between the measured input and the required output. Application of signal wavelet decomposition allows one to identify those features in this signal which carry the information relevant to the object under study. As a result, we are enabled to examine the properties of a signal both in a physical (time) and a scale (frequency) spaces. The standard method for noise suppression is the elimination of noise components from the spectrum of the signal. In application to wavelet decomposition this can be realized in a straightforward manner by removing the detailing coefficients of high frequency levels. However, wavelets afford more ample possibilities for this kind of operation. The noise components, especially large random spikes, can also be treated as a set of local features. Specifying a threshold for their level and removing the detailing coefficients according to this threshold, one can not only diminish the noise level, but also assign the threshold limitations at several decomposition levels taking into account the concrete characteristics of noise and signals for different wavelet types. This makes it possible to design adaptive systems for noise elimination depending on noise features.

Constraints and opportunities of tectonostratigraphic modeling of the Earth crust objects as oscillatory systems

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

The mechanism of tectonic layering of the lithosphere as an oscillating system (a system of standing waves) excited by a tidal wave is

discussed. Damping of such a system creates the preconditions for rhythmic tectonic layering. We proposed a constant $C_M = R_M * \rho_M$ (R_M — radius of the Moon, ρ_M — its average density) as the momentum of the Moon mass (MMM) and a postulate that the strength of the Moon gravity is able to interact only with the volume of terrestrial rocks, equivalent to the Moon mass (MMM). To estimate the point (impulse) of the penetration depth of the tidal energy into the lithosphere the formula is proposed: $C_{pte} = C_M / \rho_{El}$ (ρ_{El} — the average density of Earth's lithosphere). The calculation of the average depth of penetration of the tidal energy shows 1500 ± 500 km, this is an occasion to highlight the main oscillatory system (MOS layer) in the outer shell of the Earth. Parameters of layering of the MOS components depend on the MOS thickness. We propose a fairly accurate and simple way to calculate the thickness of the MOS layer and to estimate an average density of the Earth lithosphere material at any its point.

Tectonostratigraphic model of the earth crust block as of an oscillation system (on example of the Pechenga block, Kola peninsular)

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

The model of tectonic layering of the Pechenga block crust as of an oscillating system with the periodic nature of the excitation due to energy of the lunar-solar tides and the activation of geodynamic processes in the decay period is presented. The paper draws on the elastic properties of the core of the Kola Superdeep borehole and of rocks from the surface of the Pechenga block. Calculation of the layering was carried out by analogy with the fading of sound (standing wave) in the string with the breaking of its in modes according to the formula $M_n = M/2^n$, where M — the crustal thickness, $n = 0, 1, 2... etc.$ — number of modes (element of layering) are all whole numbers. Confirmation of the model is the high coincidence accuracy of the model boundaries with intervals of rocks - stress raisers at the comparison of the model fragment (interval 0–12 km) with dynamic rock types in the SD-3 section. The phenomenon of wave control over geodynamic processes (taken as the basic idea), considering its global nature, requires further, more detailed study.

A localization of weak seismic events near Valaam island (Ladoga graben)

Karpinsky, V.V. (Geophysical Survey RAS, St. Petersburg, Russia), and Prostnyakov, K.V. (St. Petersburg State University, St. Petersburg, Russia)

The only permanent seismic station was established on Valaam island in 2010. The continuous data recorded so far include a significant number of weak high-frequency (1–20 Hz) events. As exact epicentral location of micro-earthquakes with only one station is not feasible, a larger temporary network was deployed on the island in the summer months 2010–2012, with 3–5 stations recording simultaneously.

So far, a significant volume of geological data on Ladoga lake graben indicate post-glacial Quaternary tectonic re-activation. The quantitative data on seismic event distribution could constrain tectonic models, and so could be important for areal seismic risk re-evaluation. Since the advent of instrumental seismology, a few M3 earthquakes have been recorded within NW part of the lake. According to the Finnish regional network, series of seismic events have been recorded in this area in 1959–61.

We have analyzed three-component seismic records (1 Hz sensors) which were recorded by the local network in June 2011 and 2012. Out of continuous data stream, time intervals were manually chosen for processing, based on appearance of signal in the frequency band from 3 to 15 Hz at all stations of the network. Immediately apparent was the emergence of 3 event series (10 events in each, each event a few seconds duration, followed with interval of about a minute). In total, over 100 events were selected for formal semblance processing. Events have been grouped on the basis of the minimum dispersion of inter-event correlation maxima time delays. Correlation was computed between same channels over all of the event pairs, and dispersion was obtained from sample of different channels for a given event pair.

Events in the three obvious series (on June 8, 22, 25 in 2011) were found to have the minimal inter-event correlation dispersion over channel sample space. Events of the first and third series have similar interstation delays, the second series acting slightly different. Event waveforms are stacked over series to improve SNR. Time-delay residual is calculated over rectangular grid to estimate epicenters along with uncertainty. V_p and V_s velocity values are estimated from Rayleigh dispersion curves. Dispersion curves were partially recov-

ered from inter-station vertical channel correlation using all available data after one-bit amplitude normalization.

Sensitivity of broadband seismic instrument parameters to environment

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

The principal difficulty in the way of designing effective broadband seismic instruments, including tiltmeters, consists in noise that is frequently not of seismic origin and whose effects on the instrument are increasing as the instrument's response function is expanded to longer periods. Environmental sensitivity is sensitivity of instrument parameters to its environment (pressure changes, temperature changes, magnetic field variations, etc.). For many years authors investigated these effects that changes in external conditions have on the operation of broadband devices and on their output signal. These studies provide a comprehensive analysis of diverse methods for noise suppression. Authors investigated effects such as changes of temperature, air pressure, magnetic field, humidity, snow cover and groundwater table, examined the effects of thunderstorms, vibration, air currents, gravitational excitation, and so on. We examined the design elements of instruments, determined the effects of inelastic spring strain, Brownian motion under the instrument case, verified the sensitivity of the broadband instrument's response function to variations in the parameters of the elements around nominal values, and so on. Some interesting findings and recommendations are presented.

Thermochemical structure of the Siberian craton lithospheric mantle inferred from long-range seismic profiles Craton, Kimberlite, Rift and Meteorite

Kuskov, O.L., Kronrod, V.A., Prokofyev, A.A. (Vernadsky Institute of Geochemistry and Analytical Chemistry, Moscow, Russia), and Pavlenkova, N.I. (Institute of Physics of the Earth, Moscow, Russia)

Based on a self-consistent thermodynamic approach within the Na₂O-TiO₂-CaO-FeO-MgO-Al₂O₃-SiO₂ system with solid solutions, we map

the 2-D thermal and density structure of the lithospheric mantle beneath the Siberian craton by inverting P-velocities from long-range seismic profiles Craton, Kimberlite, Rift and Meteorite carried out in Russia with peaceful nuclear explosions, and taking into account geochemical constraints on depleted garnet peridotite xenoliths and primitive mantle composition. Our models predict significant lateral temperature variations in the lithospheric mantle. The temperature profiles exhibit a substantial decrease in temperature beneath the craton as compared to the average temperature in the surrounding mantle and paleotemperatures inferred from thermobarometry of Yakutian xenoliths. We find that cratonic root is 300–400°C colder than tectonically younger average continental mantle. The seismically derived temperatures allow us to constrain the thermal structure of the Siberian lithospheric mantle and show that the craton's center is about 50–70°C colder than its marginal parts. The present-day geotherms pass close to the 32.5–35 mW·m⁻² conductive models and suggest a low mantle heat flow, 11–17 mW·m⁻². Geotherms calculated for depleted and fertile compositions differ from each other by less than 20–50°C, which is associated with the negligible influence of chemical composition on seismic velocities. We find that lithospheric thermal thickness of the Siberian craton does not depend significantly on xenolith compositions. Therefore, the discrimination of fine differences in the composition of the lithospheric mantle as well as a location of the base of the chemical boundary layer (or petrologic lithosphere) by seismic methods only does not seem possible. The depth of the thermal lithosphere is close to the 1450°C isotherm and is estimated as 300–330 km thick for all the seismic profiles that correlates with the base of lithosphere found from theoretical and seismic density. At this depth, a modeled density (3.49 g·cm⁻³) is consistent with the AK135 and PREM density (3.486–3.4895 g·cm⁻³).

Geoacoustic and deformation observations in the seismoactive region of Kamchatka peninsular

Larionov, I.A., Marapulets, Y.V., Shevtsov, B.M., Mizhenko, M.A., Zherbina, A.O., and Solodchuk, A.A. (Institute of Cosmophysical Research and Radio Wave Propagation FEB RAS, Kamchatka, Paratunka, Russia)

The results of geoacoustic emission investigations which have been

carried out on Kamchatka peninsular since 1999 are presented. The peculiarity of the experiments is the application of broad-band piezoceramic hydrophones for the registration of the emission; the hydrophones are installed in water by the bottom of natural and artificial pools. Application of such type receivers allows us to broaden the registration frequency range up to 0.1 Hz–11 kHz in comparison to standard hydrophones. Simultaneously with that tree-component vector receivers with the same frequency range are used to study the spatial of structure geoacoustic emission and the character of medium particle movement in a wave. During the investigation it was determined that 1–3 days before strong earthquakes anomalies of geoacoustic emission in kilohertz frequency range are registered at the distances of first hundreds of kilometers from an epicenter. As an anomaly we consider a sharp increase of geoacoustic impulse amplitude and frequency similar in form to micro-earthquakes which last from tens of minutes to several hours. Signals at such frequencies cannot propagate from epicenters of preparing earthquakes and are response of a medium at the registration point to the activation of deformation processes. The forming field of stresses determines emission source primary orientation, which may be determined by vector-phase methods. The results of joint investigations of the emission and the Earth's surface deformations confirmed that anomalies are observed before earthquakes during considerable increase of deformation rate both during near surface rock compression and tension.

Features of the dynamics of formation of the main crack

Lementueva, R.A., Bubnova, N.Ja., and Treussov, A.V. (Institute of Physics of the Earth, RAS, Moscow, Russia)

We present the results of studying the process of deformation of rock samples under the influence of slowly increasing pressure (up to 24 hours). In contrast to previous studies [Sobolev and Ponomarev, 2003], in our work for a long-term loading, we used non-explosive mixture to break samples [Lementueva and Bubnova, 2009]. A dolomite was used as the sample. The appearance of internal defects in the samples caused the acoustic signals (AS) of varying amplitude. Registration of signals was performed by measuring-computer complex Aline-32. For the analysis we selected AS with an amplitude of 5 times greater the noise. A computer program was developed which

allows to determine the coordinates of the AS source using the first onset times of waves at the sensors located on opposite sides of the main crack. Analysis of the AS source coordinates can delineate the zone of the main crack. The nature of the location of AS sources in the sample shows a clustering of the future zone of destruction and the displacement of separated groups and shear cracks.

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2. Lementueva R.A., Bubnova N. Ja. Acoustic emission and testing of new methods of non-explosive mixture of breaking the destruction of rock samples. // Geophysical Researches (in Russian), 2009, Vol. 10, N 4, p.64–70.

Local magnitude scale for the North-West part of the Russian Federation

Munirova, L.M. (Geophysical Survey Russian Academy of Sciences, St. Petersburg, Russia)

A total of 667 synthesized Wood-Anderson S_g , L_g , R_g wave recordings from 210 local and regional seismic events were used to establish M_L magnitude scale for the North-West part of the Russian Federation. The hypocentral distances of the events range from 20 km to 800 km and the reported magnitudes from 0.7 to 3.5. The attenuation function ($-\log A_0$) in Richter's original definition of M_L , magnitudes and station corrections for the three stations used in this study were determined by a multiple linear regression analysis. The results are as follows:

$$Q(R) = -\log(A_0) = 1.285 \cdot \log(R) - 0.00109 \cdot R - 0.944 + S,$$

for $3 \text{ km} \leq R \leq 150 \text{ km}$

$$Q(R) = -\log(A_0) = 1.102 \cdot \log(R) + 0.00073 \cdot R - 0.996 + S,$$

for $150 \text{ km} \leq R \leq 800 \text{ km}$,

where R is hypocentral distance in kilometers and S is station correction. The absolute levels of the attenuation functions were adjusted so that at 100 km curve equal the revised for $-\log(A_0)$ southern California. Experience has shown that two stations Valaam (VAL) and Vyborg (VYB) which are located on a rock site, the maximum amplitudes on vertical and horizontal components are similar, while

the station Krasnoe ozero (IZM) is located on soil, horizontal amplitudes are higher than vertical amplitudes due to soil amplification. A station corrections were determined to compensate for the site conditions. The difference in magnitudes computed from the above distance correction functions was less than 0.1 units. The local magnitude M_L is defined as $M_L = \log(A) + Q(R)$, where A is the maximum amplitude on a Wood-Anderson seismogram, $Q(R)$ is a distance correction function and R is hypocentral distance.

Numerical simulation for velocity model building using migration of multiples and VSP data

Nasyrov, D.A. (St. Petersburg State University, St. Petersburg, Russia), Kiyashchenko, D.A. (Shell International E&P), Kiselev, Yu.V., Kashtan, B.M., and Troyan, V.N. (St. Petersburg State University, St. Petersburg, Russia)

We demonstrate the original method for the migration velocity analysis with VSP data. The method is based on the use of surface-related multiples jointly with the primary reflected data for the VSP imaging. Velocity updates are carried out by matching the images obtained by using different types of waves. To do it automatically we introduce a cross-correlation type objective function and develop a maximization algorithm based on the adjoint-state method. We show that maximization of the cross-correlation of the images built on different types of waves allows to retrieve the velocity parameters. At the same time the refinement of the velocity model could lead to significant improvements of the seismic images.

VSP data are used to obtain the high-resolution images of the subsurface in the areas around a borehole. But the accuracy of this imaging strongly depends on the background velocity model used for migration. Usually, the velocity updates derived from VSP data are based on tomographic inversion of the direct arrival travel times, but this inversion provides velocity estimate in the model areas located above borehole receivers. One way to improve the velocity model below the receivers is to use methods based on migration (for example, flatten Image Gathers (CIGs)). However, the problem with VSP acquisition is that the reflection angle range for the waves illuminating an image point strongly depends on the receiver array length and the image point location with respect to a well. For velocity updates,

it is better to have wider range of angles. We propose to use the surface-related multiples jointly with the primary reflected waves to enlarge the angular coverage of the reflection points. Due to different multiple ray paths, they illuminate the target with alternative incidence angle even for one receiver in the well.

The results of numerical study of the properties of the proposed method using a set of 2-D models are considered.

Establishment of borehole observation system and high resolution seismic studies in the western part of the main Marmara Fault in the frame of a EU-FP7 project titled as MAR-SITE

Ozel, O., Pinar, A., and Yalcinkaya, E. (Istanbul University, Istanbul, Turkey)

The main objective of this study is to install a multi-parameter borehole system and surface array as close to the main Marmara Fault (MMF) in the western Marmara Sea as possible, and measure continuously the evolution of the state of the fault zone surrounding the MMF and to detect any anomaly or change which may occur before earthquakes by making use of the data from the arrays already running in the eastern part of the Marmara Sea. The multi-parameter borehole system will be composed of very wide dynamic range and stable borehole (VBB) broad band seismic sensor, and incorporate 3-D strain meter, tilt meter, and temperature and local hydrostatic pressure measuring devices. The borehole seismic station will use the latest update technologies and design ideas to record "Earth tides" signals to the smallest magnitude -3 events. Bringing face to face the seismograms of microearthquakes recorded by borehole and surface instruments portrays quite different contents. The shorter recording duration and nearly flat frequency spectrum up to the Nyquist frequencies of borehole records are faced with longer recording duration and rapid decay of spectral amplitudes at higher frequencies of a surface seismogram. The main causative of the observed differences are near surface geology effects that mask most of the source related information the seismograms include, and that give rise to scattering, generating longer duration seismograms. In view of these circumstances, studies on microearthquakes employing surface seismograms may bring on misleading results. Particularly, the works on

earthquake physics and nucleation process of earthquakes requires elaborate analysis of tiny events. It is obvious from the studies on the nucleation process of the 1999 earthquake that tens of minutes before the major rupture initiate noteworthy microearthquake activity happened. The starting point of the 1999 rupture was a site of swarm activity noticed a few decades prior the main shock. Nowadays, analogous case is probable in western Marmara Sea region, prone to a major event in near future where the seismic activity is prevailing along the impending rupture zone. Deploying a borehole system eastern end of the Ganos fault zone may yield invaluable data to closely inspect and monitor the last stages of the preparation stage of major rupture.

The Earth's outer spheres structure and global tectonics

Pavlenkova, N.I. (Institute of Physics of the Earth, Moscow, Russia)

There are different concepts of the global tectonics but up to now they cannot explain some regularities in the Earth structure. For instance, no conception explains the differences between the Pacific and the other oceans. The Pacific continental margins form a proper arc, along which a ring of the earthquake epicenters are formed. This ring has deep roots in form of higher seismic velocity zones cutting the whole mantle. Around the Pacific two global gravity anomalies, positive and negative ones, are observed. This ocean determines the Earth's division into two hemispheres with lower and raised surfaces which are characteristic of some other planets.

The most important features of the Atlantic and Indian oceans are the regular system of mid-ocean ridges (MOR) and the absence of the corresponding subduction zones beneath the surrounding continents. The rift system forms a ring around Antarctica and the fracture zones which drift apart from this ring along the meridians with about the same distance between them.

The MOR system agrees with the idea of the Atlantic and Indian oceans formation as a result of the Earth's expansion, mostly of its southern hemisphere. It is confirmed by the astronomical data. The Pacific has another origin. It may be proposed that in its area the continental crust was never formed due to low deep fluids flow. According to petrological data the thick continental lithosphere was formed from

the mantle matter saturated with fluids. The long process of the continental crust formation should lead to the depletion of mantle rocks, their crystallization and formation of the thick continental "roots".

The greatest volume of the continental crust is related to the Proterozoic time. During this period the area of the increased fluid flows may be assumed in the Southern hemisphere, because according to the paleomagnetic data all the continents were located at that time in that hemisphere. In the Pacific areas, where the fluid flows were weak, only some separate spots of the intermediate type crust appeared. The formation of the thick continental "roots" in the southern hemisphere has led to asymmetry of the planet and can lead to the turning of the whole mantle around the liquid core. Such mantle rotation explains the palaeomagnetic data and it does not destroy the observed structural regularities of the Earth.

Nature of the upper mantle stratification in the Northern Eurasia: results of the long-range seismic profiling with nuclear explosions

Pavlenkova, G.A., Pavlenkova, N.I., and Kazeykina, E.V. (Institute of Physics of the Earth RAS, Moscow, Russia)

Several long-range seismic profiles with large chemical and 25 Peaceful Nuclear Explosions were carried out in Russia to study the mantle structure. 2-D and 3-D velocity models were constructed for all these profiles using a common method for the wave field interpretation. The profiling reveals several specific features of the upper mantle structure. It is difficultly presented in the traditional lithosphere-aesthenosphere model. From the heat flow data the Siberian "thermal" lithosphere is outlined by a zone of possible solidus at around 200–300 km depth. The upper-mantle model shows the absence of a velocity inversion at these depths. On the contrary, the low velocity layers are often observed in the lithosphere at depth of 80–100 km.

Several basic boundaries were traced over the study area. Two most important of them are N1 boundary at a depth around 100 km and L boundary at a depth of 200 km. It is also unexpected result because the seismic velocities do not depend on the mantle composition and no phase transitions were revealed at the boundary depths. All the boundaries are not simple discontinuities, they are heterogeneous (thin layering) zones which generate multiphase reflections. Such

boundaries and the low velocity layer may be a result of fluids concentration at some critical PT levels. The fluids change mechanical properties of the matter, they initiate partial melting of the mantle material. The xenoliths from the Siberian Craton kimberlites taken from the depths of the basic boundaries have indications of film melting. The deep earthquakes are also concentrated around the depths of 100 and 200 km. They may be a result of deep fluids detonation at these critical PT levels.

Another structural feature of the upper mantle is the regular change of horizontal inhomogeneity with depth, which determines three layers of different plasticity. Beneath the N boundary the block structure typical for the upper brittle part of the lithosphere disappears and low velocity layers are often observed. Beneath the L boundary the mantle structural pattern is changed too: the H boundary has a mirror form relative to the upper boundaries. This indicates the increasing of the matter plasticity, which makes an isostatic equilibrium of the upper mantle. At these depths the Q-factor is also decreased.

Variation of strain-stress state of Eurasia under Earth's oscillations with the periods more than 1 hour

Petrova, L.N. (St.Petersburg State University, St.Petersburg, Russia)

The data on 3 long-term deformations recorded by seismogravimeter at St.Petersburg are analyzed. The first deformation by duration of 12 days (1–12.12.2004) preceded the Sumatra earthquake of 26 December 2004 (M=9) with tsunami. The excitement of a set of deep earthquakes took place during the second deformation occurred from 8th August to 20th October, 2005. Deep earthquakes with high magnitude and catastrophic tsunami in Japan occurred during the 3-rd deformation recorded from 13.02 to 04.04.2011. It is revealed that last deformation was characterized by a maximal velocity of acceleration variation in its first phase corresponding to dilatation deformation. Its value exceeds the similar characteristic of deformation on an order in 2004 and in 1.5 times in 2005.

Spectral and time data representations (FTAN charts) are obtained from synchronous records of seismogravimeters at SPbGU (Russia), SSB (France), HYB (India) and INU (Japan) during the most long

deformation of 2005. FTAN charts are calculated on the basis of continuous rows of 7 days duration in the frequency range 30–450 mHz (corresponding periods 0.6–5.5 hours). Observations are performed before earthquakes with $M > 7$ and with different focal depths and epicenter locations on the planet. The spectral areas in which there is a continuous change of frequency (increase or reduction) within 20–30 hours are revealed from FTAN charts of synchronous records. The speeds of this change have close values for different frequencies. The boundary values of frequency areas repeat in a number of the synchronous observations forming profiles from pairs of stations both in the E-W (SSB-INU) direction, and in the N-S (SSB-SPbGU) direction. Thus the reduction of intensity of analyzed seismic process (with various degree of expressiveness) and change of spectrum structure are observed at all stations and at the same time. This effect is observed approximately in 3 days before earthquake. The change of oscillation frequency fixed in FTAN charts is supposed to consider as a characteristic of deformation of the geophysical environment, namely, increasing of frequency corresponds to dilation, and vice versa, decreasing of frequency corresponds to compression of environment.

Tohoku earthquake 11.03.2011

Polets, A.Yu. (Institute of Marine Geology & Geophysics (IMGG) FEB RAS, Yuzhno-Sakhalinsk, Russia)

Japan is one of the world's most earthquake-prone countries, it is located in an area where several continental and oceanic plates meet. The border of two giant tectonic plates – the Pacific plate and the Asia plate is located in 150 km to the east of the Honshu Island from north to south. A great Tohoku earthquake with magnitude $M_w = 8.9$ occurred of the east coast of Honshu, Japan, on 11 March 2011. The earthquake occurred at the Japan Trench at the junction of these plates in the subduction zone between the Pacific and Eurasian plates. The earthquake was located about 130 kilometers east of Sendai and 373 km north-east of Tokyo. It generated a large tsunami with wave heights of about 10 m on the Japanese coast. The earthquake and tsunami have caused considerable damage in Japan. The death toll for the March 11, 2011 earthquake is more than 15 300 people. This earthquake is the strongest in the history of the country according to

the Japan Meteorological Agency and one of the ten strongest earthquakes in the history of seismic observation in the world. According to USGS, the parameters of the event 11.03.2011, were $\phi = 38.320\text{N}$, $\lambda = 142.370\text{E}$, focal depth was 29.0 km. Seismic activity began to increase on March 9, 2011. A series of large foreshocks were recorded approximately 40 km from the epicenter of the main shock. The first major foreshock was a 7.2 Mw event on 9 March. The most powerful foreshock was with moment magnitude $M_w = 7.5$. A series of aftershocks with magnitudes $M_w=7.0$, $M_w=7.4$, $M_w = 7.2$, and numerous smaller quakes followed after the main shock 11.03.2011. The depth distribution of aftershocks from 11 to 20 March showed that the most events (793) occurred in the interval from 30 to 40 km. The earthquake on 11 March 2011 occurred under the influence of both tensile and compressive stresses. According to the Streltsov classification the type of focal mechanism is low-angle overthrust. As the fault plane should be considered the sub-vertical nodal plane. Stress reconstruction of the earth's crust before this earthquake was performed on the basis of the cataclastic analysis method and data on stress relief for Tohoku Earthquake. The preparation area of the Japan earthquake is characterized by medium values of effective pressure the focus of this earthquake was located in a local minimum of the effective pressure.

Seismic models and results of deep drilling at the Fennoscandian Shield

Sharov, N. (Institute of Geology, Karelian Research Centre RAS, Petrozavodsk, Russia)

The nature of geoacoustic waves is discussed, based on comparison of the results of seismic and acoustic studies in the Fennoscandian Shield with the drilling record of the Kola Superdeep Borehole: 12262 m (1970–1990), Russia; Gravberg 6337 m (1986–1987), Sweden, Outokumpu 2516 m (2004–2005), Finland; Pogranichnaya 5200 m (2004–2006), Russia; Onezhskaya, 3537 m (2007–2009), Russia. The assumption that the crystalline crust has a heterogeneous structure with gradient variations and elastic wave velocity inversions and the vertically and laterally varying degree of differentiation is well-based. The nature of seismic boundaries depends on differences in rock composition and the physical state of the rocks. The majority of seismic section obtained at the surface showed high minuteness

and close conformity with the real geological section only at the first kilometers down from the surface. In crustalline metamorphic massifs of Fennoscandia the minuteness of sections at depths exceeding 7–10 km essentially decreases. At the same time the study of real sections of deep and superdeep sections did not show a substantial decrease in alternation of rock varieties with depth. To our mind, the reason for this is repeated splitting of seismic rays at the boundaries of deep layers with various elastic anisotropic properties. This splitting is accompanied by attenuation and absorption of the rays. The results of geophysical studies, conducted during deep drilling in the Fennoscandian Shield, make investigators re-interpret the geological and geophysical data.

Investigation of Bezymianny volcano by travelttime seismic tomography

*Shishkina, M.A., Tikhotsky, S.A., Fokin, I.V., and Akopova, S.S.
(Institute of Physics of the Earth RAS, Moscow, Russia)*

Last ten years due to densifying of seismic station network near volcanoes of Kluchevskoy group (Kamchatka) new data were collected, allowed us to make the investigation of construction of magmatic systems more detailed and reliable by means of travelttime seismic tomography. This is urgent task of up-to-date Kamchatka seismology, which can help to interpret and predict activity of volcanoes of Kluchevskoy group. This work is dedicated to investigation of the construction of Bezymianny volcano by seismic tomography. It aims to building the model of interior of the volcano and explaining observed eruptive processes.

We solve this task on the base of data, obtained during the observations within "PIRE" project of investigation of volcanoes in Alaska and Kamchatka. This project made special dense network of seismic stations around Bezimianny volcano, which hadn't been there anytime before. The data is processed only partially nowadays. In this work we present the results of processing data for several months of volcanic activity, including the comparison of manual and automatic picking of wave-breaking. The work is based on materials of "PIRE" project and of Kamchatka Branch of Geophysical Survey. The algorithm of seismic tomography with adaptive parameterization is elaborated in Institute of Physics Earth (IPE RAS).

Observations of parametric variations in deep cross-sections from microseismic sounding method in association with the 2011 Great East Japan Earthquake (Mw 9.0)

Stepanova, M.Yu., and Gorbatikov, A.V. (Institute of Physics of the Earth RAS, Moscow, Russia)

To estimate the parametric variations in deep cross-section we used microseismic sounding method (MSM) utilizing the fact that velocity heterogeneities disturb in their vicinity the spectrum of low-frequency microseismic field. At the Earth's surface above high-velocity inclusions spectral amplitudes decrease for definite frequency f , and above the low-velocity ones they increase.

We used continuous records of STS-2 seismometers of F-NET network (Japan). The nearest to 2011 GEJE station KSN is located 105 km away from epicenter. It appeared to be sensitive to parametric variations of the medium tied with preparation and realization of the earthquake. The TYS station (138 km from epicenter) was chosen as the basic. Continuous spectrograms were constructed for period from 03–2005 until 05–2012. The common variations of KSN and TYS stations were removed by referring the spectrograms of one station to another. The rest part represents parametrical variations of KSN station.

From compensated spectrogram one can see systematic increase in intensity in the range 50-120 seconds from December to April of every year during the period of more than 5 years before the earthquake. 2 years prior to earthquake it is possible to notice narrow-band increase of intensity near period of 45 seconds from December to June of every year. It is clearly visible that after earthquake within the next year from December to April increase of intensity in the range 50-120 seconds disappears that is obviously connected with the occurred earthquake. According to interpretative model of MSM it can mean that under KSN station: 1) V_s decreases at the depth ~ 70 -80 km during the winter and spring period two years before the EQ and directly ahead the EQ; 2) V_s decreases in the range 80-200 km during the winter and spring period within 5 years; 3) V_s gets stabilized after EQ in all range of depths.

The depth of the upper border of the Pacific plate under KSN makes ~ 70 km. Presumably we see periodic activation during the winter-spring period of a seismofocal zone to depths of 200 km within 5 years before earthquake and activation of narrow upper border of the zone 2 years before the event. The local seismicity during this

period proves the activation to be true. The behavior of seismicity ($M=4$) within study area correlates with the revealed features of spectrograms.

Once again about the resolution issues in the travelttime seismic tomography

Tikhotskiy, S., Fokin, I., and Shishkina, M. (Shmidt Physics of the Earth Institute RAS, Moscow, Russia)

Despite the rapid evolvement of the waveform inversion methods travelttime seismic tomography still remains one of the most used approaches in regional seismology studies. Moreover in recent years one can see many examples of the travelttime tomography applications in the exploration and engineering problems. Extrapolation of methods from regional to local scale rises some doubts and illuminates hidden problems, because new applications require the resolution of details that is near to the theoretical resolution limit. We review the problem of the adequate resolution estimation and treatment in travelttime seismic tomography. Using waveform modelling we examine the problem of the "physical" resolution limit, i.e. that defined by the Fresnel zone. We further investigate the issues of the "mathematical" resolution, i.e. that defined by the inherent properties of the tomography inverse problem. Particularly we discuss the problem of the numerical estimation of the local resolution power and its relation to the ray coverage. Reconstruction of the velocity structure with the reasonable non-uniform resolution is in the center of the discussion.

Intraplate seismicity in northern Fennoscandia from data of the POLENET/LAPNET experiment

Usoltseva, O.A., Konstantinovskaya, N.L. (Institute of Geosphere Dynamics, RAS, Russia, Moscow), Kozlovskaya, E.G. (Sodankylä, Geophysical Observatory, University of Oulu, Finland, Oulu,) and the POLENET/LAPNET Working Group Team

The region of Tornio river (22–26 deg E and 66.5–69 deg N) is very interesting for seismological studies because it is crossed by systems

of tectonic faults spreading in two different directions. 56 local earthquakes originated from this region were recorded by the POLENET/LAPNET temporary array from May, 2007 to May, 2009. Hypocenter depths of earthquakes are in the range of 1–35 km and their magnitudes vary from 0.8 to 2.2. In addition to local earthquakes, the array recorded 364 blasts from this region during the POLENET/LAPNET observation period. We relocated local earthquakes using manually measured arrival times of refracted P waves at stations at local distances (less than 250 km) and the 1-D velocity model along the wide-angle reflection and refraction HUKKA profile. Program HYPOELLIPS (Lahr, 1980) and grid search method (Nelson, Vidale, 1990) were used for relocation. Usage of different location algorithms helped to find 25 events with stable parameters of hypocenter. Difference in horizontal coordinates is less than 3.5 km and difference in depth is less than 7 km for hypocenters determined by different methods and the RMS error after relocation was less than 0.4 s. We found that 7 earthquakes from this group originated from depths of 20–35 km. The epicenters of events correlate well with known faults in the area and also with aeromagnetic anomalies. We also estimated focal mechanisms of two events with largest magnitude and good data quality. Both mechanisms were of strike-slip type, with nodal plane uncertainties about 30 degrees. Strike of focal planes of both solutions correlate well with known faults. Our results indicate that two groups of faults in the area of Tornio River are active. Generally, the intraplate seismicity in the northern Fennoscandian shield is not diffuse and does not necessary originates from known post-glacial faults.

Recognition of an earthquake first appearance by neural network

Vinberg, F.E. (Institute of Earthquake Prediction Theory and Mathematical Geophysics, Moscow, Russia)

The algorithm of recognition of an earthquake first appearance designed for using with very noisy seismic signal. Special attention has been paid to work the algorithm in condition of high level seismic anthropogenic noise. The algorithm is based on the signals recognition by neural network. The type and parameters of a network must set up independently for each region of possible using. The main idea

of the algorithm is fast real-time detection of a sudden change in the monitoring noisy seismic process. It was shown that for detection of the earthquake first appearance is enough only a few (from 4 and up to 5) seconds. The algorithm is developed as part of system for using in automatic early warning earthquake systems that can work in very noisy seismic condition.

New method for 3D travel time tomography and its application for estimating velocity distribution in the mantle lid below Black Sea basin

Yanovskaya, T.B. (St.Petersburg State University, St.Petersburg, Russia), and Gobarenko, V.S. (Institute of Geophysics, NAS, Simferopol, Ukraine)

A method for 3D ray tomography that uses the data on the travel time residuals of body waves is outlined. The underlying assumption of the method is smoothness of horizontal velocity variations. The region under study is divided into layers, and the velocity correction in each layer is assumed to depend only on horizontal coordinates. The starting velocity model is specified as a function of depth, which for simplicity may be described by a linear function. The procedure for determining the unknown horizontal velocity variations is reduced to solving the 2D tomography problem in a way similar to that previously developed for the surface wave tomography. Resolution is estimated jointly with determining the velocity variations. This approach does not require adaptive parameterization of the medium, i.e. division of the region into blocks, each of which should be intersected by a sufficiently large number of rays. The method was tested at some numerical models.

The method was applied for estimating 3D P-wave velocity distribution in the mantle lid below the Black Sea depression. The data used are P-wave travel times from local events recorded by the stations located around the Black Sea as well as DSS data along some profiles crossing the Black Sea. Total number of the data is about 7000. Effect of the crust on the travel time residuals was removed on the basis of a new crust model. Velocity distribution was estimated in the depth interval from Moho down to 160 km. Resolution estimated by the checkerboard test delineates the area where the anomalies of size greater than 200 km may be revealed with confidence. It was found

that the mantle lid under the Black Sea is strongly inhomogeneous laterally. The results confirm the existence of three zones of different structure: East and West Black Sea Basins and the Mid-Black Sea Ridge.

Upper mantle structure in the vicinity of the Tornquist-Teisseyre zone from the ambient noise surface wave tomography

Yanovskaya, T.B., Koroleva, T.Yu., and Lyskova E.L. (St. Petersburg State University, St. Petersburg, Russia)

Methods for suppression of the effect of earthquakes on the cross-correlation function (CCF) of seismic ambient noise are analyzed. It is shown that elimination of the parts of seismograms with earthquake M5 records does not lead to satisfactory results: effect of earthquakes though decreasing but is not completely excluded. Much better result turns out to be if we use the records for the years without clusters of earthquakes within areas of small size. It was shown that such years are 2001, 2002, 2003. The results are improved by summation of CCFs for these three years. Using such an approach we obtained the CCFs at pairs stations of and correspondingly Rayleigh wave dispersion curves at the interstation paths crossing the East-European Platform and the eastern part of the West Europe. Lateral distribution of the Rayleigh wave velocities are obtained in the period range of 10-100 s from which local dispersion curves are determined in some selected points in the study region. The local dispersion curves are used to reconstruct vertical velocity-depths curves for S-waves on a grid. Finally lateral S-wave velocity variations at different depths in the upper mantle in the depth interval of 50–300 km are obtained. A considerable difference in the upper mantle structure at the opposite sides of the Tornquist-Teisseyre Line (TT) is found out: in the asthenosphere (100–200 km) S wave velocities at the western side of TT are found be lower than at the eastern side, and vice versa, at large depths (250–300 km) the velocities at the western side are higher than at the eastern side.

Gravity signal from the lithospheric mantle of the Black Sea constrained by seismic tomography model

Yegorova, T., and Gobarenko, V. (Institute of Geophysics, National Academy of Sciences of Ukraine, Kiev, Ukraine)

At present the BS consists of two large depressions — the West- and East-Black Sea basins filled with thick (up to 12 km) Cretaceous sediments and underlain by a thin crust of oceanic/sub-oceanic type. Velocity structure of the Black Sea lithosphere has been studied by new seismic tomography method using the P-wave data from the earthquakes occurred inside the study region and recorded by seismic stations located around the BS. Derived velocity distribution represents the BS not as single velocity domain, but rather heterogeneous one with two distinct areas of increased velocities within the western and eastern part of the BS. Independently we implemented a 3D gravity analysis, which results in residual gravity anomalies obtained by the removing from the initial field the gravity effect of constrained layers. The final residual anomalies (after stripping away the sea water, sediments, Moho topography and large scale crustal heterogeneities) reveal no significant long wavelength anomalies attributed to density variations in the upper mantle. The seismic tomography and the gravity analysis approaches were integrated by calculating the upper mantle gravity effect of the tomography model and comparing this to the mantle gravity signature inferred from the gravity analysis itself. Gravity signal from the lithospheric mantle, calculated from density equivalent of mantle velocity model from seismic tomography, outlines two areas of small positive gravity in western and eastern parts of the BS. In general this mantle impact agrees with that derived by 3D gravity analysis. Both approaches reveal slight positive mantle gravity signal that could be indicative of lack of the asthenosphere or mantle diapir at the depth less 100 km below the BS and on the presence of reologically strong and cold continental lithosphere below the BS. This corresponds with very low surface heat flow and low deep calculated temperatures within the study region.

Structure of the upper mantle of Russia from joint 2D velocity/density models on seismic profiles with peaceful nuclear explosions

Yegorova, T.P. (Institute of Geophysics, National Academy of Sciences of Ukraine, Kiev, Ukraine), and Pavlenkova, G.A. (Institute of Physics of the Earth, RAS, Moscow, Russia)

The super-long seismic profiles, carried out in Russia using the Peaceful Nuclear Explosions (PNE), provide new data for setting up joint geophysical models for the continental upper mantle structure. The obtained velocity models reveal some new features of the upper mantle structure of the Northern Eurasia. Four regular seismic boundaries are traced along all the profiles at the depths of around 100, 150, 200 and 300 km. Upper mantle down to a depth of approximately 150 km is laterally heterogeneous and is represented by blocks of high and low velocities. The asthenosphere is not traced as a continuous low velocity layer. On the contrary, the 10–20 km thick velocity inversion zone is revealed around at the depth of 100 km, which relates to a layer of high electrical conductivity that could be indicative on deep fluids concentration. The horizontal inhomogeneity of the upper mantle correlates with tectonics and heat flow data, but no straight forward correlation is found between the upper mantle velocity blocks and gravity field. Since upper mantle of different composition have the same seismic velocities, but differ in their densities, density modeling is considered to be a good tool to determine the composition of the upper mantle. In order to do that, we initiated 2D gravity modelling along the PNE seismic profiles Quartz, Craton and Kimberlit. They cross East European Platform, Urals, Pechora Basin, West Siberian Plate and Siberian Craton. Initial density models were constrained by seismic velocities using the density/velocity conversion function of Earth referent models. Initial gravity data are taken from satellite GOCE data and from the EGM2008 model of global gravity field. The modeling shows that the local high velocity blocks in the uppermost mantle correlate well with positive gravity anomalies only in the Urals, but they are not expressive in the gravity field within the Siberian Craton. The upper mantle of Siberian Craton, characterized by uplift of seismic boundaries and by high velocities, reveals decreased densities. The latter explains the strong gravity low (-100 mGal), observed in the Siberian Craton. These results could be indicative of variation in composition due to depletion of the cratonic upper mantle in Archean time.

Differential equation for geometrical spreading on a ray and second derivatives of eikonal matrix structure

Znak, P.E. (St. Petersburg State University, St. Petersburg, Russia)

Dynamic ray tracing implies calculation of geometrical spreading for the purpose of the ray method amplitude obtaining. And for 3D inhomogeneous isotropic elastic media it is usually executed by solving M. Popov's system of ordinary matrix differential equations with further determinant taking, which is exactly the geometrical spreading, or as consequence by solving the matrix Riccati differential equation followed by a special integration.

The problem whether it is possible to deduce the scalar differential equation directly for the geometrical spreading is considered. It is also shown how second derivatives of eikonal matrix can be represented in terms of geometrical spreading.

Section SEMP. Seismic-ElectroMagnetic Phenomena

Variations of induction vector before earthquake 11.03.2011 near Japan

Babak, V.I. (S.I. Subbotin Institute of Geophysics NAS of Ukraine, Kiev, Ukraine); Klymkovych, T.A. (Carpatian branch of Subbotin Institute of Geophysics NAS Ukraine, Lviv, 79060 Ukraine); Rokityansky, I.I., Tereshyn, A.V. (S.I. Subbotin Institute of Geophysics NAS of Ukraine, Kiev, Ukraine)

After recent catastrophic earthquake of 11.03.2011 near Japan we processed available data of 17 Japanese geomagnetic observatories during last 10–20 years. We used time series of 3 components of geomagnetic field with temporal reading every 1 min. Our high resolution processing program allows calculate induction vector for 5 period intervals: 2.5–5, 5–10, 10–20, 20–40, 40–60 min. We obtained monthly mean values of 4 components of induction vector A_u , B_u , A_v , B_v (where A — northern component of induction vector, B — eastern component, indexes u and v are real and imaginary components respectively) for 5 period intervals mentioned. At long periods we see annual periodic variations of induction vectors. We can suppose that earthquakes (EQ) and volcano eruption precursors have an aperiodic temporal regime appearing once or several times before EQ. Periodic variations we observed earlier both in active and stable geodynamical environment. They have by itself geophysical interest and also should be taken into account as a background for the precursors study. Aperiodic variations of induction vectors were observed at shorter periods 2.5–20 min at 4 stations [Haramachi (HAR), Kakioka (KAK), Otaki (OTA) and Kanozan (KNZ)] near the epicentral zone. These variations lasted 2–5 years (depending on station) before EQ mainly at real eastern component with clear enhancement to the shortest period. Variations of induction vector of geodynamic origin can be caused by change of underground electrical conductivity and by lithospheric EM emission. We process also the data of every observatory synchronously with the reference observatory Kakioka and obtain anomalous tensor of horizontal geomagnetic components. It reflects two mentioned causes of temporal variations differently then induction vector and can help to distinguish the causes. EM

response functions variations open new information channel from the Earth's interior useful for understanding of geodynamic processes and activities.

Polar motions and seismic activity of spreading zones in southern hemisphere

Blagoveshchenskaya, E.E. (SPbF IZMIRAN, St.Petersburg, Russia)

Astronomical observations have indicated that quasi-periodic latitude variations connected with polar motion (LV-PM) amounts of about 0.3" amplitude at every point on the globe. These variations have two main periods – annual (12 months) and Chandler's (about 14 months). The annual variations are caused by atmosphere and ocean seasonal circulations and they somehow excite Chandler's oscillations connected with the solid Earth. Energy exchange through the Earth's crust is large. So it is reasonable to suggest some relation between meridional latitude variations and seismic regional activity. This relation is most likely to occur in spreading zones.

To reveal the connection between latitude variations and regional seismic activity 2 different methods were applied and about 2 thousands earthquakes with epicenters in southern hemisphere spreading zones were used. The data on seismic events were extracted from NEIC-catalog (<http://earthquake.usgs.gov/regional/neic/>) from 1950 through 1994. The specific feature of the meridional latitude variations is that along the meridian they do not depend on latitude and have opposite sign at opposite meridians at the same moment. This feature was the basis of the first, correlation method to separate any meridional variations from zonal variations and random fluctuations. As preprocessing, we perform each time row of events as a single cycle (1 period length, annual or Chandler's) for two regions at opposite meridians. Then we calculate the correlation coefficient (COR) between these two specimens. The great negative COR would denote that variations of regional seismicity have some similar features and the same period as PM. It turns out that some pairs of regions which longitude difference is 180 deg., have very high negative COR on Chandler's period (about 430 days). The first pair to be mentioned involves ocean ridges triple junction in Indian ocean (70 E) and triple junction in Pacific ocean (250 E). The second pair consists of high

latitude spreading zones of W-E direction in (10–30 E) and (165–220 E) longitude intervals. Both of them have negative COR about 0.9.

The second way of investigation based on the statistical method of superposition of epochs (MSE). As preprocessing, we use astronomical PM data as time-row to calculate the LV time-row for region of our interest taking into account its longitude. For each earthquake the 1-year-interval around earthquake time was cut from LV time-row. Then all the 2-year-long fragments were summarized. So the mean local LV value for our earthquake array was obtained and if its amplitude stands out above error level it is possible to assume that LV_PM somehow induce the earthquake moment. As soon as PM consists of annual and Chandler's components the MSE was applied for each of them. These plots can be useful for understanding what factor of PM is the leader for the seismicity in region under study – atmosphere or solid Earth. It was noticed that in some regions the annual factor is dominated (Pacific ocean and surrounding areas). The influence of Chandler's factor is more frequently in Indian ocean.

GPS based total electron content (TEC) anomalies and their association with large magnitude earthquakes occurred around Indian region

Chauhan, V., Singh, O.P. (Department of Physics, Faculty of Engineering & Technology, R.B.S. College, Bichpuri, Agra-283105, India), and Singh, B. (Department of Electronics & Communication Engineering, Faculty of Engineering & Technology, R.B.S. College, Bichpuri, Agra-283105, India)

In this paper, we have examined the effect of earthquakes on total electron content (TEC) data at Agra (Geographic Lat. 27.20N, Long. 780E), India. We have carried out this study for the period of 18 months from 01 January, 2009 to 30 June, 2011 and a dual frequency GPS receiver system is used for recording TEC data. To investigate the seismic effects on TEC, we have selected an epicentral distance of 2000 km from the observing station. This region includes 22 cases of earthquakes in the period of study with large magnitudes ($M \geq 5.5$). Different statistical procedures are used to observe the anomalies in TEC data. The results show that TEC fluctuated in the form of enhancements and depletion and maximum precursors are found 5–10 days prior to these earthquakes. We have also studied the solar and

geomagnetic activities during the cases of earthquakes and data on disturbed days are omitted to separate out the seismic effects. Hence, the observed TEC anomalies may be due to the occurrences of large magnitude earthquakes around Indian region. The ExB drift due to the electric field generation during earthquake preparation process and ground wave oscillations are may be the significant contributors of these anomalies in TEC data.

Comparison of volcano eruptions in Kamchatka with coordinates of atmospherics

Cherneva, N.V., Holzworth, R.H., Ivanov, A.V., Druzhin, G.I., and Mel'nikov, A.N. (Institute of Cosmophysical Research and Radio Wave Propagation, Kamchatka, Russia)

On the basis of the present WWLLN network: Global Volcanic Lightning Monitor – GVLM (<http://wwlln.net/volcanoMonitor.html>) identification of ash cloud lightning, caused by explosive eruption, is carried out. Volcano GLVM data, renewed every minute, for all the global volcanoes form an alarm signal in the case of coincidence of geographic coordinates of a lightning with volcano ones. Comparison of direction finding and meteorological data has shown that azimuthal distribution of lightnings, obtained by VLF direction finder of IKIR FEB RAS, quite well coincide with that calculated on the basis of WWLLN world station network data. Retrospective analysis of VLF direction finder data archive of IKIR FEB RAS for one and a half year period allowed us to find the cases of lightning locations generated at the moments of eruptions of Sheveluch, Kizimen and Besymyanniy volcanoes.

The peculiarities of seismo-ionospheric effects detection at the background of space weather changes

Cherniak, Iu.V., Zakharenkova, I.E., and Shagimuratov, I.I. (West Department of IZMIRAN, Kaliningrad, Russia)

At present one of the most effective tools for diagnostic of ionosphere phenomenon in a global scale is the method based on analysis of TEC variations obtained from global navigation systems signals and

radio occultation techniques. The main drivers of ionospheric variability are the solar and geomagnetic activity. The ionospheric effects caused by process from below are appreciably weaker in compare with effects of space weather changes. The extensive study of ionospheric perturbations of various origin accentuate problem of detection weak ionospheric phenomenon on a background of space weather modifications.

For recognizing of ionospheric anomalies of lithosphere origin effects it is usually used the statistical processing of long-term datasets for calculation of non-disturbed averaged diurnal variation of TEC or peak ionospheric parameters, estimation of differences within the examined period and anomaly recognizing. This approach without taking into account space weather background can lead to different results obtained by different authors for the same earthquake cases.

Analysis of possible seismo-ionospheric anomalies during years 2007–2011 revealed that estimation of differences, obtained by traditional techniques, can led to anomalies during seismo-quiete periods, but strongly correlated with variations of solar radiation flow (F10.7 index). The similar effects can be caused by different kinds of waves in the ionosphere (planetary, terminator, Poincare waves, etc).

We studied the impact of different space weather factors on the reliability of detection seismo-ionospheric anomalies. It was considered the optimal temporal intervals used for background calculation. It is proposed several approaches in order to take into account the space weather impact on the ionosphere during the process of detection of seismo-ionospheric phenomenon.

Acknowledgments. We acknowledge the IGS community for providing GPS permanent data. This work was supported by Russian Federation President grant MK-2058.2011.5.

Discussion of the model of atmospheric conductor with extrinsic currents which is often used for explanation of the electric field penetration into the ionosphere from ground

Denisenko, V.V. (Institute of Computational Modelling, Krasnoyarsk, Russia)

A well known model of the electric field penetration into the ionosphere from ground (Sorokin, V.M., Yaschenko, A.K., Hayakawa, M.,

2007. A perturbation of DC electric field caused by light ion adhesion to aerosols during the growth in seismic-related atmospheric radioactivity, *Natural Hazards and Earth System Sciences*, 7, 155-163.) includes extrinsic currents which exist due to the vertical convection and turbulent diffusion of air with embedded charged particles of aerosol.

We do not believe that such a model can be adequate for the Earth's atmosphere.

Our estimations on the base of their set of the input parameters give thousands times less extrinsic current than their calculations give. We have additionally estimated the vertical electric field in the near ground atmosphere that exists in frame of the model. First we are to stress that charges are not compensated with negative ones in the analyzed atmospheric layer since no extrinsic current could exist due to convection or diffusion of electrically neutral air. The corresponding negative charge remains at ground. Such a flat capacitor produces such a huge vertical electric field near ground that was never observed.

If a charge is placed into a conducting medium, it is compensated by charges of the opposite sign by conductivity current. This time is about 10 minutes in the Earth's atmosphere while time scale in the model equals a day. The movement of air with embedded positive particles with surrounding negative ions or electrons of the same concentration gives almost zero total current.

While the model aerosol particles are going up during a few days they are horizontally moved thousands kilometers away from the area of interest due to usual winds. It also means existence of a thin almost horizontal jet instead of vertical movement above the area of origination at ground. Such a jet would quickly disappear due to diffusion.

Mathematical simulation of quasi-stationary electric fields penetration through the Earth's atmosphere

Denisenko, V.V. (Institute of Computational Modelling, Krasnoyarsk, Russia), Hausleitner, W., Stangl, G., and Biernat, H.K. (Space Research Institute, Graz, Austria)

A quasi-stationary three-dimensional model of electric fields and cur-

rents in the conductor that includes the Earth's atmosphere and ionosphere is created. The results of the three dimensional model are simpler regarding interpretation and explanation than two dimensional ones. Known approaches regarding the ionosphere as a boundary condition at the upper boundary of the atmospheric conductor are analyzed. It is shown that for the large scale electric field penetration from ground into the ionosphere it is sufficient to take into account only integral conductivity of the ionosphere and it is not adequate to ignore ionospheric conductivity or to approximate its value with infinity. Our mathematical simulation has shown that such a penetration can not be a physical process which creates ionospheric precursors of earthquakes. Also a criticism of the models with extrinsic currents which could exist in the Earth's atmosphere due to diffusion and convection is presented.

Contribution of the electromagnetic pre-seismic emissions in the MHz and kHz bands to the earthquake prediction

Eftaxias, K. (Department of Physics, Section of Solid State Physics, University of Athens, Greece), and Potirakis, S.M. (Department of Electronics, Technological Education Institute of Piraeus, Athens, Greece)

Fracture induced electromagnetic fields allow a real-time monitoring of damage evolution in materials during mechanical loading. Pre-seismic electromagnetic emissions in the MHz and kHz bands have been consistently detected prior to significant on-land or near coast-line earthquakes. These are not only observed both at laboratory and geophysical scale, but also the MHz radiation precedes the kHz one, in both scales. This contribution concentrates, in an appropriately critical spirit, on asking 3 crucial questions: (1) How can we recognize an electromagnetic observation as a pre-seismic one? (2) How can we link an individual electromagnetic precursor with a distinctive stage of the earthquake preparation? (3) How can we identify precursory symptoms in electromagnetic observations which signify that the occurrence of the prepared earthquake is unavoidable? The answer on these questions is attempted within the following two stage model: The pre-seismic MHz EM emission is thought to be due to the fracture of the highly heterogeneous system that surrounds the family of large high-strength entities distributed along the fault sus-

taining the system, while the kHz EM radiation is due to the fracture of the aforementioned large high-strength entities themselves. In the frame of the above mentioned two stage model, the identification of MHz and kHz EM precursors requires different methods of analysis including: (i) organization in terms of traditional and nonextensive statistical mechanics, (ii) criticality, (iii) scale-free statistics, (iv) universal characteristic of faulting and fracture, (v) correlation with forerunners from other disciplines, and (vi) similarities to other extreme events.

Discharge pulse during the Tunguska disaster

Gladysheva, O.G. (Ioffe Physical-Technical Institute of RAS, St. Petersburg, Russia)

The Tunguska cosmic body's explosion took place in the atmosphere at altitude ~ 6 km above the Siberian taiga. This explosion was accompanied by an unprecedented energy release. The Tunguska disaster was accompanied by earthquake, geomagnetic disturbance, which was registered by Irkutsk observatory, and atmospheric discharge, which took place at altitudes of 10–90 km above the Earth's surface. The emission energy, released during this discharge, could reach $\sim 10^{10}$ J. Discharge currents flew on the ground in the circle with a radius of ~ 15 km and carried a charge of $\sim 10^5$ C.

Hidden periodicities of the geoelectromagnetic and seismic events

Guglielmi, A.V. (Schmidt Institute of Physics of the Earth, Russian Academy of Sciences, Moscow, Russia), and Zotov, O.D. (Borok Geophysical Observatory, Schmidt Institute of Physics of the Earth, Russian Academy of Sciences, Borok, Yaroslavl oblast, Russia)

We recently discovered the phenomenon of synchronism of the electromagnetic and seismic events which manifests itself in the form of so-called Big Ben and Week End effects. The phenomenon indicates that the technosphere has a nontrivial impact on the magnetosphere and lithosphere. The hidden strictly periodical human impact on

the electromagnetic and seismic activity has been discovered previously by method of superposed epochs. In the presented report we describe the result of investigation by another method, namely by the method of spectral analysis. The result of analysis indicates the presence of pronounced maxima at periods of 7 d, 1 hour, 30 minutes and 15 minutes in the spectra of electromagnetic Pc1 wave activity and earthquakes. This result is consistent with what was found earlier by the superposition epochs analysis. At the same time, in the spectrum of seismic activity along with the peak at 1 h, having clearly anthropogenic in origin, there is a strong peak at 54 min. The value 54 min coincides with the period of the fundamental mode of eigen spheroidal oscillations of the Earth. It is suggested that the global seismic activity is modulated by the oscillations of the Earth as a whole. We checked this idea by analyzing the aftershocks in epicentral and antipodal zones of the strong earthquakes. The hidden period of 54min was detected in both cases. The result testifies that the spheroidal oscillations ${}_0S_2$ of the Earth have modulating effect on the global seismicity. The work was supported by the Program N 4 of the Presidium of RAS and RFBR (grant no. 10-05-00661).

Modeling of seismic-electromagnetic processes in hierarchic structures

Hachay, O.A. (Institute of Geophysics UB RAS, Ekaterinburg, Russia), and Khachay, A.Yu. (Ural Federal University, Ekaterinburg, Russia)

Rock massive can be described by four functions: structure, physical features, content and state. The last feature plays the main role by forecasting the dynamical events which can occur in it. The energy and intensity of the dynamical events depend from the volume of the massive and the space-time changes of the influence on it. The second feature of the state evolution is: the local volume massive does not immediately respond on the changing of the surrounded it stress state. Therefore it stores the response energy and then extracts it through a high energy dynamical effect. It is very significant to define the time of reaction lagging, in spite of the influence on the massive can be assumed as elastic. The unique model which can explain that effect is a model of the massive with a hierarchic structure. We developed a mathematical algorithm using integral and integral-

differential equations for 2-D model for two problems in a frequency domain: diffraction a sound wave and linear polarized transverse wave through a arbitrary hierarchy rank inclusion plunged in an N-layered medium. That algorithm differs from the fractal model approach by a freer selecting of heterogeneities position of each rank. And the second the problem is solved in the dynamical approach. The higher the amount of the hierarchic ranks the more is the degree of nonlinearity of the massive response and the longer can be the time of massive reaction lag of the influence.

To the theory of identification of the tectonomagnetic effects

Karimov, F.H. (Institute of Geology, Earthquake Engineering and seismology AS RTajikistan, Tajikistan)

In interpreting of the tectonomagnetic effects of tectonic earthquakes' preparation the problems of identification of these anomalies' origin in the variations of the local geomagnetic field turn up. The prevalence of geopiezomagnetic mechanism requires the high sensitivity of remanent magnetization and magnetic susceptibility to the pressures. The prevalence of electrokinetic mechanisms requires a high degree of salinity of groundwater, a high zeta-potential at the boundaries between the surface of the porous medium and the groundwater, high porosity and capillarity, or high telluric potentials of the geo environments and their variations under the influence of pressures. When identifying the mechanisms of tectonomagnetic effects of deep earthquakes, with hypocenters deeper than 70 km, it's taken into consideration that the magnetization and the susceptibility of rocks at depths greater than 20–30 km are negligible, since they are below the magnetoactive layer defined by the Curie's isotherms. If the tectonic stresses in the deep focus earthquakes preparation zone don't cover the magnetoactive layer, the case possible for the earthquakes with relatively small magnitudes, one can conclude that in this case the tectonomagnetic effect is of electrokinetic origin. If the magnitude of impending earthquakes is very high, for example, 7 or more, the zone of tectonic stresses, which has linear dimensions of the order of several hundred kilometers, will cover the magnetoactive layer, and then both the geopiezomagnetic and electrokinetic mechanisms could perform. On the territory of Tajikistan the remanent magnetization and magnetic susceptibility of rock normally don't exceed 10^{-5} and

10^{-4} emu units respectively, their piezo susceptibility is less than 10^{-4} , so the tectonomagnetic effects don't exceed a few nT, typically first nT. An important criterion for the separation of mechanisms of tectonomagnetic effects may be a phase shift in the local anomalies in the variations of local geomagnetic field at different points in earthquake preparation zone. This phase shift can be attributed to the spread of crust deformation waves from the epicenter of the upcoming earthquake due to the spread of the most dynamic component of geo environment, representing by groundwater at rates of about 1–10 km per day.

Three-dimensional structure of the ionospheric electron density disturbances created by vertical electric currents flowing between the Earth and the ionosphere

Karpov M.I., Namgaladze A.A., and Zolotov O.V. (Murmansk State Technical University, Murmansk, Russia)

The ionospheric and plasmospheric electron density disturbances created by the vertical electric currents flowing between the Earth and the ionosphere have been simulated using global numerical Upper Atmosphere Model (UAM). The calculated three-dimensional structure of the ionospheric electron density disturbances demonstrates importance not only vertical component F2-region ionospheric plasma drift in producing NmF2 and total electron content (TEC) disturbances but also meridional and zonal plasma drift movements. The calculated electric potential and TEC disturbances are discussed in relation with the features of the TEC anomalies observed before strong earthquakes. A reality of the vertical electric currents with current density of 10^{-8} A/m² required for producing TEC disturbances of magnitude 30–50% relative to quiet conditions is considered as well.

Electromagnetic regularities of differential rotation of deep physical covers of the Earth and regularities of atmospheric, hydrochemical, tectonical ash value

Kharitonov, A.L., and Kharitonova, G.P. (Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation RAS, Troitsk, Moscow Region, Russia)

In the paper the main attention is given to application of the new method of the differential spatial-temporal magnetic measurements (gradientometry) for allocation of elements of differential rotation of physical covers of Earth according to the magnetic field measured on spacecrafts "MAGSAT", "CHAMP". It is shown that regularity of differential rotation of physical covers is inherent in the most part of natural space objects (Earth, planets), which generate of the magnetic field in the subsoil. It is shown, how the structure of the magnetic field arising from deep physical not uniformity of substance influences emergence of atmosphere-hydrodynamic, hydrochemical, tectonical ash value of oceanic regions of Earth. Work is executed with Russian Foundation of Basic Research support on the grant of No. 10-05-00343-a.

Geoinformatics support for the monitoring of the Wiese-Parkinson vectors in the Carpathians seismic zone

Klymkovych, T. (Carpathian Branch of Subbotins Geophysical Institute, Lviv, Ukraine)

Magnetovariational monitoring of seismic-tectonic processes, which has wide application during last decade, requires fast and effective processing of considerable digital observations data bases.

So, we have developed informational system for calculations of Wiese-Parkinson vectors components. It allows calculating real and imaginary components and some additional parameters of induction vectors for short series (3 hours for 5 – 10 min. variations data).

This system is used for monitoring of dangerous seismic processes in the Transcarpathian fore deep. On such base main amplitude and frequency features of induction vectors variations were studied. Also were outlined some correlations between anomalous variations of induction vectors and local seismic activity. Bay-like anomalies before

small local earthquakes were defined (Beregove, November, 23.2006, $M=3.9$; Uglya, December, 14. 2010, $M=3.3$). During increasing of local seismic activity the large dispersion in magnetovariational time series were observed.

The system of Wiese vectors information monitoring can be used in other regions. The analysis of induction vector variations and the comparison with seismic regime on the base of magnetovariational data from some magnetic observatories of Russia, Japan and China were done.

Anomaly disturbances of secular magnetic fields and ULF magnetic variations before the strongest earthquake in Japan on March 11, 2011

Kopytenko, Yu.A., and Ismaguilov, V.S. (SPbF IZMIRAN, St. Petersburg, Russia)

The strongest earthquake (EQ) with magnitude $M=9$ happened under a sea bottom near the Japan east coast on March 11, 2011. Secular variations of the main geomagnetic field were investigated by means of three-component 1-hour data at three magnetic observatories during 11-year period of 01.01.2000–31.01.2011. Magnetic stations Esashi and Mizusawa are situated northwest of the EQ epicenter at distances ~ 170 – 200 km and the observatory Kakioka is situated southwest of the EQ epicenter at distance ~ 300 km. During the period, we found four local anomalies in the secular variations. All anomalies are most distinctly recognized in the form of differences of corresponding magnetic components at these remote magnetic stations. It was found that four seismic active zones were aroused near the magnetic stations Esashi and Mizusawa before (0.5–1 year) the four local anomalies. The last anomaly is the biggest one that had begun ~ 3 years prior to the EQ moment.

For investigation of the ULF magnetic field disturbances three-component 1-sec data at two magnetic stations (Kakioka and Uchiura) were used. The Uchiura station is situated south of Kakioka at a distance 119 km and at a distance of ~ 420 km from the EQ epicenter. Data from the time interval of 18.02 – 10.03, 2011 (only night times 01–04 LT) were investigated in a wide frequency range. It was found that in the frequency range of $F=0.033$ – 0.01 Hz there was observed

the clearest anomaly as a decrease in correlation coefficients of corresponding magnetic components at these two stations from 22.02, 2011. Differences of Z components exhibited an increase and became positive after this date. It may suggest that the ULF lithospheric source appeared north of the Kakioka station. Outside the specified frequency range, the anomalies are not well defined.

Ionosphere-lithosphere coupling and a possibility of electromagnetic earthquake triggering

Kuznetsov, V.D., Ruzhin, Yu.Ya. (Pushkov Institute of Terrestrial Magnetism, Iono sphere and Radio-Wave Propagation (IZMIRAN), Troitsk, Moscow Region, Russia), and Novikov, V.A. (Joint Institute for High Temperatures of Russian Academy of Sciences, Moscow, Russia)

Preseismic perturbations in ionosphere have been reported since 1970s as possible precursors of strong earthquakes. Along with these phenomena it is well known that various events influence seismicity. Theoretical and field/laboratory experimental results obtained during implementation of research projects in Russia within recent ten years show an evidence of artificial and natural electromagnetic triggering of earthquakes and implication of electromagnetic phenomena for earthquake preparation and occurrence. It has been proposed as well, that some natural phenomena, such as geomagnetic storms, may affect seismicity. Since these events also disturb the atmosphere-ionosphere, it might be possible that some of the reported preseismic atmospheric/ionospheric anomalies simply were observed as a trigger of the earthquakes. To clear the details of ionosphere-lithosphere coupling and a possibility of electromagnetic triggering of seismic events the special project was launched last year in Russia directed to R&D of a model of electromagnetic triggering of seismic events caused by ionospheric electromagnetic perturbations. Development of such a model is a complex interdisciplinary problem at the junction of the ionospheric plasma physics, electrodynamics, geodynamics, and fracture mechanics of rock. The project is directed to study a possibility of development of short-term earthquake prediction method based on electromagnetic triggering effects. The project is a continuation of interdisciplinary studies of ionospheric disturbances and the triggering deformation processes in the Earth crust by weak electromag-

netic impacts. Results of critical analysis of ionospheric precursors of earthquakes, statistical analysis of geomagnetic field variations and seismic activity, laboratory studies of dynamics of deformation of stressed rocks under the electromagnetic impact, as well as theoretical analysis of the possible mechanisms of interaction of rocks with electromagnetic field and their verification in laboratory experiments at the special test equipment simulated the behavior of the fault zone under external triggering factors are presented and discussed.

Temporal variations of Wiese-Parkinson vectors in the Transcarpathian active seismic zone

Maksymchuk, V., Klymkovych, T., Tregubenko, V., and Yakas, Y. (Carpathian Branch of Subbotin's Geophysical Institute, Lviv, Ukraine)

Permanent magnetovariational (MV) observations in Transcarpathians active seismic zone for monitoring of local earthquakes precursor were started in 1989. This allows to obtain continuous series of Wiese-Parkinson vectors for a long time. One of the main features of the Transcarpathians active seismic zone is slight seismic activity (7 accordingly MSK-64 scale) and Carpathian Conductivity Anomaly, which defines values and direction of Wiese-Parkinson vectors in the region. The most detail induction vectors series are available since 2000 yr. after launching modern LEMI MV instrument. This allows to obtain diurnal series of real and imaginary induction vectors components in 4 periods bands: 5 m -10 m; 10 m -20 m; 20 m -40 m; 40 m -60 m.

Analysis of long-term series of Wiese-Parkinson vectors during 2000 – 2011 yrs. shows the presence of variations with different period and nature: diurnal, annual, episodic, with duration from some weeks to some months. It is supposed, that diurnal and season variations of Wiese-Parkinson vectors are corresponded to the external source influences. Episodic deviations in induction vectors directions were determined during increasing of seismic activity in the region and before significant earthquake in the zone of the Transcarpathians deep fault (M=3.3, December, 14.2010). The complexity of Wiese-Parkinson vector components temporal variations and perspectives of such a method for definition of local earthquakes precursors with M3 in the Transcarpathian fore deep are represented.

Model of singular source as an indicator of disturbance of the geophysical environment in seismic region. Data processing of magnetic observatory Japan 2009–2011

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

We analyzed time series of the magnetic field of three observatories Japan: Kanoya, Kakioka, Memambetsu (<http://wdc.kugi.kyoto-u.ac.jp/>) and seismic data catalog (<http://www.ncedc.org/anss/catalog-search.html>).

Model interpretation. Model interpretation was a homogeneous geoelectric space in which parallel to the plane of observation horizontal current is flowing.

A horizontal line current which is equivalent of the real distribution of current relative to chosen parameters of the magnetic field in the set points of observation, we called the effective singular source. The task was to define the coordinates of the effective singular source in a perpendicular plane to the line of current. Calculations of the effective concentration of the current source were carried out for three variants of the models of interpretation: the geometric, the energy and mixed.

The apparent height of the generalized concentrated source. The average levels of the apparent heights are differ for different ways of solving the problem.

The character of behavior of the functions of the apparent heights defined by the data at various stations, was significantly different in the period immediately preceding the explosion of seismic activity on March 11, 2011, and while it is in the highest level. The apparent height, calculated on a neighbor stations, revealed the sharp anomalous reduction of the level in the form of several long deep local minima of functions on an interval of seismic activation. Assessment, made on the data of the remote stations, is not found such a tendency. The abnormal reduction of the apparent height in the period of seismic activation also clearly manifested in the energy approach which uses measurements of three stations. This suggests that the cause of such a change of conduct in the local electromagnetic heterogeneity. It is concentrated in the neighborhood of central observatory Kakioka and reinforced in connection with seismic activation zone.

Dependence variations of the apparent parameters of a generalized source on the rhythm of seismic activation of the structure. Analysis

of time sequence of seismic events of average and high energies ($M \geq 4$) in 2009–2011 found that in the area of the station Kakioka clearly manifested the rhythmic nature of tectonic processes.

It turned out that almost all launches of series of earthquakes are preceded by apparent heights reduction of effective current sources. Height reduction is also accompanied by the decrease of the homogeneity of the field. The most powerful seismic shocks ($M \geq 6$), taking place within the series, also may be preceded of reducing the apparent height.

Appeared as a result of processing of monitoring data of the magnetic field patterns in the variations of parameters of the concentrated source are consistent with available physical representations of the reflection of the geodynamic processes in the behavior of the geoelectrical parameters of the lithosphere-atmosphere-ionosphere.

Singular generalized source diagnoses measure electromagnetic heterogeneity of the ionosphere in the neighborhood of magnetic observatories. A system of three observatories has proved itself as electromagnetic locator of phenomena, connected with the seismic activity in the area of observatory Kakioka.

Reflection of geodynamic phase state of the tectonic structure by the statistical parameters of generalized singular source. According data of magnetic and seismic monitoring in Japan in 2006–2010

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

We used geometric method of estimating of the apparent height of the generalized source. By measurements of magnetic field on the three observatories were made by the three variants of estimation.

There were developed two methods of statistical analysis for joint processing apparent heights functions and data of seismic monitoring. The method of signal accumulation, attributable to the days of high seismic activity, and analysis of the distribution of extremums around of seismically active days. There were studied variations of heights, acceleration and speed.

Have been identified intervals sustainable behavior of statistical parameters heights variations of the generalized source: 2006–2007,

2008, 2009–2010. These intervals correspond to the geodynamical processes in the structure and reflected different degrees of seismic activity. The change of the characteristic features of the statistical parameters of variation was recorded for the station Kakioka in 2008. Interval training of the catastrophic earthquake, 2009—20010 years, stands out the special behavior of statistical parameters.

There is lithosphere-atmosphere-ionosphere interaction. Displacement of the centers of the main tectonic forces causes the displacement of the locations of the effective generalized source. As a result the integral and local statistical parameters of variations height of the source are change. Geodynamic regime structure is reflected in the image of statistical parameters variations heights of a singular source.

Physical interpretation of the TEC disturbances observed before strong earthquakes

Namgaladze, A.A., and Zolotov, O.V. (Murmansk State Technical University, Murmansk, Russia)

The observed before strong EQs ionosphere Total Electron Content (TEC) relative disturbances have the following features according to many papers. They are (1) long-living ($\geq 6-8$ hours) and (2) strong ($\geq 30-50\%$ by magnitude). (3) They happen near the EQs' epicenter and often in $\sim 50\%$ cases magnetically conjugated to it areas; anomalies (4) occupy areas of about 1000 km in latitude vs. ~ 2500 km in longitude. (5) Their shape and locations are rather stable. (6) The anomalies do not propagate along the magnetic meridians. (7) TEC relative disturbances dominate at night-time, reduce with sunlit ionosphere income and restore with sunset terminator coming. (8) Positive disturbances usually dominate.

We interpret these features basing on the physics of the $F2$ -layer of the ionosphere because TEC depends mainly on $N_m F2$. Night-time $N_m F2$ disturbances are mainly driven by ion-molecular loss rates in reaction with N_2 and O_2 . The N_2 and O_2 densities and corresponding loss rates may be changed by income of the molecules from the high-latitude regions or by the vertical plasma movements. Neutral atmosphere horizontal movements should produce ionosphere disturbances traveling along meridians (TIDs). The electromagnetic $[\vec{E} \times \vec{B}]$ drift of the $F2$ -layer plasma is able to generate more localized ionosphere

disturbances related with the electric field sources locations. Electric fields $\sim 4\text{--}10\text{ mV/m}$ are required to generate noticeable $N_m F^2$ and TEC disturbances. The vertical electric currents magnitude required to generate such fields and TEC disturbances according to the UAM modeling is about several 10^{-8} A/m^2 at night and much more intensive for day-time. The reality of such currents is discussed. If such currents exist, all the above mentioned features can be naturally explained in terms of $[\vec{E} \times \vec{B}]$ drift mechanism.

Experimental verification of possible mechanisms of electromagnetic earthquake triggering

Novikov, V.A., Okunev, V.I., and Klyuchkin, V.N. (Joint Institute for High Temperatures RAS, Moscow, Russia)

There are many field patterns of earthquake triggering by weak dynamic and electromagnetic impacts on rocks under critical stress state. Nevertheless, the physical mechanism of these phenomena is not clear yet. Among research methods the laboratory simulation of "stick-slip" fault behavior under controlled stress state and weak disturbances of the fault gouge seems as a promising tool for analysis of various scenario of earthquake triggering. Since the introduction of the Burridge–Knopoff model of fault mechanics many spring-block models have been proposed, which are attractive due to simplicity of variation of loading, fault gouge properties, and triggering conditions. For verification of various hypotheses of earthquake triggering mechanisms the spring-block facility was developed, which allows studying the fault gauge (granular medium) behavior under external mechanical and electric triggering impacts. Dimensions of moving block are of $50 \times 50 \times 50\text{ mm}$ to $200 \times 100 \times 50\text{ mm}$. Normal pressure is up to 0.5 MPa . Drag force of electric drive is up to 100 kg , velocity of movement of running block is 0.010 to 500 mm/min . The system allows the studying an influence of weak vibrations, dynamic impacts, heating, electromagnetic actions and fluid injection as the separate and combined triggering factors acting on the compressed granular layer between two blocks simulating the fault zone. The triggering phenomena were studied under external vibrations (frequency of 1 to 200 Hz) and electric current across and along the fault gouge (10V DC , 10 V AC of 1 Hz to 10 kHz), as well as fluid injection into the fault gouge. The possible triggering mechanism

based on magneto-hydrodynamic fluid pumping into the fault from fluid reservoirs located near the fault under critical stress state due to interaction of telluric currents flowing through the fluid-saturated rocks with geomagnetic field is proposed and discussed in detail.

Total electron content disturbances before strong seismic events of 2005–2007

Romanovskaya, Yu.V., Namgaladze, A.A. (Murmansk State Technical University, Murmansk, Russia), and Prokhorov, B.E. (Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences, Potsdam, Germany; University Potsdam, Applied Mathematics, Interdisciplinary Center for Dynamics of Complex Systems, Potsdam, Germany)

We investigate seismo-ionospheric precursors of earthquakes in Total Electron Content (TEC) of the ionosphere using regular Global Positioning System observations. From the U.S. Geological Survey list we have selected seismic events of years 2005–2007 that are of $M \geq 6$ by magnitude and of $D \leq 80$ by depth. Earthquakes which happened at subauroral and high geomagnetic latitudes were rejected. For the selected events global and regional relative TEC disturbances maps (per cents) were plotted considering eight days before each event for possible seismo-ionospheric precursors. According to the hypothesis on electromagnetic mechanism of the pre-earthquakes TEC anomalies formation, TEC disturbance was accepted as a precursor when it was observed near the epicenter and/or magnetically conjugated point at the same time and lasted for six hours at the least.

We have analyzed 91 events (29 for year 2005, 21 for year 2006 and 41 for year 2007) and found out that before 43 earthquakes the TEC anomalous variations were observed both near the epicenter and magnetically conjugated point. Approximately 60% of these revealed precursors showed positive effects in TEC, about 17% — negative effects. About 23% of maps with precursors demonstrated both negative and positive TEC disturbances near the epicenter and in the magnetically conjugated point.

Seismo-ionospheric anomalies observed in European and Far East regions

Shagimuratov, I.I., Cherniak, Iu.V., Zakharenkova, I.E., and Tepenitsyna, N.Iu. (West Department of IZMIRAN, Kaliningrad, Russia)

The West Department of IZMIRAN has many years' experience of the ionosphere's research. Besides the ionospheric reaction on space weather modifications the seismo-ionospheric effects can be registered prior strong core earthquakes. We consider the occurrence of pre-seismic ionospheric anomalies for series earthquakes took place in the Europe and Far East regions. In this study we used the permanent GPS network to derive variations of the ionospheric total electron content (TEC). The influence of geomagnetic conditions as well as variations of solar activity to the ionosphere behavior for the considered temporal intervals was considered. The differential TEC maps were constructed in order to reveal spatial characteristics of TEC anomalies over epicentral region. Additionally the diurnal TEC variations over individual GPS stations were examined to recognize the temporal evolution of these anomalies.

As test cases we study the Kaliningrad (21 September 2004, Mw 5,2), Abruzzo (6 April 2009, Ml 5,8), Elazig M6.1 (March 8, 2010), Nevelsk (2 August 2007, Mw 6,2), Van (23 October 2011, Mw 7,1), Tohoku (Sendai) (11 March 2011, M 9,0) earthquakes.

For all test cases the daytime enhancement of TEC were revealed. This effect was registered in diurnal TEC variation over stations located within earthquake preparation zone (Dobrovolsky radius) and on differential TEC maps. According to the series of characteristics (its locality, affinity with the epicenters, dome-shaped zone of manifestation, characteristic time of existence) the revealed anomalies may be associated with precursors of seismic activity.

The research leading to these results has received funding from the European Union Seventh Framework Program (FP7/2007-2013) under grant agreement No. 263502 – PRE-EARTHQUAKES project. We acknowledge the IGS community for providing GPS permanent data.

Use of the magnetic ratio for research of the seismoelectric effect of the first kind (numerical modeling)

Sholpo, M.E. (SPbF IZMIRAN, RAS, St.Petersburg, Russia)

Time and spatial dependencies of the magnetic ratio (ratio of the vertical component of geomagnetic field to its horizontal component) and its sensitivity to changes in the electric conductivity of the elements of a geoelectric structure are studied using 2D model.

Most important of the found peculiarities are the following.

1. Unlike apparent resistivity which has a sensitivity maximum in epicenter of the conductive block, the maximum of the sensitivity of the magnetic ratio as well as of the maximum of the magnetic ratio are located over its edges, and they that more than are stronger contrast of resistivity of contacting elements.
2. In different points of a profile on the surface of structure element (or on its projection to the earth surface), including at the opposite edges of the element, there can be different time dependencies of the magnetic ratio and its response to variations in the resistivity of the element.
3. On a part of a profile near to epicenter of the conductive block the negative response of the magnetic ratio to changes in the conductivity of rocks can be observed, that is here at increase in the conductivity of rocks the magnetic ratio can decrease.

From this it follows that, without having sufficient data of a geoelectric structure of the research area, it is impossible to interpret the behavior of the magnetic ratio correctly.

A search for precursors of earthquakes from multi-station ULF observations and TEC measurements in India

Singh, O.P., Chauhan, Vishal, Pandey, Uma, and Singh, Birbal (Faculty of Engineering & Technology, R.B.S College, Bichpuri, Agra, India), Arrora, B.R., and Rawat, Gautam (Wadia Institute of Himalayan Geology, Dehradun, India), Pathan, B.M., and Sinha, A.K. (Indian Institute of Geomagnetism, Navi Mumbai, Panvel, Mumbai, India), Sharma, A.K., and Patil, A.V. (Department of Physics, Shivaji University, Kolhapur, India)

Ground based observations have been carried out for Ultra Low Frequency (ULF) precursors of earthquakes at four different stations in India namely Agra (Geograph.Lat 27° N, long. 78° E), Guttu (lat 31.53 deg N, long 78.75 deg E), Shillong (lat. 25.92 deg N, long. 91.88 deg E) and Kolhapur (lat 16.40 deg N, long 74.15 deg E) using identical 3-component search coil magnetometers ($f= 0.01-30$ Hz) obtained from Lviv center of space research, Ukraine. An offline analysis of the combined data has been carried out in relation to a major earthquake of magnitude $M=7.9$ occurred in the neighbouring country China under the National Program of Earthquakes Precursors (NPEP) launched in India since May, 2009. The results of the analysis show occurrence of amplitude anomalies as precursors whose amplitudes decrease with distance. The precursory periods range between 2 and 5 days and are large for the stations nearer to epicenter. A graphical determination of location of the epicenter is found to be satisfactory with errors within about 20.5%. Further, the TEC data for a period of 03 months from 01 April to 30 June, 2008 have been analysed and the results show enhancement in TEC 22 days before the occurrence of Wenchuan earthquake.

Anomalous subsurface VLF electric field emissions associated with some major earthquakes in India and around and their lithosphere atmosphere coupling observed at Mathura

Singh, R.P. (Dept. of Physics, Institute of Applied Sciences, GLA University, Mathura, India), and Singh, B. (Department of Electronics and Communication, FET R.B.S. College, Bichpuri, Agra, India)

Monitoring of vertical component of subsurface VLF electric field emissions has been started at Chaumuhan, Mathura (Lat. $27^{\circ}17'$ N and $77^{\circ}25'$ E) India since 24 March 2011 employing borehole and vertical antennas. Daily variations of the nighttime data of both the borehole and vertical antennas have been examined in the light of some major earthquakes that have occurred in India and around. Anomalous amplitude enhancement is observed in the data of the antennas before and/or after the occurrence of the earthquakes. Results are also examined in the light of magnetic storms and it is found that these amplitude enhancements are not correlated with magnetic storms except one case. These results have also been confirmed statistically.

Scattering of VLF signals from localized perturbations in the lower ionosphere

Singh, V. (Department of Physics, Eshan College of Engineering, Farah, Mathura-281122, India), and Singh, B. (Department of Electronics and Communication Engineering, Faculty of Engineering and Technology, R.B.S. College Bichpuri, Agra-283105, India)

A wave-slab interaction model has been used to study the scattering of very low frequency (VLF) ground transmitter signals from localized enhancements of ionization in the lower ionosphere caused by transient luminous events (TLEs) such as sprites. The variation of reflection coefficients has been studied for a fixed frequency VLF transmitter signals of frequency 19.8 kHz (NWC, Australia) monitored at Agra for different slab thicknesses, incident angles, and enhancement factors. The results show that sufficient strength of the reflected signals is obtained for a slab thickness of 3 km, enhancement factor between 2.5 and 3, and incident angle around 75° . These results explain satisfactorily the VLF amplitude and phase anomalies

in subionospheric VLF transmitter signals recorded at Agra station which are interpreted as caused by transient luminous events.

Multifractal approach to study the earthquake precursory signatures using the ground-based observations

Smirnova, N.A. (St. Petersburg State University, St. Petersburg, Russia), Kiyashchenko, D.A. (St. Petersburg State University, St. Petersburg, Russia; Shell International Exploration and Production Bellaire, Houston, TX, USA), Troyan, V.N. (St. Petersburg State University, St. Petersburg, Russia), and Hayakawa, M. (The University of Electro-Communications, Chofu Tokyo, Japan)

In a series of papers by Smirnova and Hayakawa, fractal analysis of the ULF emissions in the range of $f = 0.001 - 0.3$ Hz has been fulfilled based on the data obtained in seismic active regions of Guam Island and Izu Peninsula. A certain dynamics of the spectrum slopes and the corresponding first-order fractal dimensions has been revealed in relation to the preparation phase of some strong earthquakes (EQs). To advance such fractal approach, which seems to be promising for development of the EQ forecasting methods, we consider multifractal aspects in analysis of geophysical data dynamics. First we concern with seismicity distribution in the Kobe area of Japan in relation to the powerful Kobe earthquake of 17 January 1995. Applying a multifractal approach, we have revealed that the certain high order fractal dimensions, which organize the spectrum of singularities (multifractal spectrum) of the local seismicity distribution, decrease gradually when approaching the date of the Kobe earthquake. The other examples of the multifractal spectrum dynamics in relation to the strong geophysical events are introduced. It is concluded that multifractal analysis of geophysical data could be a promising tool for extraction of the precursory signatures of the extreme natural events including the strong earthquakes.

Connection of acoustic and electromagnetic emissions of rock in the conditions of microseismic overactivity

Uvarov, V.N., Isaev, A.Yu., and Sannikov, D.V. (Institute of Cosmophysical Research and Wave Propagation FEB RAS, Kamchatka, Russia)

The relationship between acoustic and electromagnetic emissions of the rock in situ under conditions of elevated microseismic activity on geophysical observation station IKIR FEB RAS, "r. Karymshina" was conducted.

Sustained and significant increase in cross-correlation function of these emissions for certain values of the time shift was detected.

The hypothesis of acoustic-electromagnetic manifestations of crust compression waves was offered to explain this phenomenon.

On the way to the electromagnetic earthquake control

Velikhov, E.P. (National Research Centre "Kurchatov Institute", Moscow, Russia); Zeigarnik, V.A., and Novikov, V.A. (Joint Institute for High Temperatures of Russian Academy of Sciences, Moscow, Russia)

Recent devastating earthquakes in Haiti, New Zealand, and Japan demonstrated again failure of general measures for earthquake hazard mitigation based on short-term prediction, preparedness, and earthquake engineering. This situation stimulates the search of alternative approaches to solve the problem. One of the proposed novel methods of earthquake hazard mitigation is artificial safe release of tectonic stresses accumulated in the Earth crust by active mechanical or electromagnetic action on seismic-prone tectonic faults. At first sight the control of huge tectonic energy looks fantastic. Nevertheless, experience of mankind in safe managing the nuclear energy, as well as the natural patterns of silent slip events ("silent earthquakes") discovered recently in many regions of the world where the accumulated tectonic energy releases safely without radiation of seismic waves verify a possibility of implementation of this technology in the future. 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, the Institute of Dynamics of Geospheres (Moscow, Russia), the Research Station (Bishkek, Kirghizia) of Russian Academy of Sciences carried out the two-year (2009–2010) interdisciplinary project entitled “Development of basic physics of man-made electromagnetic action on deformation processes in the Earth crust” for investigation of electromagnetic triggering phenomena and their implication for earthquake control based on safe 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 implemented at the junction of applied seismology, electrodynamics, and rock mechanics and directed to development of physical grounds of earthquake hazard mitigation technology based on safe release of tectonic stresses due to initiation of deformation processes in the Earth crust by relatively weak electromagnetic and vibration actions. The new basic results obtained to-date from statistical analysis of field experiments with pulsed power systems, laboratory research of dynamics of rock deformation under weak electromagnetic and mechanical disturbances, as well as theoretical analysis of mechanisms of interaction of stressed rocks with electromagnetic field unambiguously confirmed a possibility of development of novel technology of earthquake hazard mitigation based on electromagnetic triggering phenomena.

DEMETER ULF observations of during earthquake precursor phases

Walker, S.N. (ACSE, University of Sheffield, Sheffield, United Kingdom), and Pokhotelov, O.A. (Schmidt Institute of Physics of the Earth, RAS, Moscow, Russia)

During the period before a major earthquake, the electrical properties of the crust change as the stresses increase. These changes can generate perturbations in the electric and magnetic fields, generating waves which may propagate through the atmosphere, resulting in perturbations of the ionosphere. In this present paper, data from the DEMETER satellite is analysed to search for enhancements in ULF wave activity in the vicinity of earthquakes as a prelude to the seismic event. Results are presented for two seismic events, the Sichuan event in 2008 and l'Aquila 2009 which show enhancements in wave activity with frequencies $f < 0.5\text{Hz}$ during the build up to a major earthquake.

Variations of the ionospheric Es layer parameters over Japan region

Zakharenkova, I.E., Cherniak, Iu.V., and Suslova, O.V. (West Department of IZMIRAN, Kaliningrad, Russia)

The information about statistical characteristics of sporadic E layer (Es) is necessary for various investigations of the ionospheric dynamics. In this study we analyzed seasonal variations of critical frequency of Es layer (foEs) and probability of the layer's appearance during period of low solar activity years 2007–2011 over Japan region. This study is based on the data provided by Japanese ionospheric sounding stations (Wakkanai, Kokubunji and Yamagawa). For each stations it was calculated the monthly median and seasonal median diurnal variations. Additionally it was calculated the average probability of Es layer appearance during each month and seasons. The Es layer with probability more than 30% was appeared from 08 to 17 LT in winter. This time limit was practically coincided with sunrise and sunset in winter. At night time Es layer practically did not appear. For summer season at day-time the probability of Es layer appearance was about 80%.

In order to investigate variability of sporadic E layer around the time of seismic events several strong earthquakes with magnitude M6.5, which occurred close to the ionosondes' location points, were selected. For each event it was analyzed the occurrence of sporadic E layer, its magnitude, frequency and correspondence of these parameters to the obtained average statistical characteristics of Es variability. Special attention was focused on the study of night-time sporadic E-layer appearance.

We acknowledge the National Institute of Information and Communications Technology (NICT) in Japan for providing ionosonde data. This work was supported by Russian Federation President grant MK-2058.2011.5.

Seismo-electromagnetic TEC disturbances observed before Great Tohoku March 11, 2011 and October 23, 2011 Turkey Van earthquakes

Zolotov, O.V., Namgaladze, A.A. (Murmansk State Technical University, Murmansk, Russia), and Prokhorov, B.E. (Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences, Potsdam, Germany; University Potsdam, Applied Mathematics, Interdisciplinary Center for Dynamics of Complex Systems, Germany)

We discuss the GPS (Global Positioning System) observed ionosphere TEC (Total Electron Content) variations prior to the M 9.0 Great Tohoku (Japan, Sendai) March 11, 2011 and M 7.1 Oct. 23, 2011 Turkey Van earthquakes as possible seismo-ionosphere precursors. We calculated background quiet variations (undisturbed states) as 7-days LT-grouped running medians before the current calculation moment, using Global Ionosphere Maps (GIM) from the NASA ionex product. After that, we calculated global and regional relative TEC deviations (%) maps for time intervals March 08–11, 2011 and Oct. 20–23, 2011, i.e. preceding M 9.0 Great Tohoku (Japan) March 11 and Turkey Van Oct. 23 earthquakes, respectively.

Both cases revealed the TEC deviations that may be treated as seismo-ionosphere precursors to earthquakes: (1) TEC anomalies were observed a few days before the main shock event, linked to the near-epicenter and magnetically conjugated areas, also followed by Appleton anomaly's modifications. (2) They did not propagate along the meridians. (3) Their lifetime was in general limited to approximately 15LT–04LT (varied from 4 hours to 8 hours), reaching disturbances magnitude maximum up to 40–60%. (4) They occupied spatial area of about 10° via latitude and 20° via longitude. (5) TEC anomalous structures were rather stable, i.e. their forms and locations remained "slowly changing" These anomalies are interpreted and explained in terms of electromagnetic lithosphere-ionosphere coupling.

Section STP. Solar-Terrestrial Physics

Prediction of the auroral westward electrojet index

Amariutei, O.A. (Finnish Meteorological Institute, Helsinki, Finland), and Ganushkina, N.Yu. (University of Michigan, Ann Arbor, USA)

Most contemporary technological systems are susceptible to the adverse effects caused by space weather disturbances, so the forecasting of space weather dynamics has become one of the most important applications of space physics. An ARMAX and neural network based model is proposed for the forecast of the auroral electrojet index which would quantify the magnitude of the magnetospheric disturbances. The NN – ARMAX model has the ability to predict from 10 to 60 steps ahead the dynamics of the AL index. It is shown that the model possess a reliable forecast, including throughout the duration of intense geomagnetic activity.

Atmospheric pressure variations at high latitudes associated with Forbush decreases of galactic cosmic rays

Artamonova, I.V. (St.Petersburg State University, St.Petersburg, Russia), and Veretenenko, S.V. (Ioffe Physical Technical Institute, St.Petersburg, Russia)

Changes of the lower atmosphere pressure associated with short-time variations of cosmic rays were analyzed during 1980–2006 years using data of NCEP/NCAR reanalysis. A pressure growth was revealed at the North and South Atlantic regions during Forbush decreases of galactic cosmic rays. Maximum of pressure growth was observed on the 3rd–4th days after event onset over Scandinavia, North of the European part of Russia and between South Africa and Antarctica. Both of maximums are on the latitudes 60°S and 60°N correspondingly. It was assumed that the observed pressure growth results from an intensification of anticyclones in these regions. The presented results suggest that cosmic ray variations may contribute the development of baric systems and play an important role in the solar-terrestrial relationships.

Climate problems as task of the ionospheric and solar-terrestrial physics

Avakyan, S.V. (All-Russian Scientific Center S.I. Vavilov State Optical Institute; Central (at Pulkovo) Astronomical Observatory of RAS, St. Petersburg, Russia)

The following scheme of the radiooptical three stage trigger mechanism in the solar - weather-climate links is substantiated:

- the transformation in the ionosphere of absorbed fluxes of solar ionizing radiation and corpuscles from the radiation belts into a flux of microwaves through the excitation of Rydberg states;
- the regulation of the rates of formation and destruction of water cluster ions by the microwave radiation at the troposphere;
- the contribution of clusters to the formation of cloud affecting the energy flux of the solar radiation and the heat flux from the underlying surface.

The water vapor content increased from the 1986 till 1999, and then it is decreasing. The global cloud cover, which decreased from 1985–1987 through 2000, increased in 2000–2004, and since 2004 has again been decreasing. All of the observed changes completely correspond to the radiooptical trigger mechanism, because, first, a decrease in the content of water vapor means its transformation into clusters and then into clouds, and, second, since the absolute maximum of geomagnetic activity was in the end of 2003, the concentration of water clusters was large. After 2004, the global cloudiness started to drop. It has been established that all cosmic factors of influence on the global surface air temperature are changing in such a manner that this is leading to climate cooling. At night, the presence of nighttime optically dense cloudiness in the winter period causes a slowed down cooling of the surface air. On the nighttime side, the entire cloudiness, both optically thick and thin, newly formed under the influence of a nighttime geomagnetic storm, actually slows down the surface air cooling in the winter period. This phenomenon can lead to such effects of the global climate change as “the predominant warming of winters” and “the doubled (in recent decades) growth rate of nighttime surface air temperatures compared with daytime temperatures” which were misunderstood until recently.

Geomagnetically induced currents as the cause of pipeline corrosion

Avakyan, S.V. (All-Russian Scientific Center S.I. Vavilov State Optical Institute; Central (at Pulkovo) Astronomical Observatory of RAS, St. Petersburg, Russia), Voronin N.A. (All-Russian Scientific Center S.I. Vavilov State Optical Institute, St. Petersburg, Russia), and Namgaladze A.A. (Murmansk State Technical University, Murmansk, Russia)

At present geomagnetically induced currents (GIC) are not even mentioned in the actual GOSTs, which regulate the processes of electrochemical corrosion of pipe metal underground constructions. According to the findings, this is the main source of violations in pipeline operation that result in anomalously fast corrosion wear. Any magnetic fields are created by electric currents, which may be called primary; then GIC may be called secondary currents, because they emerge when primary currents are alternating. Primary alternating electric currents, which induce GIC, exist in the following spheres:

- in magnetosphere – ring currents, responsible for the main phase of a magnetic storm, and currents in the tail part of the magnetosphere;
- in ionosphere, most intense in the auroral zone, as well as the equatorial electrojet;
- between the ionosphere and the magnetosphere, field aligned currents, streaming along geomagnetic field lines;
- in earth's crust – telluric currents;
- in atmosphere between the Earth and the ionosphere, currents related to thunderstorms, typhoons, and earthquakes; some of these currents stream in the ionosphere.

Precipitations of charged energy particles from the magnetosphere and the radiation belts can form part of field aligned currents, but the main contribution to GIC works according to the following scheme. Particles of keV-energies that precipitated in the ionosphere create additional ionization in the E-layer and increase conductivity in this areas, which, according to Ohm's law, leads to increased horizontal ionospheric currents and magnetic fields created by them. Temporal changes in these fields (the most intense during storms and substorms) induce GIC in pipelines according Faraday's law. The contribution of precipitated particle to GIC emergence is the largest

compared to other sources. Such currents are constantly viewed as a threat to the efficiency of large energy systems, including the accelerated corrosion of the main pipelines.

Spectral studies of oscillations observed by the high-latitude radar and magnetometers

Badin, V.I. (IZMIRAN, Troitsk, Moscow region, Russia)

The Tukey solutions found for the Schuster problem of hidden periodicities formulated for the data obtained by the meridian array of IMAGE magnetometers reveal equidistant ULF spectra of two types which differ from each other by shifting the spectral peaks to higher frequencies. A routine spectral analysis applied to the Doppler data obtained by the Norwegian STARE radar reveals isolated (solitary) millihertz frequencies well localized in the field of radar reflections. Within the errors of the weighted spectral estimates, the solitary frequencies found in the radar data coincide with the frequency steps between successive peaks of the equidistant spectra found in the magnetic data for the same auroral events. Since the velocity (and the electric field) of the magnetospheric convection dominates in the Doppler radar data, we can attribute the origin of the solitary frequencies found in the radar data to the ionospheric irregularities rotating along the closed trajectories of the magnetospheric convection. The agreement between frequencies found in the radar and magnetometer data supports a hypothesis suggesting that the oscillating currents observed by magnetometers can be generated by vortices of the magnetospheric convection. This explanation takes into account the Doppler shift, which appears between the magnetic and radar data since the high-latitude atmosphere at ionospheric altitudes is dragged by the magnetospheric convection. Additional information on the observed oscillations can be found by studying the cross correlations within the radar data. High correlations between the signals detected for distant points of the field of radar reflections seemingly indicate a global phenomenon observed by the radar. These correlational indications together with spectral indications can apparently help us to distinguish resonant (i.e. natural) magnetospheric oscillations from those driven by vortices of the magnetospheric convection.

System approach radiation belt electron fluxes: forecast and advance in understanding

Balikhin, M.A, Boynton, R.J., and Billings, S.A. (ACSE, The University of Sheffield, Sheffield, United Kingdom)

The Sheffield online forecast of daily fluxes at geostationary orbit became operational in spring 2012. The forecast is based on the mathematical model identified in the frame of the systems approach to complex dynamical systems. For the first stage, an orthogonal least squares technique was used to identify solar wind parameters that control fluxes of electrons for different energy ranges. For the second stage, NARMAX models for various energy ranges were identified. The Sheffield model forecast reliability is compared with other available online tools. In addition to providing the reliable online 24 hours ahead forecast the identified models are able to advance physical insight into the evolution of the fluxes at the geostationary orbit. In particular, it will be shown how the results of the orthogonal least squares technique can be used to differentiate between effects of radial and local energy diffusion.

Variations of parameters of the medial ionosphere during the solar eclipse on January 4, 2011

Barabash, V.V., and Chernogor, L.F. (Institute of Ionosphere, Kharkiv, Ukraine)

The purpose of the report is to present the results of observing the effects in the ionosphere caused by the partial (magnitude is 0.78) solar eclipse 4 January, 2011. Digisondes are used for observation of solar eclipse effects. Eclipse beginning was at 09:30, the main phase – at 10:59 and ending – at 12:29 local time, which lead world time on 2 hours. The oblique reflection of sounding radio wave and diffuse reflection were recorded near the main phase of the solar eclipse practically in the whole range of frequencies and heights. An increase in the virtual height, which averaged about 70 km was observed. The value of f_oE decreased by approximately 0.4 MHz. The minimum value of f_oE lag with respect to the solar eclipse main phase was approximately 0 minutes. The value of f_oF2 decreased by approximately 1.5 MHz. The minimum value of f_oF2 lag with respect to the solar eclipse main phase was about 16 minutes.

Applications of statistical models to calculations of the ionosphere distribution maps of currents and electric potential for individual substorms

Bazarzhapov, A.D., Tolochko, M.V., Mishin, V.M., and Lunyushkin S.B. (Institute of Solar-Terrestrial Physics, SB RAS, Irkutsk, Russia)

Maps of the distribution in the ionosphere of the electric potential, the system of ionospheric currents and electric potential during magnetospheric disturbances are calculated using the MIT programs from the data of ground-based magnetometers. However, for individual events, there are significant errors in calculations due to heterogeneity and voids in distribution of the magnetometers on the Earth's surface. When averaging the input data of many substorms observed in different UT, these errors are smoothed out due to the daily rotation of the Earth. The report shows how the above fact can be used for leveling the above calculation errors by combining maps of statistical substorm data and data of the 01.09.2008 individual substorm under consideration.

Dynamics of the polar cap boundary and the tail lobe magnetic flux during the 09.01.2008 substorm

Bazarzhapov, A.D., Tolochko, M.V., Mishin, V.M., Mishin, V.V., and Lunyushkin, S.B. (Institute of Solar-Terrestrial Physics, SB RAS, Irkutsk, Russia)

Using the magnetogram inversion technique (MIT) we obtained a time series of maps, each of which shows the position of permanent polar cap (PC) boundary prior to substorm, and the border, which varies during substorms. Using these maps, PC parts are marked, which showed reduction in the area of PC after the expansion onset. We measured the area of these parts, calculated values of the magnetic flux $\delta\Psi$ through each called area, and the values of the electromagnetic energy flux (Poynting flux ϵ'), that is proportional to Ψ^2 . On the maps of the electric potential we marked a flow of plasma convection, which occurs in the distant tail at the end of the growth phase, and then propagates Earthward. Beginning of expansion phase was observed a few minutes after flow crossing of PC border. The results are interpreted in the framework of the scheme,

in which the appearance of the flow is identified with the beginning of reconnection in the most distant tail.

Poloidal geomagnetic Pc5 pulsations and pulsations in the fluxes of energetic particles

Belakhovsky, V.B. (Polar Geophysical Institute, Apatity, Russia), and Pilipenko, V.A. (Institute of the Earth Physics, Moscow, Russia)

The event of 9 May 2003 when the poloidal geomagnetic Pc5 pulsations were observed at geostationary orbit on GOES-10 spacecraft was considered. The radial he-component of the geomagnetic field on GOES-10 exceeds the azimuthal hn-component. It is also seen the strong Pc5 pulsations in the module of the geomagnetic field. It confirms that the observed Pc5 pulsations are pulsations of the poloidal type. It is seen the cloud of protons on LANL-1991 satellite before the appearance of the poloidal geomagnetic Pc5 pulsations. Obviously this cloud is the source of the observed poloidal geomagnetic Pc5 pulsations due to development of kinetic instabilities. The poloidal geomagnetic Pc5 pulsations at GOES-10 spacecraft were accompanied by the pulsations in the fluxes of protons with energies 50-75 keV at LANL-1991 spacecraft. The geomagnetic Pc5 pulsations at geostationary orbit were accompanied by the Pc5 pulsations in fluxes of energetic electrons at LANL-1991 spacecraft and in cosmic noise absorption (CNA) at MCM station with the same frequency. The MCM station is located near the conjugate point according to the GOES-10 satellite. The coherency between the geomagnetic field variations and variations of the fluxes of energetic electrons is 0.92, while the coherency between the geomagnetic field variations and variations of CNA is 0.85 at the frequency of the maximum power spectrum. The poloidal geomagnetic Pc5 pulsations were not well seen on the ground magnetometers due to shielding effect of the ionosphere. The important parameter of the pulsations is modulation depth. The depth of modulation for the Pc5 pulsations in CNA reaches the value 85%. So in our work we firstly show that the poloidal geomagnetic Pc5 pulsations observed on the geostationary orbit were accompanied by the corresponding Pc5 pulsations in CNA near the conjugate point. Thus it is shown that the poloidal geomagnetic Pc5 pulsations were accompanied by the pulsations of precipitated energetic electrons.

The simultaneous Pc5 pulsations in magnetic field, auroral intensity and cosmic noise absorption

Belakhovsky, V.B. (Polar Geophysical Institute, Apatity, Russia), and Pilipenko, V.A. (Institute of the Earth Physics, Moscow, Russia)

We consider some events in the morning sector when the simultaneous Pc5 pulsations were observed in the magnetic field, auroral intensity, cosmic noise absorption (CNA) on the stations of the CARISMA, NORSTAR networks. The auroral Pc5 pulsations were registered by the meridian scanning photometer (MSP). For the geomagnetic Pc5 pulsations were observed the signatures of the field-line resonance (FLR) namely the decrease of the frequency with increase of the latitude, propagation from the low to high latitudes. The signatures of the FLR were also observed for the auroral Pc5 pulsations. By considering the relation of the 630.0/557.7 emissions we suppose that the auroral Pc5 pulsations may be caused by electron acceleration in the ionosphere.

Modelling of the lower and upper atmosphere interconnection

Beloushko, K.E. (Physics Department, Murmansk State Technical University, Murmansk, Russia)

Attempt to develop the united numerical model of the Earth's atmosphere is undertaken. Purpose of the project is development of the general methodologies and technologies of coupling of models with use of the so-called frame approach. As a basis to this meta-model was taken Upper Atmosphere Model (UAM) [1, 2]. UAM is for today the advanced and perspective Russian model of the upper atmosphere qualitatively comparable to foreign analogues and in a number of aspects surpassing them (on a covered range of heights, for example, from 60 up to 100000 km). As model of the lower atmosphere the General circulation model of atmosphere and ocean by Institute of Numerical Mathematics of the Russian Academy of Science (INM RAS, Moscow) is chosen. This model is equal to quality and competes with modern foreign forecasting models of weather and climate. Coupling of UAM and INM RAS models will allow not only to develop united model of atmosphere of the Earth, but also

thus to remove the uncertainty, connected with definition the upper boundary conditions in weather area and lower boundary conditions in upper atmosphere.

As a result of named problem analysis the following algorithm for coupling of models is offered: on range of coverage by both models an interval of heights (60–90 km) the iterative exchange of boundary conditions performed.

Results of some joined simulations on the basis of model of upper atmosphere UAM and model of general circulation of INM RAS are presented and discussed.

Author thanks for discussions and giving model data by A.A. Namgaladze and E.M. Volodin.

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Effects of the hot oxygen in the topside ionosphere

Bessarab, F.S., Korenkov, Yu.N., Klimenko, V.V., Klimenko, M.V. (Western Department of IZMIRAN, Kaliningrad, Russia)

The hot oxygen geocorona is an important region of the near-Earth space that plays a significant role for the maintenance of the nighttime ionosphere. The hot oxygen is important for the analysis of physical properties and experimental data of the upper atmosphere parameters. In this paper we studied the effects of the global distribution of the hot oxygen density in the topside ionosphere with using GSM TIP model (Global Selfconsistent Model of the Ther-

mosphere, Ionosphere, Protonosphere) developed in WD IZMIRAN, Kaliningrad. Model runs were performed for the moderate solar activity. and geomagnetic conditions and winter period. Our results shown a presence of the superthermal oxygen fraction about 0,1% relatively ambient oxygen at the 500 km altitude with temperature that is higher of the ambient oxygen temperature. The hot O density is close to ambient O density at about 1500 km altitude and exceeds main O at the exosphere altitudes. The influence of the hot oxygen atoms on the global structure of the topside ionosphere is discussed.

The comparison of the orbital-climatic diagram with the oxygen isotope record LR04 for investigation of the middle pleistocene transition

Bol'shakov, V.A. (M.V. Lomonosov Moscow State University, Dept. of Geography, Moscow, Russia)

Investigations of the Middle Pleistocene transition characteristics by comparing the composite oxygen isotope record Lisiecki and Raymo LR04 with the orbital-climatic diagram for the time interval 0-1500 thousand years ago has been provided. It is concluded that the record LR04 in the time interval from about 950 to 1070 thousand years ago, is distorted. It is shown that the change of rhythm glaciations from 41-thousand-year, related to variations in the Earth's axial tilt, to the 100-thousand-year eccentricity variations, there was about 1.24 million years ago. Since that time, the eccentricity cyclicity of glaciation was not interrupted.

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Peculiarities of fractal characteristics of the ULF emissions during quiet and disturbed conditions based on the data of 210 MM stations

Bondareva, T.V., and Smirnova, N.A. (St. Petersburg University, St. Petersburg, Russia)

Fractal analysis of ULF emissions – fluctuations of the Earth' magnetic field in the ULF ($f=0.001-1$ Hz) range, – have been fulfilled based on the magnetic records (1Hz sampling rate) of the 5 stations

situated along the 210 geomagnetic meridian (210 MM). The profile covers a wide range of latitudes from the near-equatorial region to the auroral zone. This chain of stations includes the Guam, Moshiri, Paratunka, Magadan and Chokurdakh locations. The 22 months period (1992–1994) has been analyzed. We have used the Higuchi method to get the stable values of fractal characteristics (fractal dimensions D and spectral exponents β). Dynamics of D and β have been investigated in relation to the quiet and disturbed conditions as it is followed from the Dst index dynamics. It is revealed that ULF emissions change their behavior from the antipersistent regime (during quiet conditions) to the persistent regime during geomagnetic disturbances. The results obtained are considered on the basis of the SOC (Self-organized criticality) concept.

Phenomena in the latitude F region of the ionosphere induced by powerful HF radio waves at the heater frequencies near the fourth electron gyro harmonic frequency

Borisova, T.D., Blagoveshchenskaya, N.F., Kalishin, A.S., Ivanova, I.M. (Arctic and Antarctic Research Institute, St. Petersburg, Russia), Kosch, M., Senior, A. (University of Lancaster, Lancaster, UK), Rietveld, M.T. (EISCAT Scientific Association, Tromso, Norway), Yeoman, T.K. (University of Leicester, Leicester, UK), Hagstrom, I. (Swedish Institute of Space Physics, Kiruna, Sweden)

We present the experimental results related to the studies of phenomena in the high latitude F-region of the ionosphere induced by high power HF radio waves when the heater frequency is near the fourth electron gyro harmonic frequency. Experiments reported here were conducted with using EISCAT HF heating facility at Tromso, Norway, on 22 and 23 February 2012 in early evening hours. HF pump waves of ordinary polarization (O-mode) radiated towards the magnetic zenith by 18 min cycles from 0 to 18 and from 30 to 48 minutes of each hour. In the course of each heater-on cycle the frequency was varied in the range from 5300 to 5600 kHz by 3.125 kHz step every 10 seconds. Effective radiated power of about 600 MW was used. The modified ionospheric F region was probed by the EISCAT UHF incoherent scatter radar (ISR) which operates at a frequency of 930 MHz, the CUTLASS (SUPERDARN), Hankasalmi, Finland radar, the software-based HF receiver to capture the stimulated elec-

tromagnetic emission (SEE), and ionosonde (dynasonde) at Tromso. In addition the bi-static HF Doppler scatter observations were carried out at several diagnostic paths having a common reception points located near St. Petersburg and Lovozero. The distinctive features in the behavior of the electron temperature and density, the stimulated electron emission components, the heater-enhanced ion and plasma lines are studied in detail under different relations between the heater frequency and critical frequency of F2 layer, $fH/foF2 = 0.89-1.12$. Multiple resonance phenomena occurred in the ionospheric F region, when the heater frequency is near the fourth electron gyro harmonic frequency, are analysed.

The numerical modeling of the background variations of the ionosphere total electron content and peak F2-layer electron density

Botova, M.G., and Namgaladze, A.A. (Murmansk State Technical University, Murmansk, Russia)

We investigated the ability of the Earth's Upper Atmosphere Model (UAM) to reproduce the background variations of the ionosphere total electron content (TEC) for the problem of search of the ionospheric precursors of the earthquakes. We understand under the background TEC variations the quiet variations of the ionospheric TEC taking place in absence of the seismogenic and geomagnetic disturbances. The TEC variations have been considered together with N_mF2 because the total electron content is determined by the peak F2-layer electron density.

The numerical modeling have been carried out with using the global, three-dimensional, time-dependent numerical model UAM in two different versions: (1) using the empirical thermospheric NRLMSIS-00 model for neutral components (UAM-TM) and (2) with theoretically calculated thermosphere parameters (UAM-TT). The model calculations have been carried out for quiet equinox and solstice conditions and different levels of solar activity ($F_{10.7} \sim 90$ and $F_{10.7} \sim 180$).

The results of the TEC and N_mF2 modeling were compared with the data obtained from the empirical ionospheric model IRI-2007 and GIM (Global Ionosphere Maps) of the TEC provided by the NASA in IONEX format derived from IGNSS network data. The results of the numerical experiments showed that a quantitative agreement

between theoretical and empirical TEC and $N_m F_2$ is satisfactory except the main ionospheric trough region for all date's simulations.

Parameters of wave disturbances in the ionosphere

Burmaka, V.P., Chernogor, L.F., Domnin, I.F., and Panasenko, S.V. (Institute of Ionosphere, Kharkiv, Ukraine)

The necessity of studying wave disturbances (WDs) in the atmosphere and in the geospace is due to the fact that WDs are indicators of high energy natural processes occurring in the Sun, the atmosphere and in the Earth's crust as well as of large scale disturbances accompanying, for example, the effect of high power radio transmission on the ionospheric plasma.

The observations of WDs in electron density in the ionosphere are made by Kharkiv incoherent scatter radar at altitudes of 120–600 km. The measurements are carried out during the periods around the spring and fall equinoxes as well as winter and summer solstices. Altitude and temporal dependences of relative amplitudes of WDs and spectral content of disturbances are analyzed. It is shown that WDs in the ionosphere with periods of 10–180 min are occurred at almost any time of day and any seasons. The relative amplitudes of WDs are changed from 0.01 to 0.5 and their maximum values were at altitude about 200 km. Solar terminator moving changed essentially the parameters of WDs.

The amplification of WDs in 5–120 min period range in the ionosphere over Kharkiv is detected during the operation of "Sura" heating facility located at distance of about 1000 km from the observation site. A factor of 1.5 to 4 increase of the relative amplitude of WD with a period of about 30 min, which is close to the period of cyclic mode of "Sura" facility, is revealed at altitudes of 160–235 km for all the days after start of heating facility operation. The parameters of this WD are the following: time delay with respect to first switching-on of heating facility is of 30 to 60 min, duration of WD is of 3–6 periods, relative amplitude is of 0.2–0.8. The obtained results have demonstrated that internal gravity waves, caused observed WD, are ducted in the atmospheric waveguide with altitude of about 200 km and width of 80 to 100 km.

Spectral characteristics of whistlers

Cherneva, N.V., Sivokon', V.P., Agranat, I.V. (Institute of Cosmophysical Research and Radio Wave Propagation, Kamchatka, Russia)

Investigation of whistlers appearing in the result of lightning discharges after passing through the ionosphere along the Earth magnetic field line is very significant for determination of electron concentration in the ionosphere and for the study of the results of natural and man impact on the upper layers of the atmosphere. In order to make long-term statistics of whistlers we develop a system for automatic detection. The received intermediate results of automatic detection of whistlers were compared with the data of World Wide Lightning Location Network (WWLLN), the relation of growth of the received whistler number with the increase of lightning activity of magneto-conjugated points (Kamchatka, Russia and Canberra, Australia) was analyzed. Taking into account the medium of whistler propagation (ionosphere) and its relation to lightning discharges, we may suppose that man impact on the ionosphere may also entail the growth of the number of whistlers. As long as at the present moment the American system HAARP (High Frequency Active Auroral Research Program) is actively influencing the ionosphere, a hypothesis is appearing on the connection of operation of this system and the dynamics of whistler occurrence. In order to check it, spectrograms of ionosphere heating process by HAARP antennas and whistler occurrence statistics were compared.

The January 4, 2011 solar eclipse effects in the ionosphere over Kharkov

Chernogor, L.F., Domnin, I.F., Emelyanov, L.Ya., and Lyashenko, M.V. (Institute of Ionosphere, Kharkov, Ukraine)

Observations and modeling results of January 4, 2011 solar eclipse (SE) effects in variations of the geospace plasma parameters are presented. The SE on January 4, 2011 was partial. The SE over Kharkov was observed from 07:29 to 10:28 UT. The total duration of solar eclipse was 2 h 59 min. The solar disk maximum cover occurred in 8:58 UT. Coverage of the solar disk by area and diameter was 0.71 and 0.78, respectively. Illumination of the Earth's surface and

near-Earth environment during SE decreased by a factor of 4. It was found that the SE has led to a decrease in the critical frequency foF2 and the F2-layer peak electron density Nm up to 31% and 52% respectively. The height of the layer F2 zm in the maximum phase of the SE has increased approximately up to 10 km. During the main phase of the eclipse observed a decrease in the electron density of 47–20% in the altitude range 190–410 km, respectively. The effects of the eclipse well marked in variations of electron and ion temperatures. The decrease of the electron temperature in the maximum phase of eclipse was approximately 130–370 K in the altitude range 190–410 km. In variations of the ion temperature effects of the eclipse revealed weak. During SE, an increase in the absolute values of the downward plasma transfer velocity Vz and their subsequent recovery. The greatest deviation in the Vz was observed during the main phase of the SE and was 9, 18, 34, 54 m/s at heights of 250, 300, 350, 400 km, respectively. The report also presents the results of simulations of variations in the physical processes in the ionosphere during the SE on January 4, 2011. The calculations show that the effects of SE led to a significant change in the dynamic and thermal modes of geospace plasma in a wide range of altitudes.

Ionospheric processes during geospace storm of August 5–6, 2011

Chernogor, L.F., Domnin, I.F., Emelyanov, L.Ya., Lyashenko, M.V., and Kharytonova, S.V. (Institute of Ionosphere, Kharkiv, Ukraine)

The objective of this report is to present the observation results according to the Kharkov incoherent scatter radar and the simulation of ionosphere parameters variations during the severe storm on August 5–6, 2011 (the maximum value of Kp = 8- and AE = 1741 nT, the minimum value of Dst = -113 nT). During the main phase of the magnetic storm (from 20:00 UT on August 5 to 04:00 UT on August 6) the relative deviation of the F2-layer critical frequency reached -25%. The F2-layer maximum height increased from 310 km to 510 km. The electron density in the range of heights 250–450 km decreased to 90–25% respectively. The temperature of electrons reached to 1250–2500 K, and the temperature of ions reached to 1110–1550 K. From August 6 to August 7 the negative ionospheric disturbance was observed over Kharkov. The maximum relative deviation of the F2-

layer critical frequency to -45% was detected on August 6 in 21:00 UT. The maximum height of this layer increased on 20–30%. The electron density decreased in 2–3 times at heights of 200–700 km. The ionospheric storm also had caused the significant changes of the high-altitude profile forms of the electron density. At night the temperature of electrons increased to approximately 650–2000 K, and the values of the ion temperatures increased to 650–1800 K for this range of heights. The magnetic storm had caused the significant disturbance of ionospheric dynamics. The largest variations of vertical component of plasma transport velocity were observed during the main phase of the magnetic storm. The oscillation amplitude of the velocity was 20–40 m/s, and the quasiperiod was about 3 hours. Such changes of plasma transport velocity affected the ionosphere structure. The simulation of the processes, which was accompanied the magnetic storm, was done: changes in the structure of neutral atmosphere, the electron gas heating, the temperatures of neutrals, the flows of heat, the plasma flows etc.

Geophysical and radio propagation effects of the January 4, 2011 solar eclipse

Chernogor, L.F., Garmash K.P., Leus S.A., and Rozumenko V.T. (Kharkiv V.N. Karazin National University, Kharkiv, Ukraine)

At the city of Kharkiv, the time variations in the amplitude and the Doppler shift of the signals reflected from the ionosphere have been observed over four decameter radio circuits during a partial (0.8 magnitude) solar eclipse in Central Europe. To study effects in the ionospheric F region, the measurements were acquired at 3.2 MHz and 4.2 MHz at near-vertical incidence with the transmitter and receiver spaced by ~ 70 km. To study effects in the ionospheric E region, 6.005 MHz and 6.075 MHz radio signals obliquely propagating between the transmitter and receiver over ~ 2100 km slant propagation path and reflecting over Poland were utilized. The solar eclipse was first associated with a decrease in the Doppler shift by 0.10 Hz, 0.25 Hz, ~ 0.19 Hz, and ~ 0.19 Hz at 3.2 MHz, 4.2 MHz, 6.005, and 6.075 MHz, respectively, and then with an increase of approximately the same magnitude. The solar eclipse also acted to widen the Doppler shift spectrum up to 1–1.3 Hz, which is due to an enhancement in plasma turbulence. We have not managed to detect

variations in the amplitude of the signals masked by multipath propagation. Doppler shift measurements and calculations showed good agreement.

Near the time of greatest obscuration, calculations produce a decrease in the electron density by 45% and 70% at E- and F-region heights, respectively. An increase in the reflection level altitude reached 15 km, 25 km, ~ 5 km, and ~ 5 km at 3.2 MHz, 4.2 MHz, 6.005, and 6.075 MHz, respectively.

The temporal variations in the Doppler shift and the amplitude of the signals reflected from the ionosphere generally show features characteristic of a solar eclipse. Naturally, they differ in numerical value due to the solar eclipse magnitude, space weather conditions, the time of the eclipse occurrence, the choice of radio circuits, etc.

Processes in the bottomside ionosphere accompanied by the January 4, 2011 solar eclipse

Chernogor, L.F., Podnos, V.A., Rozumenko, V.T., and Tyrnov, O.F. (Kharkiv V.N. Karazin National University, Kharkiv, Ukraine)

The partial (0.78 magnitude) solar eclipse acted to decrease the F2 layer critical frequency by 1.9 MHz. The minimum in the electron density lagged occurrence of the maximum obscuration by 16.0 ± 1.4 min.

A relative decrease in the E-region electron density was equal to 0.41 (0.46 from calculations) and to 0.50 (0.53 from calculations) in the lower part of the F-region. At the F2 layer peak, a decrease in the electron density was equal to 0.52 (0.51 from calculations). The agreement between the theoretical estimates of this decrease with the experimental values reconfirms the validity of the quadratic and linear dependency of the loss rate on the electron density in the ionospheric E and F regions.

The loss rate derived from the experiment and the value theoretically estimated from model profiles actually coincide. At an altitude of 240 km, this loss rate is equal to 10^{-3}s^{-1} .

The solar eclipse is determined to be associated with enhancements (as compared to reference day values) in critical F2-layer frequency oscillations with 0.2-MHz and 0.4-MHz amplitudes and ~ 30 -min and

60-min periods, respectively. These oscillations appeared in ~ 30 min after the solar eclipse onset. The corresponding normalized amplitudes of the electron density N were equal to ~ 0.08 and 0.16 , respectively. The durations of these oscillations were equal to 3 h and 5–6 h, respectively.

The solar eclipse was detected to be associated with variations of Doppler spectra that have been measured at 3.2 MHz and 4.2 MHz. The spectra showed one mode character virtually during the entire eclipse time interval. The most notable processes were quasi-periodic processes with periods of 15 min, 25 min, and 55 min and amplitudes of 0.15–0.25 Hz. Estimates have shown that these processes correspond to oscillations in the electron density that fall within the normalized amplitude range of 0.02–0.10. These processes appeared in ~ 30 min after the solar eclipse onset and lasted for 2–4 h.

The Doppler shifts were determined to attain minimum values of -0.10 Hz and -0.25 Hz at 3.2 MHz and 4.2 MHz, respectively, in ~ 40 min after the solar eclipse onset. The Doppler shift DC components, $\overline{f_d}$, were equal to -0.10 Hz and -0.25 Hz at the same operating frequencies, respectively. Calculations show that these $\overline{f_d}$ values correspond to the upward movement of the reflection levels with speeds of 2.8 ms^{-1} and 4.5 ms^{-1} , respectively. Calculations also show that the reflection levels for 3.2 MHz and 4.2 MHz radio waves shifted from approximately 145 km to 160 km and from 190 km to 215 km, respectively, over the time interval from the first contact to the maximum phase of the eclipse. The $\overline{f_d}$ values were positive within the time intervals from 09:05 UT to 10:15 UT and from 08:45 UT to 09:45 UT at 3.2 MHz and 4.2 MHz, respectively. The reflection levels descended 15 km and 20 km, respectively.

The variations in the Doppler spectra appreciably differed from those occurring on reference days. This permits us to claim that the quasi-periodic variations of these spectra were due to wave processes associated with the solar eclipse.

Associated with the solar eclipse was detected a significant enhancement in plasma turbulence in the ~ 100 –200 km altitude range.

Sporadic enhancements in the electron density were detected along with its expected decrease, which is, most likely, due to soft electron precipitation from the magnetosphere, i.e., due to the excitation of coupling within the Sun-interplanetary-medium-magnetosphere-ionosphere-atmosphere-Earth system.

Bursty bulk flows and plasma injections into the inner magnetosphere

Chernyaev, I.A., Sergeev, V.A., Dubyagin, S.V. (St. Petersburg State University, St. Petersburg, Russia), and Miyashita, Y. (Department of Geophysics, Kyoto University, Kyoto, Japan)

Recent studies show that the bursty bulk flows (BBFs) make the main contribution to the earthward plasma convection from the magnetosphere plasma sheet. In this study, we identify key characteristics of BBFs and evaluate their plasma and magnetic parameters, using the Geotail satellite located at the center of the plasma sheet at a distance of 8–15 R_E from the Earth. The fact of the penetration into the inner magnetosphere was determined from the geostationary satellites data (LANL). In the plasma bubble model, the motion is caused by the electric polarization due to lowest values for the entropy $S_B = PV^\gamma$. To estimate the volume of earthward moving plasma tubes we used the formula from the (Wolf et al., JGR, 2006). On the one hand, we obtained that the BBFs with lowest values of entropy SB and large amplitudes of dipolization have a better chance to penetrate into the inner magnetosphere, and the penetration depth of the BBFs does not depend on its initial velocity. That is good confirmation of plasma bubble model. On the other hand, the entropy parameter depends on the radial distance. That contradicts the model of a plasma bubble.

We obtained that the depth of penetration also depends on the state of the magnetosphere, as expected. The closer the registration point of BBF to the geostationary orbit, the greater the chance to discover the plasma injection into the inner magnetosphere. This is unexpected and interesting result. Thus, this study identifies the key parameters that control the penetration depth of the BBFs and provide some evidence in favor of plasma bubble model.

Very strong increases in the electron density of ionospheric F2 maxima observed during winter nights

Deminov, M.G., Deminova, G.F., and Badin, V.I. (Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation RAS, Troitsk, Russia)

An analysis of very strong increases in the electron density Nm of

F2 maxima (exceeding the double background) observed by midlatitude ionospheric stations during winter nights (02–04 LT) is presented. The background Nm is given by the local empiric models of the quiet Nm constructed by the data obtained at each station. The statistical analysis of the ionospheric data shows that the very strong Nm increases are observed during 1–3% winter nights. A significant portion of these cases corresponds to the periods of magnetospheric substorms. The very strong Nm increases observed at the low geomagnetic activity mainly correspond to the low solar activity. During the magnetic storms, such Nm increases are observed only for the high solar activity. For a given geomagnetic activity, the relative occurrence of the very strong Nm increases is mainly determined by the occurrence of the given activity, but this is not a sole cause of the observed behavior. For the low geomagnetic activity, the very strong Nm increases can apparently originate from several sources which include the changes in the thermospheric composition, enhancements in the midlatitude westward electric field occurring due to the Bz IMF rotation from north to south, and increases in the electron density of the conjugate (summer) ionosphere.

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Formation of spectrum of magnetospheric chorus emissions

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

We extend a model of spectrum formation for VLF chorus emissions in the magnetosphere to the case of both rising and falling tones. The model is based on the backward-wave oscillator regime of the cyclotron instability suggested by V.Y. Trakhtengerts (1995, 1999) as a chorus generation mechanism. We study possible mechanisms of formation of falling tones in chorus emissions and discuss their relevance for magnetospheric conditions. We also verify numerically the relationship between the wave saturation amplitude and the linear growth rate for the inhomogeneous plasma. This relationship is one of key relationships in the chorus generation model which determines the relation between the frequency drift rate and the linear growth rate. The latter relation based on analytical formula for the saturated wave

amplitude in a uniform medium (Trakhtengerts, 1984) has been employed when studying the observational data on VLF chorus detected by Cluster spacecraft in the equatorial magnetosphere (Macusova et al., 2010; Titova et al., 2011). In this paper we verify the analytical relationship obtained by Trakhtengerts (1984) and update it for the nonuniform medium typical of the near-equatorial magnetospheric region. For that we use the numerical model of self-consistent nonlinear resonant interactions between energetic electrons and whistler-mode waves (Demekhov and Trakhtengerfts, 2005). The implications for the estimates of electron-distribution parameters based on the parameters of observed VLF chorus elements will be discussed.

Magnetic reconnection site in the magnetotail during different solar wind streams

Despirak, I.V., Liubchich, A.A. (Polar Geophysical Institute, Apatity, Russia), and Koleva, R. (Space Research and Technologies Institute, BAS, Sofia, Bulgaria)

In this work we discuss the problem of the location of magnetic reconnection site in the magnetotail during substorms associated with different solar wind streams. It was shown recently that solar cycle variations of the solar wind control the location of magnetic reconnection in the tail. A well-known fact is that solar wind high-speed streams have different nature during different phases of solar activity. During the declining phase and minima of the solar cycle predominate the recurrent streams (RS) originating from coronal magnetic holes. During solar cycle maxima the flare streams connected with coronal mass ejections prevail. We analyze the relationship between the locations of the tail magnetic reconnection site during substorms connected with solar wind magnetic clouds (MC) and recurrent streams. We use data from Geotail spacecraft in the magnetotail and solar wind parameters from Wind spacecraft observations; the auroral bulge parameters were obtained by the Ultra Violet Imager onboard Polar. We show that magnetic reconnection in the magnetotail takes place closer to Earth when substorm is observed during MC, and further in radial distance for substorms during solar wind recurrent streams.

Variations in ion composition in the topside ionosphere

Domnin, I.F., Kotov, D.V. (Institute of Ionosphere of NAS and MES of Ukraine, Kharkiv, Ukraine), and Chernogor, L.F. (Institute of Ionosphere of NAS and MES of Ukraine, Kharkiv V.N. Karasin National University, Ukraine)

The study of variations in ion composition in the topside ionosphere is an important fundamental problem in the study of geospace. Results of studies of variations in the hydrogen ions fraction $N(H+)/N$ are valuable for the further development of ideas about the complex interaction between geospace subsystems and necessary for the successful solution of a number of actual applications, in particular, for space weather forecasting.

The spatial and temporal variations in the hydrogen ions fraction in the topside ionosphere obtained by the Kharkiv incoherent scatter radar for different seasons under low solar activity conditions are presented. The comparison of these variations with the data provided by the international reference ionosphere model IRI-2012 is made.

Analysis of the $N(H+)/N$ variations reveals the following features. For December 14, 2009, experimental values exceed the corresponding model values at almost all altitudes. It should be noted that very significant differences were between experimental and model variations. For example, at 07:00 LT, the experimental value of $N(H+)/N$ 0.8 at altitude 530 km, while the model gives the corresponding value less than 0.1. For June 23, 2010, in the daytime, differences between the experimental and model data are insignificant, but in the nighttime the model data are significantly underestimated. For example, at 02:00 LT the experimental value of $N(H+)/N$ reaches 0.9 at altitude 640 km, while the corresponding model value doesn't exceed 0.05.

It is concluded that the IRI-2012 model doesn't show the characteristic features of the diurnal variations in hydrogen ion fraction in the ionosphere over Ukraine (Central Europe) any qualitatively or quantitatively in the general case.

On a new subtype of Pc1 geomagnetic pulsations

Dovbnya, B.V. (Borok Geophysical Observatory, Schmidt Institute of Physics of the Earth RAS, Yaroslavl region, Borok, Russia), and Potapov, A.S. (Institute of Solar-Terrestrial Physics SB RAS, Irkutsk, Russia)

Geomagnetic pulsations with unusual properties were found in the frequency range between 1 and 4 Hz. At frequency-vs-time display the pulsations occur as a series of slant patterns with unexpectedly large repetition period of 10 to 30 minutes. Other peculiarities include lack of quasiperiod dependence on frequency and constant frequency dispersion (persistent slope of structure patterns) in the course of Pc1 series development. All observed events recorded at Borok Geophysical Observatory (58.0°N, 38.2°E) occurred during magnetospheric storms. In most cases beginning of the events coincided with the storm sudden commencement SSC. It was found also that during magnetic storms a series of successive broadband pulses can be observed with the same repetition period between separate elements of series as for Pc1. The revealed similarity of the two wave phenomena behavior is used for consideration of possible nature of the anomalous Pc1 dynamic spectra.

Peculiarities of spectra of the ionospheric Alfvén resonator emission

Dovbnya, B.V., Zotov, O.D, Klain, B.I. (Borok Geophysical Observatory, Schmidt Institute of Physics of the Earth RAS, Borok, Yaroslavl, Russia), and Potapov, A.S. (Institute of Solar-Terrestrial Physics, Siberian Branch RAS, Irkutsk, Russia)

Analysis of dynamic spectra of the noise-like pulsations with resonance structure of spectrum (RSS) over the range of 1–10 Hz has been performed in observatory Borok (latitude=58.03; longitude = 38.97). A peculiar feature of the observed spectra is that emission harmonics have a discrete structure which is typical for Pc1 pulsations. It is supposed that the detected phenomenon results from the fact that RSS are generated by cyclotron instability of protons in the magnetosphere.

Spectral properties of the Pc1 waves and noise-like pulsations with resonance structure

Dovbnya, B.V., Zotov, O.D., Klain, B.I., Kurazhkovskaya, N.A. (Borok Geophysical Observatory, Schmidt Institute of Physics of the Earth RAS, Borok, Yaroslavl, Russia), Potapov, A.S., and Rakhmatulin, R.A. (Institute of Solar-Terrestrial Physics, Siberian Branch RAS, Irkutsk, Russia)

Spectra of simultaneous observations of pulsations Pc1 and noise-like emissions over the range of 0.1–10 Hz is explored. We have analyzed the data from observatories Borok (latitude=58.03; longitude=38.97) from 1984 to 1986 and Mondy (latitude=52.2; longitude=104.5) from April to May 2010. It was revealed that a change of the 1 reference frequency and first harmonic of emission with resonance structure of spectrum (RSS) of the ionospheric Alfvén resonator are identical in 30% of simultaneous observations. It is possible to assume that RSS emission is generated in the same way as pulsations 1 in the Earth's magnetosphere.

Evening-side equatorial current during magnetospheric storm

Dubyagin, S.V., Ganushkina, N.Y. (Finnish Meteorological Institute, Helsinki, Finland), Apatenkov, S.V., Kubyshkina, M.V. (St. Petersburg State University, St.Petersburg, Russia), and Singer, H. (Space Weather Prediction center, Boulder, CA, USA)

Analysis of spacecraft observations in the vicinity of geosynchronous orbit has revealed the existence of a relatively thin (half-thickness of less than $1R_E$) current sheet in the dusk MLT sector during the main phase of a moderate magnetic storm on July 22 2009. Evaluation of the total westward current (integrated along the Z-direction) on the duskside at $r \sim 6.6R_E$ was comparable with that in the midnight sector. Isotropic boundaries (IB) of 80 keV protons observed by low-altitude satellites in the dusk sector were shifted $\sim 5^\circ$ equatorward relative to the IBs in the midnight sector. Both the equatorward IB shift and the current strength on the duskside correlate with the Sym-H* index. Such a configuration can not be adequately described by existing magnetic field models with predefined current systems (error in B_{60} nT), where knowledge of the magnetic field in the dusk-midnight sector is crucial for understanding the physics governing

magnetospheric particle flow. Analyzing results of previous statistical studies, we conclude that such geometry of equatorial current on the duskside is an inherent feature of a magnetic storm during the main phase.

Study of Mars and Venus interaction with the solar wind using a spherical hybrid model

Dyadechkin, S., Kallio, E., and Jarvinen, R. (Finnish Meteorological Institute, Finland)

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

We are developing a spherical hybrid model, a spherical hybrid model based on the HYB hybrid simulation platform for planetary plasma interactions, to study how, for example, Mars and Venus interact with the solar wind. The globally unmagnetized planets are under the influence of the super-alfvenic and super-sonic solar wind from the Sun. The ionospheres of such objects form an obstacle to the magnetized solar wind flow, and, as a result, an induced magnetosphere is formed around these objects.

The most important advantages of the spherical grid compared with the Cartesian grid, are: the better grid resolution, because the grid size decreases automatically near the obstacle (the planetary surface) and natural boundary conditions for the obstacle, because the planetary surface overlaps r-constant surface of the grid. In this report we demonstrate the latest achievements of the spherical grid development and illustrate the usage of the new spherical HYB hybrid model (HYBs) by showing results from simulations of the Mars- and Venus-solar wind interactions.

Application of thin magnetic filament approach for flapping oscillations

Erkaev, N.V., Lopatina, A.A. (ICM SB RAS and Siberian Federal University, Krasnoyarsk, Russia), Semenov, V.S., and Ainov, M.A. (St. Petersburg State University, St. Petersburg, Russia)

Thin magnetic filament approach is applied for modelling of nonlinear flapping oscillations of the magnetotail current sheet. The main assumption of this approach is that the total pressure (sum of the magnetic and plasma pressures) inside the magnetic tube is considered to be a known function of the coordinates, which is determined from the background equilibrium solution. The two-dimensional exact Kan's type solutions of the Vlasov's equations were used to set the background equilibrium conditions for magnetic field and plasma. The boundary conditions for the magnetic filament were found to be dependent on the ratio of the ionospheric conductivity and the Alfvén conductivity of the magnetic tube. A finite ionospheric conductivity causes a damping of the flapping oscillations. Introducing different initial displacement of the magnetic tube, we investigated both "kink" and "sausage" modes of flapping oscillations. These modes are independent only in case of symmetric background magnetic field configuration with respect to the current sheet. The "kink" and "sausage" modes are coupled in cases of a nonsymmetric background conditions. This means that the initial "sausage"-like disturbance can produce also the "kink"-like mode.

Behaviour of the accelerated magnetosheath plasma due to IMF

Erkaev, N.V., Mezentsev, A.V. (ICM SB RAS and Siberian Federal University, Krasnoyarsk, Russia), Farrugia, C.J. (Space Science Center, University of New Hampshire, Durham, USA)

We apply our previously developed semi-analytical "magnetic string" approach for analysis of the effects related to the magnetosheath plasma acceleration near the magnetopause due to IMF. The physical mechanism is that of draping of the magnetic field lines around the magnetosphere, and the associated magnetic tension and total pressure gradient forces acting on the flow. The maximum velocity can exceed the solar wind speed, and this effect is strongly pronounced

for low Alfvén-Mach numbers. The accelerated flow, streaming perpendicular to the magnetic field lines, produces slow magnetosonic waves propagating towards the higher latitudes along the magnetic field lines. We studied evolution of these waves and found that they develop to slow shocks characterized by abrupt jump of the plasma density and plasma pressure. We investigated the amplitudes and locations of these waves for different Alfvén-Mach numbers.

The spectral structure of the ULF magnetic noise as an indicator of local ionosphere conditions

Ermakova, E.N., Kotik, D.S., Pershin, A.V., Ryabov, A.V. (Radio-physical Research Institute, Nizhny Novgorod, Russia); Bosinger, T. (University of Oulu, Oulu, Finland); Zhou, Q. (Miami University, Oxford, Ohio, USA)

The spectral resonance structure (SRS), the broadband spectral maximum (BSM) and fine spectrum structure (FSS) of background noise in the frequency range 0.1–15 Hz were experimentally and theoretically studied basing on the data collected during 2009–2011 at the mid latitude station. The parameters of the mentioned above structures are determined by the parameters of the local ionosphere according this investigations. The character of the daily BSM dynamics and the SRS fundamental frequencies was analyzed. It was found sporadic decrease of the center frequency of BSM and variations of the boundary frequency that separates negative value of the polarization parameter spectra from positive. Also it was found the large-scale variations (from 2 to 6 hours) of the fundamental frequencies of the traditional SRS. The analysis of the simultaneous ionosonde data showed that such features in the daily dynamics of the spectral structures of the magnetic noise can be connected as with the variations of electron density in the local ionosphere f0F2 or only with the redistribution of electron density at altitudes of the E-layer and “valley”. The numerical calculations of the SRS using the IRI-2007 model cannot explain the sporadic nature of the change of BSM parameters and the SRS harmonics variation during the day. The simulations of the SRS at low latitudes using the model obtained from Arecibo incoherent radar have confirmed the possibility of sporadic character in BSM appearance at these latitudes, the appearance of which sometimes coincides with the formation of Es. The FSS features at the mid lat-

itudes and its appearance dependence on the solar activity are also investigated.

Formation of low energy electron population in the inner Earth's magnetosphere

Ganushkina, N.Yu., Amariutei, O.A. (Finnish Meteorological Institute, Helsinki, Finland), Shprits, Y.Y. (Institute of Geophysics and Planetary Physics and Department of Atmospheric and Oceanic Sciences, UCLA, Los Angeles, CA, USA), and Liemohn, M.W. (University of Michigan, Ann Arbor, MI, USA)

We focus on the formation of the solar wind driven low energy electron population in the region of the inner Earth's magnetosphere at $L=2-10$. This seed electron population ($E \approx 300$ keV) is a critical determinant of the radiation belts. A critical determinant of the radiation belts is the availability of a seed population. We use the Inner Magnetosphere Particle Transport and Acceleration Model (IMPTAM), which follows electrons with arbitrary pitch angles from the plasma sheet to the inner L-shell regions with energies reaching up to several MeVs in time-dependent magnetic and electric fields. By modeling of several storm events we investigate main factors influencing the formation of seed electron population, such as: (1) How does the plasma sheet act as a source for low energy electrons?, (2) What is the role of convection and inductive electric fields in transport and acceleration of the plasma sheet electrons?, and (3) How does the access of the plasma sheet electrons depend on nondipolar magnetic field? The relative contributions of these features and their influence on the intensity and location of electron fluxes in the radiation belts represents an important part of the assessment of the drivers of radiation belt physics.

Test of the GUMICS-4 global MHD code using empirical relationships

Gordeev, E.I., Sergeev, V.A. (St. Petersburg State University, St. Petersburg, Russia), Facsko, G., Palmroth, M., Honkonen, I. (Finnish Meteorological Institute, Helsinki, Finland)

Global MHD modeling is a powerful tool in magnetospheric physics research. There is a set of advanced and fast improving global MHD codes that are used widely in solar wind – magnetosphere interaction studies. Most of those models are accessible for everyone in the World Wide Web in automatic mode. Thus, the validation of simulation results is very important and acute question. We present the examination of the GUMICS-4 global MHD code correspondence to real magnetospheric measurements. Since the GUMICS-4 model provides unique and stable solutions under specified stationary input conditions, the best way for code validation is to compare numerical solutions with empiric relations (statistically averaged response of magnetosphere on specific solar wind / IMF conditions). More than 150 stationary solutions of GUMICS-4 code with different IMF / solar wind inputs were utilized. We use the large-scale characteristics that reflect the global state of magnetospheric system, such as: magnetopause size, cross – polar cap electric potential, tail lobe magnetic field, tail plasma sheet configuration and other. We found that stationary solutions of GUMICS-4 code satisfactorily fit with the main solar wind - magnetosphere empirical relations.

Is the magnetosphere of the Earth a similar obstacle as a PBS to the solar wind shock wave?

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

When one considers the terrestrial magnetopause to be a magnetohydrodynamic (MHD) tangential discontinuity (TD) one may study it, in some way, as a pressure balanced structure (pbs or PBS), typical of the solar wind flow. Thus as the solar wind shock wave contracts the magnetopause it becomes a source for the emergence of a secondary MHD rarefaction wave reflected from the magnetosphere, as well as for a refracted fast shock wave within it. Looking to a pbs with a decrease of plasma density and an increase of the interplanetary

magnetic field across a boundary of the pbs, one may find a refracted shock wave and a reflected rarefaction wave that are in many ways similar to the the collision of a solar shock wave and the terrestrial magnetosphere. The main difference is a free superalfvenic solar wind flow blocking the reverse fast rarefaction wave on its way from the pbs to the Sun. The recorded data from the spacecrafts Voyager 2 and WIND shows that there is usually an increase and/or decrease of plasma density anticorrelative to the change of the intensity of the interplanetary magnetic field across the boundary of the solar wind pbs. Solving Riemann-Kotchine's MHD problem we find for the first instance, a reflected MHD shock wave, and for the second instance, a reflected MHD rarefaction wave; in both instances the solar wind shock wave approaches the pbs. The magnetic holes, tangential discontinuities and stream interfaces are discussed as different examples of pbs. By the way, solar wind PBSs are indicated to have more TDs than rotational discontinuities.

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On modelling the Earth's magnetosphere with Vlasiator – a new global hybrid Vlasov code

Honkonen, I., von Alfthan, S., Pokhotelov, D., Palmroth, M., Kempf, Y., and Sandroos, A. (Finnish Meteorological Institute, Helsinki, Finland)

Global magnetohydrodynamic (MHD) codes have been used to successfully model the Earth's magnetosphere for a long time but they cannot describe non-Maxwellian plasma and leave out small scale physics of the magnetosphere. We are developing a global hybrid Vlasov model (Vlasiator) in which ions are modeled using a 6-dimensional distribution function and the electrons are a charge neutralizing massless fluid. We will present an overview of Vlasiator consisting of: an introduction to the system of equations, their discretization and solvers; our approach to developing a highly scalable simulation with inhomogeneous grids in real and velocity spaces; and some results we have obtained so far from various test cases.

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, MP and AS is supported by the Academy of Finland.

Occurrence of the middle-latitude red (SAR) arc due to the impact of a solar wind density pulse on the magnetosphere during southward IMF

Ievenko, I.B. (Yu. G. Shafer Institute of Cosmophysical Research and Aeronomy, Yakutsk, Russia)

A close connection of geomagnetic and auroral activity with the southward IMF Bz and solar wind (SW) speed is well-known. Recently Boudouridis et al. (2005, 2008) have shown that the increase of dynamic pressure owing to a fast growth of SW density at southward Bz immediately strengthens the convection electric field in the magnetosphere. In this work we analyze the manifestations of impulse increase of SW density at southward IMF in the dynamics of SAR arc and aurorae in 557.7 and 630.0 nm emissions at the Yakutsk meridian (200°E, geomagnetic) for the isolated event of December 28, 2010.

The main development features of the phenomena of December 28, 2010. After a fast southward turn of IMF Bz there is a slow depression of the Earth's magnetic field at low latitudes with the ASYM-H / SYM-H = 3-4 ratio. From 12 UT the growth of magnetospheric convection is observed in the equatorward extension of diffuse aurora (DA) at the Yakutsk meridian.

A sudden pulse of SW density up to $\sim 70 \text{ sm}^{-3}$ with a duration of ~ 10 minutes is observed in SI at low latitudes at 1340 UT and causes: (1) the impulse intensification of the westward electrojet at auroral latitudes at midnight sector of MLT with a duration of SI and also the increase of ASYM-H up to $\sim 100 \text{ nT}$; (2) the sharp brightening of auroral arc and DA at lower latitudes; (3) the appearance of intense SAR arc in the equatorial region of DA and its southward movement with velocity of $\sim 70 \text{ m/s}$ till 1630 UT.

Subsequent sudden changes of the SW density are well manifested in the brightening of auroral arc, DA and SAR arc during 4 hours of observations. Magnetic and auroral activities promptly damp after the sharp northward turn of IMF Bz. We assume that the observed

dynamics of aurorae and SAR arc in this event is caused by the fast intensification of convection and asymmetric ring current in the magnetosphere as consequences of the impulse increase of SW density during southward IMF.

Pulsating auroras at the SAR arc latitudes as a result of the generation of ion-cyclotron waves

Ievenko, I.B., Parnikov, S.G., and Alexeyev V.N. (Yu. G. Shafer Institute of Cosmophysical Research and Aeronomy, Yakutsk, Russia)

Photometric observations at the Yakutsk meridian (CGMC: 55-61°N; 200°E) have shown that during the substorms recovery phase at latitudes of SAR arc the luminosity pulsation splashes in the 427.8 nm emission are usually observed. These pulsations map the pulsating precipitations of the ring current energetic particles in the outer plasmasphere (Ievenko, 1995; Ievenko et al., 2008).

In this paper we consider possible mechanisms for two types of the observed luminosity pulsations. It is known that the pulsating precipitations can be caused by electromagnetic ion-cyclotron (EMIC) waves due to the modulation of the pitch-angle diffusion and, consequently, particle flux in the loss cone with the wave frequency (Coroniti and Kennel, 1970). We have performed the analysis of dependence of frequency of EMIC wave on the energy of the H⁺ and O⁺ ring current ions in the range L=3-5 for the cold plasma density from 100 to 1000 cm⁻³. For two observation situations of the luminosity pulsations it has been obtained the following:

1. The pulsation splashes with frequencies of 0.5-1 Hz are registered only in zenith and southward of the observation station at L=3-3.3. In this case, pulsating precipitations is likely due to the generation of EMIC waves at cyclotron resonance with energetic O⁺ ions.
2. The luminosity pulsations with frequencies of 0.05-0.1 Hz are observed in the latitudinal range of 4 degrees, in the diffuse aurora in the north and in the SAR arc region in the south. The Pulsations in this case, we also associate with the generation of EMIC waves at L=4-5 and their propagation into the inner magnetosphere. In both situations, the observed modulation frequencies of precipitations can be explained only by cyclotron waves resonance with heavy

ions O^+ , which can dominate in the ring current during magnetic storms.

Three-dimensional evolution of erupted flux ropes from the Sun (2–20 Rs) to 1AU

Isavnin, A. (Division of Space Science, Department of Physics, University of Helsinki, Helsinki, Finland), Vourlidas, A. (Space Science Division, Naval Research Laboratory, Washington DC, USA), and Kilpua, E.K.J. (Division of Space Science, Department of Physics, University of Helsinki, Helsinki, Finland)

Studying the evolution of magnetic clouds entrained in coronal mass ejections using in-situ data is a difficult task since only a limited number of observational points is available at large heliocentric distances. Remote sensing observations can, however, provide important information for events close to the Sun. In this work we estimate the flux rope orientation first in the close vicinity of the Sun (2–20 Rs) using forward modeling of STEREO/SECCHI and SOHO/LASCO coronagraph images of coronal mass ejections and then in situ using Grad–Shafranov reconstruction of the magnetic cloud. Thus, we are able to measure changes in the orientation of the erupted flux ropes as they propagate from the Sun to 1AU. We use these techniques to study 15 magnetic clouds observed during the minimum following the Solar Cycle 23 and the rise of the Solar Cycle 24. This is the first multievent study to compare the three-dimensional parameters of CMEs from imaging and in-situ reconstructions. The results of our analysis verify with earlier studies showing that the flux ropes tend to deflect towards the solar equatorial plane. We also find evidence for rotation on their travel from the Sun to 1AU. In contrast to past studies, our method allows one to deduce the evolution of the three-dimensional orientation of individual flux ropes rather than on a statistical basis.

HF-induced phenomena in the high latitude ionosphere F region on the depending the ratio between the heater frequency and the critical frequency of F2 layer

Ivanova, I.M., Blagoveshchenskaya, N.F., Borisova, T.D. (Arctic and Antarctic Research Institute, St. Petersburg, Russia), Yeoman, T.K. (Leicester University, UK), and Rietveld, M.T. (EISCAT, Tromsø Division, Norway)

The experimental results obtained in the course of four Russian EISCAT heating campaigns from 2009–2010 years are analysed. The EISCAT HF heating facility located near Tromsø in Northern Norway (geographical coordinates 69.6° N, 19.2° E; magnetic dip angle $I=78^\circ$) was used to modify the ionosphere in the high-latitude F region. The effective radiated power was about 190–250 MW. The HF pump wave with the ordinary (O-mode) polarization was radiated towards the magnetic zenith by 10 min on, 5 min off cycles. The ratio between the heater frequency and the critical frequency was varied from 0.7 to 1.1, $fH/foF2 = 0.7 - 1.1$. The modified ionosphere F region was probed by the EISCAT UHF incoherent scatter radar (ISR) which operates at a frequency of 930 MHz, the CUTLASS (SUPERDARN) coherent radars located at Hankasalmi, Finland and Reykjavik, Iceland, and by the ionosonde (dynasonde) at Tromsø. It was found the strong dependence of the electron temperature (T_e) and intensity of small-scale artificial field-aligned irregularities (AFAIs) in the heated patch on the ratio of $fH/foF2$. The strongest electron heating, AFAI intensity, and the spatial size of the heated patch were observed when the heater frequency is near the critical frequency, $fH=foF2$. The possible mechanisms of the observed phenomena are discussed.

Large-scale structure of the tail current by THEMIS data

Kalegaev, V.V., Alexeev, I.I., Nazarkov, I.A. (Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Moscow, Russia), Angelopoulos, V., and Runov, A. (UCLA, Los Angeles, California, United States)

On the base of simultaneous measurements from the THEMIS satellites, the radial profile of the magnetic field and the position of the inner edge of the magnetospheric tail were determined during selected events in 2009. The magnetic field of the currents other than the tail

current was subtracted from measurements. It was found that during quiet times the inner edge of the tail current sheet is located in the night side magnetosphere, at distances of about 10 Re. In the vicinity of the inner edge of the tail current the magnetic field B_x and B_z components were about -20 nT, while in the distant tail, at Xgsm -30 Re, these values were about -10 nT. During geomagnetic disturbances the inner edge of the tail current sheet shifted towards the Earth to a distance of about 7 Re. At the same time strong currents in the magnetotail were detected. During the disturbance of February 14, 2009 (min Dst -35 nT), the B_x component of the magnetic field near the inner edge of the tail current sheet was about 70 nT, and the B_z component was about -50 nT. Solar wind conditions on 14.02.2009 were consistent with those during moderate magnetic storms with minimum Dst of about -100 nT. However, strong currents, measured in the geomagnetic tail did not cause the expected Dst-effect. Calculations in terms of the magnetospheric magnetic field model A2000 give a tail current contribution to the magnetic field at the Earth's surface of about -20 nT. Actually, the magnetospheric current systems (magnetopause and cross-tail currents) were located at larger geocentric distances than typical during the 2009 extremely quiet epoch. The event of February 14 was accompanied by solar wind and magnetospheric conditions characteristic of a moderate storm. However, only a very small disturbance on the Earth's surface was detected consistent with an "inflated" magnetosphere.

Influence of geomagnetic activity on recurrence quantification indicators of human electroencephalogram

Kanunikov, I.E., and Kiselev, B.V. (St. Petersburg State University, St. Petersburg, Russia)

The investigation deals with the revealing of influence of a geomagnetic field on human electroencephalogram by means of recurrence quantification analysis (RQA). Zbilut and Webber developed RQA for definition of numerical indicators. They offered the measures using density of recurrent points and diagonal structures of the diagram: indicator of similarity (RR), determinism (DET), maximum length of diagonal lines (L), entropy (ENTR), trend (TREND). Slightly after Marwan offered the measures based on horizontal (vertical) structures of recurrent diagrams: laminarity (LAM) and indicator of a

delay (TT). V.B. Kiselev suggests the indicator CLEAN which shows influence of a stochastic component of process, thus prevalence of the stochastic component leads to increase of CLEAN value. The EEG base of 10 subjects was processed. The database included electroencephalogram records carried out from 16 points under three background conditions. Each subject took part in 15–50 experiments which are carried out to the period of time from half a year about one year. EEG was registered from temporal, central, parietal and occipital areas of the left and right hemispheres. The duration of EEG record was about 1 minutes. EEG was quantized with frequency of 200 Hz. For each subject for each of 16 points of EEG registration 9 recurrent measures of EEG were calculated (RR, DET, L, DIV, ENTR, RATIO, LAM, TT, CLEAN). Then the factor of correlation of these measures with an index of geomagnetic activity of Ap in a day of carrying out experiment and local daily K-index were calculated. As a result of this research the following conclusions were received.

1. Significant influence of intensity of a geomagnetic field on recurrent EEG dynamics indicators is shown. Thus the interrelation with indicators of local intensity of a geomagnetic field appeared higher than with planetary indicators.
2. Existence of significantly bigger number of relations between geomagnetic activity and recurrence quantification indicators of the left hemisphere EEG is shown.
3. The conclusion suggests that the geomagnetic field makes the main impact on a chaotic component of EEG.

Superstorm 20.11.2003: identification of hidden dependencies of the tail lobe magnetic flux on the solar wind dynamic pressure

Karavaev, Y.A., Shapovalova, A.A., Mishin, V.M., and Mishin, V.V. (Institute of Solar-Terrestrial Physics of Siberian Branch of Russian Academy of Sciences, Irkutsk, Russia)

A series of papers actively discuss the linearity/nonlinearity of the tail lobe magnetic flux Ψ dependence on the solar wind parameters (e.g., Petrinc and Russell, 1996; Shukhtina et al., 2004, 2005). Based on the magnetogram inversion technique (MIT), we obtained maps of

the field-aligned currents density distribution in the polar ionosphere and the time series of the tail lobe magnetic flux Ψ . We carried out a comparative analysis between changes of Ψ and solar wind dynamic pressure P_d for the 20.11.2003 superstorm. On the basis of the original method we noted the pronounced (in contrast to earlier results) P_d dependence on P_d . We obtained a plot of the $\delta\Psi/\delta P_d$ derivative hidden dependence on variable P_d , i.e., described a previously unknown effect of Ψ saturation at continuous P_d growth up to 20 nP.

REST way to provide web access to Auroral Precipitation Model

Katkalov, Ju.V. (Polar Geophysical Institute, KSC RAS, Apatity, Russia)

A web service to provide access to numeric data for Auroral Precipitation Model (APM) is developed. We used REST-style software architecture as a web service design model. The web service allows us to obtain the data in different formats (xml, json, text) from common range of applications, which support web content requesting. We provide well-documented API for access to web service for users. We also provide Matlab/Octave interface for web service API. The documentation and description of APM are available online from <http://apm.pgia.ru/>. In this report a few examples of using web service API are shown.

Night-side substorms and associated morning Pc5 pulsation activity: Case study

Kauristie, K., Uspensky, M.V., Dubyagin, S. (Finnish Meteorological Institute, Helsinki, Finland), Kleimenova, N.G., Kozyreva, O.V. (Institute of Physics of the Earth and Space Research Institute RAS, Moscow, Russia), and Vlasov, A. (Institute for Meteorology and Climate Research, Karlsruhe, Germany)

Two substorm events in the midnight sector accompanying by beautiful geomagnetic Pc5 pulsations in the morning sector have been analyzed using the Themis and the MIRACLE instrumentation. During

both events the sudden pulsation suppression has been observed simultaneously with substorm onsets. During our primary event, which took place on Jan 18 2008, Geotail had a good location at $X_{gsm} \sim 26$ for monitoring solar wind conditions and an abrupt IMF Bz turning towards positive values demonstrated the substorm onset and decay in the pulsations. Detailed analysis of the space- and ground based observations suggest, that the IMF turning led to a global change in the magnetospheric configuration so that the conditions favoring Field Line Resonances disappeared. During this event, the strong BBF-flows ($V_{ix} \sim 200$ km/s) were absent. We note that Themis satellites covered only a limited sector in the magnetotail which was somewhat aside (~ 3 Re to east) from the onset longitude and for this reason they may have missed some BBF-activity. In the second case (Feb 19, 2008) we cannot see as clear connection between solar wind properties and magnetospheric activity as in the first case. This case has two subsequent substorms, first at MLAT ~ 67 and second at MLAT ~ 80 . The first substorm onset is accompanied by enhancement in the morning sector pulsations (like reported previously in literature) but during the second substorm the magnetosphere repeats the same behavior as the primary case: the substorm onset seems to kill the pulsations. The plausible scenarios which could explain the midnight-morning sector coupling are discussed.

Space climate cycles and physical&tectonic, climatic changes in the Earth

Kharitonov, A.L., and Kharitonova, G.P. (Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation RAS, Troitsk, Moscow Region, Russia)

The analysis of available ideas of the role of Space climate factors in global climatic changes of environment and Earth geosphere in the course of its evolution is carried out. As basic experimental data geomagnetic K-Ar Kox timeline for the last 5 million years, the scale of paleomagnetic inversions of Pechersky during about 550 million years, the data of change of level of waters of the World Ocean for the last 180 million years, paleotectonic data for 4.0 billion years, the data of spasmodic emergence and development of new species for the last 4.0 billion years, the data of geochronology of the ice ages calculated from the maximum and minimum distribution evaporites

for the last 800 million years was used. Data were analyzed by the spectral method of the maximum entropy. As a result of the spectral analysis some main periodicity, corresponding $\phi_1 = 740 - 100$, $\phi_2 = 370 - 50$, $\phi_3 = 185 - 35$, $\phi_4 = 25 - 10$, $\phi_5 = 3 - 1$, $T_6 = 0.6 - 0.4$, $T_7 = 0.2 - 0.1$ to millions the years, being shown in various geophysical and climatic processes are allocated. By results of the analysis of the allocated periodicity in various geobiophysical data the possible model of geophysical and climatic changes which are connected with periodic impacts on Earth of Space climate factors (change of intensity of the magnetic field, change of superficial density of the ionized and neutral hydrogen, concentration of substance of the remains supernew) at Earth movement, in the course of its evolutionary development was formulated and discussed. Work is executed with Russian Foundation of Basic Research support on the grant of No. 10-05-00343-a.

Space weather and physical processes on the Earth

Kharitonov, A.L., and Kharitonova, G.P. (Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation RAS, Troitsk, Moscow Region, Russia)

Results of research steady plasma heterogeneity of the interplanetary magnetic field of anomaly density, speed, temperature of plasma of solar wind and the sign magnetic field and the magnetic field configuration from the "Ace" spacecraft data are considered. For acknowledgment of anomaly physical parameters considered interplanetary magnetic-plasma heterogeneity are analyzed the independent geophysical data of other spacecrafts for the investigated time period of work of the "Ace" spacecraft in the flight orbit. Such steady magnetic-plasma heterogeneity at collision with the magnetosphere of the Earth is 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 the heliosphere electrojet through the chain of the physical processes leading finally to physical&tectonical changes is considered. The activity is executed at support of Russian Foundation of the Basic Research grant No 10-05-00343-a.

MHD model of Jupiterian magnetodisk

Kislov, R.A. (Space Research Institute of Russian Academy of Sciences; Moscow Institute of Physics and Technology, Moscow, Russia)

Jupiter has a great dipole magnetic moment and a high rotation speed that, taking into account interior magnetospheric plasma sources (generally Io's volcanism), lead to the formation of magnetodisk where magnetic field lines are elongated in radial direction. In a frame of MHD approximation 2D equilibrium model of magnetodisk is constructed; the influence of centrifugal force on this structure is investigated; the cases of isothermic and adiabatic plasma states are considered. Self-consistent profiles of current density and magnetic field in three different cross-sections are obtained, correspondingly to intervals of differential rotation. It is shown that the tangential magnetic field of magnetodisk tends to constant value at the edges of current sheet that is decreased in radial direction as well as the current amplitude. The cross distribution of temperature in the adiabatic magnetodisk model is studied and demonstrated that current sheet plasma is warmer in the central magnetodisk region and is colder at its edges. It is shown that magnetodisk thickness is decreased in radial direction gaining the minimum in some intermediate region that it becomes larger in the external magnetodisk part, that is due to violation of plasma corotation at the periphery of the system. The validity region of the model is investigated. It is shown that this model is in agreement with available qualitative and quantitative experimental results.

Effect of substorm activity on properties of long-period geomagnetic pulsations generated by fronts of solar wind dynamic pressure inhomogeneities

Klebanova, Yu.Yu., Mishin, V.V., and Tsegmed, B. (Institute of Solar-Terrestrial Physics, Siberian Branch of RAS, Irkutsk, Russia)

We investigate properties of daytime long-period geomagnetic pulsations caused by a series of solar wind dynamic pressure sharp changes, accompanied by the development of the 01 August 1998 substorm for the 18.25–18.48 UT period. The properties of initial pulsations, detected before the substorm development, correspond to the quiet time

excitation model in the contact point between inhomogeneity front and the magnetopause, when pulsations propagate from this point antisunward with the amplitude increase, and with the opposite polarization at dawn and dusk sides. The substorm development leads to more complex behavior of pulsation amplitude and polarization on the dayside. It was possibly caused by the arrival to dayside of waves generated by substorm processes at the night side. Spectral analysis, carried out for several events, has shown that the strong dynamic pressure difference at the inhomogeneity front causes global geomagnetic pulsations at ca 2.5 mHz. Such global pulsations, observed at high and mid latitudes, can be a manifestation of the radial magnetospheric oscillations.

Geomagnetic Pi2-3 pulsations and auroras associated with polar substorms

Kleimenova, N.G., Kozyreva, O.V., Malysheva, L.M. (Institute of Physics of the Earth RAS, Moscow, Russia); Kornilova, T.A., Kornilov, I.A. (Polar Geophysical Institute RAS, Apatity, Russia); Antonova, E.E. (Institute of Nuclear Physics of Moscow State University, Russia)

High-latitude isolated substorms (or polar substorms), observed at geomagnetic latitudes higher 71°CGM and not accompanied or preceded by substorms at auroral latitudes, have been studied during the minimum of the solar activity. The maximum in the diurnal occurrence of the polar substorm was in the late evening. The bay-like geomagnetic disturbances with much lower amplitudes were observed at auroral stations, located near local magnetic mid-night. The evening polar substorms were typically accompanied by high-latitude auroras and long-lasting very strong Pi2 and Pi3 geomagnetic pulsations. Contrary to "classical" substorms, these pulsations were not observed at lower latitudes. The geomagnetic pulsations have been recorded simultaneously with aurora activity at these latitudes. The polar substorm source localization is discussed.

Storm-associated equatorial Pc3-4 geomagnetic pulsations based on the one-second INTERMAGNET multi-stations measurements

Kleimenova, N.G. , Kozyreva, O.V., Malysheva, L.M. (Institute of Physics of the Earth RAS, Moscow, Russia); Soloviev, A.A., Bogoutdinov, S.R., Zelinsky, N.R. (Geophysical Center RAS, Moscow, Russia); and Chulliat, A. (Institut de Physique du Globe, Paris, France)

New 1-s sampled magnetic data have been obtained from 6 equatorial longitude spaced INTERMAGNET stations. For the first time, the multi-station behavior of the equatorial geomagnetic pulsations, ranged in 8-20 mHz (Pc4) and 20-50 mHz (Pc3), have been analyzed during different phases of several magnetic storms in the beginning of new (24-th) cycle of the solar activity in 2010-2011. It was found, that Pc3-4 geomagnetic pulsation bursts occur simultaneously at all considered equatorial stations with significant amplitude enhancement near local magnetic noon. The pulsation amplitude spectra demonstrated the clear similarity at all equatorial stations. Some of Pc3-4 events were compared with the simultaneous pulsation data obtained at INTERMAGNET subauroral station Kerguelen (PAF) and mid-latitude stations Crozet (CZT) and Chambon-le-Forêt (CLF). The possible effects of the solar wind and Interplanetary Magnetic field (IMF) disturbances on the behavior of Pc3-4 geomagnetic pulsations have been studied.

Middle atmosphere influence on the parameters of the global thermosphere–ionosphere system

Klimenko, M.V., Klimenko, V.V., Bessarab, F.S., Koren'kov, Yu.N. (Western Department of IZMIRAN RAS, Kaliningrad, Russia), Rozanov, E.V. (Physikalisch-Meteorologisches Observatorium, World Radiation Center, Davos, Switzerland, Institute for Atmospheric and Climate Science ETH, Zurich, Switzerland), and Karpov, I.V. (Western Department of IZMIRAN RAS, Kaliningrad, Russia)

The prolonged continuous minimum of solar and geomagnetic activity of 2007–2009 allows more carefully examine the relationship between processes in the middle and upper atmosphere. The purpose of this report is: (1) the study of the global response of the

thermosphere-ionosphere system to the disturbances on the middle atmosphere; (2) carrying out the model calculations of the thermospheric and ionospheric parameters, taking into account the influence of the lower and middle atmosphere using different models. Based on the model calculations, we have drawn the conclusions about the possible scenarios and formation mechanisms of the Earth's middle atmosphere effects in the upper atmosphere parameters. These investigations were carried out at financial support of Russian Foundation for Basic Research (RFBR) – Grant No. 12-05-00392.

PSBL field-aligned beams and currents, and their auroral and ground manifestations

Koleva, R. (Space Research and Technologies Institute of BAS, Sofia, Bulgaria), Grigorenko, E.E., Zelenyi, L.M. (Space Research Institute of RAS, Moscow, Russian Federation), and Sauvaud, J.-A. (IRAP, University of Toulouse, CNRS, Toulouse, France)

The plasma sheet boundary layer (PSBL) is characterised by field-aligned high-velocity ion beams and it is naturally to expect associated field-aligned currents (FAC) streaming in the lobe-plasma sheet interface. Recent statistical analysis revealed two different types of ion beams. Ion beams typical for quiet and slightly disturbed geomagnetic periods (Type I) are collimated in energy and are accompanied by isotropic electrons. Under these conditions no FACs or FACs of very small current density are registered. In active periods, powerful field-aligned ion beams with large parallel temperatures are observed, along with anisotropic electron fluxes, with distributions bearing the signature of a separatrix. Electrons produce a pair of FACs: at the lobeward edge directed earthward, and inside PSBL — tailward. We studied statistically a database of 364 CLUSTER observations of PSBL ion beams. Their auroral and ground manifestation was investigated using POLAR and IMAGE UV images and magnetograms of appropriate ground stations. As a rule in cases of Type I ion beams CLUSTER footprints are in the region of diffuse aurora and the magnetograms exhibit no or small variations in the horizontal magnetic field component. In cases of Type II beams (with currents), CLUSTER footprints are located adjacent to the brightest auroral spot and the magnetograms exhibit large negative variations of the horizontal magnetic field component. However, in

considerable number of cases PSBL currents are observed in quiet conditions. CLUSTER spectrograms for these cases reveal that the electrons are accelerated to energies lower than usually in substorm conditions. There are several noteworthy exceptions, when PSBL ion beams of Type I without currents are observed in quite active periods. This could imply energy deposition from the near tail coexisting with acceleration process on closed field lines in the distant tail.

Super-nonlinear Alfvénic waves in solar coronal plasma

Kolotkov, D.Yu., Dubinov, A.E. (Sarov Institute for Physics and Technology National Research Nuclear Institute, Sarov, Russia), and Benevolenskaya, E.E. (Pulkovo Observatory, St. Petersburg, Russia)

It is demonstrated, that Super-Nonlinear shear Alfvénic waves (SNW), characterized by the nontrivial topology of their phase portraits: their phase trajectories envelop one or several separatrix layers, can exist in solar coronal multispecies plasma. Theoretical indications of SNW, supported by data from SDO, INTEGRAL and CORONAS-F, are given.

The effect of microscopic charged particulates in space weather

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

Space weather is a relatively new and important field of research. It is relevant to diverse topics such as radio communication, space travel, diagnostics of ionospheric and space plasmas, detection of pollutants and re-entry objects, prediction of terrestrial weather and global warming. Recently it has been shown that nano- and micrometre-sized electrically charged particulates from interplanetary space and from the Earth's atmosphere can affect the local properties as well as the diagnostics of the interplanetary, magnetospheric, ionospheric and terrestrial complex plasmas. In this report the sources of the charged dust particulates and the effects of the latter on the near-Earth space weather are examined. This work is supported by the

Presidium of the Russian Academy of Sciences (the basic research program No. 22 "Fundamental problems of research and exploration of the solar system"), the Division of Earth Sciences of the Russian Academy of Sciences (the basic research program "Nanoscale particles: conditions of formation, methods of analysis and recovery from mineral raw"), and the Russian Foundation for Basic Research (grant No. 12-02-00270-a).

Effects of the solar radiation in the dusty plasma system in the exosphere of the Moon

Kopnin, S. I., Golub', A. P., Izvekova, Yu. N., Popel, S. I. (Institute for Dynamics of Geospheres RAS, Moscow, Russia); Dol'nikov, G. G., Zakharov, A. V., Zelenyi, L. M. (Space Research Institute, Moscow)

The day-side surface of the Moon is charged under the action of the electromagnetic radiation of the Sun, solar wind plasma, and plasma of the Earth's magnetotail. The day-side surface of the Moon interacting with solar radiation emits electrons owing to the photoelectric effect, which leads to the formation of the photoelectron layer over the surface. Dust particles located on or near the surface of the Moon absorb photoelectrons, photons of solar radiation, electrons and ions of the solar wind, and, if the Moon is in the Earth's magnetotail, electrons and ions of the magnetospheric plasma. All these processes lead to the charging of dust particles, their interaction with the charged surface of the Moon, and rise and motion of dust. Small dust particles (smaller than several microns), repulsing from the surface, can rise from several meters to kilometers over the surface of the Moon. Thus, dust over the Moon is a component of the dusty plasma system; investigations of this system in the surface layer of the Moon are of significant interest, including technological interest, for instruments mounted on lunar stations, choice of a Moon landing site, etc. Here, we consider the motion of single charged dust particles, we study the dusty plasma system in the surface layer of the Moon. The situations where a dust particle is formed over lunar regolith regions and hydrogen enriched regions of the surface of the Moon are analyzed. The problem of the existence of the dead zone near a lunar latitude of 80 degree, where, as was assumed earlier, dust particles cannot rise over the surface of the Moon, is discussed. The dust density over

the surface of the Moon is calculated. This work is supported by the Presidium of the Russian Academy of Sciences (the basic research program No. 22 "Fundamental problems of research and exploration of the solar system"), the Division of Earth Sciences of the Russian Academy of Sciences (the basic research program "Nanoscale particles: conditions of formation, methods of analysis and recovery from mineral raw"), and the Russian Foundation for Basic Research (grant No. 12-02-00270-a).

Ground based and THEMIS observations of 24.01.2012 CME event

Kornilov, I.A. (Polar Geophysical Institute, Murmansk Region, Apatity, Russia), Sigernes, F. (The University Centre in Svalbard (UNIS), N-9171 Longyearbyen, Norway), and Kornilova, T.A. (Polar Geophysical Institute, Murmansk Region, Apatity, Russia)

On the base of auroral white light TV observations at Lovozero, Barentsburg and Canadian THEMIS ASI data magnetospheric and auroral effects of 24.01.2012 strong CME (Coronal Mass Ejection) event were investigated. Principally new feature in ours aurora study was using the data of recently developed hyperspectral all-sky cameras (NORUSCA project) installed in Longyearbyen and Barentsburg in 2011. Cameras use electro-optical tunable filters to image the night sky as a function of wavelength throughout the visible spectrum with no moving mechanical parts. Comparison of fine details of aurora dynamics detected by b/w cameras and spatio-temporal variations of 5577 and 6300 emissions with THEMIS satellites data on magnetic and electric fields and particle fluxes in energy range 10 eV – 500 keV allowed making preliminary conclusions concerning auroral electrons source localization and acceleration mechanism.

Spatio-temporal dynamics of counterstreaming auroras during the substorm active phase

*Kornilova, T.A., and Kornilov, I.A. (Polar Geophysical Institute, Ap-
atity, Russia)*

Using of filtered keograms from the Lovozero, Loparskaya and Tu-
manny all-sky TV cameras and THEMIS all-sky imager array al-
lowed us to investigate in detail optical signatures of poleward forms
propagating equatorward and getting involved in the auroral pattern
in the course of substorm expansion. We found that poleward forms
(nearly east-west oriented auroral arcs) often penetrate into poleward
expanding regions of active auroras from preceding breakup activa-
tions in the south. In total, forty such events have been analyzed.
The major point that we aimed to clarify is whether these auroral
forms fade, disperse or keep moving equatorward in such occasions.
We were able to trace their fate and demonstrate that they keep
their equatorward motion against the background of bright, pole-
ward expanding auroras, forming a counterstreaming auroral pattern
at substorm expansion.

An analysis of the velocities of equatorward moving auroral forms
inside the bulge (namely, optical intrusions from auroral poleward
boundary and auroral arcs referred to breakup at the equatorial
boundary of the auroral oval) for the considered events allows us
to suppose that the electron acceleration mechanisms are different
for counterstreaming auroras. Probably northern structures can be
caused by electrons accelerated by tail reconnection processes (20–
25 Re) and active spreading northward breakup forms are accelerated
near the Earth in parallel electric fields (1–2 Re).

Kink branch of a double gradient magnetic instability in MHD modeling

*Korovinskiy, D., Biernat, H. (Space Research Institute, Graz, Aus-
tria), Divin, A., (Katholieke Universiteit Leuven, Leuven, Belgium),
Erkaev, N. (Siberian Federal University, Krasnoyarsk, Russia), and
Semenov, V. (St.Petersburg State University, St.Petersburg, Russia)*

The paper presents the detailed numerical investigation of the double
gradient mode, which is believed to be responsible for the magnetotail

flapping oscillations - the fast vertical oscillations of the Earth's magnetotail plasma sheet (quasi-period $\sim 100 - 200$ s). The instability is studied using the magnetotail near-equilibrium configuration. For the first time, linear three-dimensional numerical analysis is complemented with full 3D MHD simulations. It is known that the double gradient mode has unstable solutions in the region of the tailward growth of the magnetic field component, normal to the current sheet. The unstable kink branch of the mode is the focus of our study.

Linear MHD code results agree with the theory, and the growth rate is found to be close to the peak value, provided by the analytical estimates. Full 3D simulations are initialized with the numerically relaxed magnetotail equilibrium, similar to the linear code initial condition. The calculations show that current layer with tailward gradient of the normal component of the magnetic field is unstable to wavelengths longer than the curvature radius of the field line. The segment of the current sheet with the earthward gradient of the normal component makes some stabilizing effect. The overall growth rate is close to the theoretical double gradient estimate averaged over the computational domain.

On the nature of the magnetic background noise at Schumann resonances band

Kotik, D.S., Ermakova, E.N., and Ryabov, A.V. (Radiophysical Research Institute, Nizhny Novgorod, Russia)

In this paper we attempted to study the source of magnetic background noise at frequency range 0.1–15 Hz in three ways: Correlation analysis of daily variations of noise amplitude at the frequency of the 7.8 Hz and at a frequency below first Schumann resonance; analysis of the influence of data special processing of the horizontal magnetic components on the spectral resonance structure (SRS); numerical simulation of the spectra of the magnetic component by the source, which has the "white" noise structure. Basing on the mid latitude observatory New Life (NL: 55.97 N, 45.74 E) data the comparison a of diurnal variations of the amplitude of the magnetic component at the different frequencies was made. Analysis of the weekly averaged diurnal variations of the amplitude noise at different frequencies showed their identity on selected frequencies in all seasons, except summer, when it can be substantial local thunderstorm

activity. In order to show that the source of the SRS, at the same time with lightning impulses (spherics) is a noise component, the special processing was undertaken. The threshold value was specified, above which the values of the impulse noise component were replaced by "white" noise with amplitude not exceeding the threshold. As a result, the spectra were obtained at different levels of threshold, and it was shown that shape of the spectrum does not change in the frequency band 0.1–15 Hz. Thus, it can be concluded that the noise component significantly determines the phenomenon of SRS, together with the impulse noise component. On the basis of the quantity theory of SRS the numerical simulation with remote source in the form of "white" noise was performed. The results of this simulation showed the appearance of clear SRS structure with a typical diurnal variation of ionospheric parameters.

The role of the interplanetary and substorm factors in the development of the geomagnetic storm (GS) main phase (MP) on the evidence of the cluster analysis

Kovalevsky, J.V. (Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation RAS, Troitsk, Russia)

The role of the interplanetary and substorm factors in generation and development of the geomagnetic storm main phase on the evidence of the cluster analysis realized in the form of the "nearest neighbour" method are investigated. The 31 GSs with D_{st}^{min} in range from -37 to -226 nT (hourly data) are used. The $D_{st} - AE - B_Z$ scale cluster classification of 31 GSs (in terms of mean values of D_{st} , AE-indices and B_Z -component of interplanetary magnetic field (IMF) and their standard deviations in MP time interval) have allowed to select moderate (MGS: $D_{st}^{min} = -62\text{nT}$), intense (IGS: $D_{st}^{min} = -130\text{nT}$) and very intense (VIGS: $D_{st}^{min} = -213\text{nT}$) storm MPs (the samples) associated with AE-index and B_Z -component of IMF.

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 ($CP = [D_{st}] + [B_T] + [B_Z] + (B_Y) + (\varepsilon)4$) of internal IPPs structure, and in turn the MPs of every sample has own common part IPPs internal structure ($MGS = CP + (AE) + B_X + (DCF)$; $IGS = CP + (AE) + T$; $VIGS = CP + B_X + (V) + T$) depending on the D_{st}^{min} scale. Hence their MPs are

characterized by different physical development. The availability of CP testifies that the essential part of magnetospheric activity ($[D_{st}] = D_{st} + DR + Q + U_T$, where $Q = dDR/dt + DR/6$) of all samples is defined mainly by interplanetary factors, namely, by the B_Z -, B_T -, B_Y - IMF components and by IMF intensity B (and related with them some derived coupling functions) and also by ε Akasofu factor, but to a smaller degree. It has been found that the factor VxB_S are most geoeffective.

The substorm factor (AE-index) mainly caused by VxB_S , make contribution in development of the D_{st} -index only during the MP of moderate and partly intense storms. So, for investigated events collection VxB_S is the storm and substorm key factor. Hence, the most relevant factor for prediction of the D_{st} -index the injection function Q and the AE-index during investigated MPs is the factor VxB_S .

MAIN (Multiscale Aurora Imaging Network) auroral cameras: data access and analysis of events

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

The MAIN (Multiscale Aurora Imaging Network) is a new system which consists of 5 auroral cameras installed at Kola Peninsula in Apatity for observations of auroral structures at different scales: from fine structured near magnetic zenith to all-sky luminosity. The data are available through INTERNET and we describe the access to data of previous and current observations. The MAIN cameras and all-sky camera in Lovozero observatory give possibilities to triangulate auroral structures. Two pairs of cameras can be employed (i) narrow (180) field-of-view cameras with 4 km distance between them and (ii) two all-sky cameras which were 86 km spaced. Triangulation abilities and discrepancies are tested by events of satellite flashes and meteor tracks. By several examples we discuss the traditional features of different auroral structures (time scales, periods, spatial size, altitudes), as well as new approaches: number of degrees of freedom, coherency, spatial modes, etc. The work was partly supported by Presidium of Russian Academy of Sciences through Program 22 and by grant RFBR 11-02-00397.

Rapid Bz decrease before dipolarization in the near-Earth plasma sheet

Kozelova, T.V., and Kozelov, B.V. (Polar Geophysical Institute, Apatity, Murmansk region, Russia)

We examined the equivalent transverse currents of perturbations dJ during an event of explosive local magnetic field line stretching and sequent slower depolarization using the THEMIS observations at pre-midnight sector on 6 January 2008. In this time the satellite was located at 6.3 Re near the boundary of trapped energetic ions in transition region between different particle populations. During the substorm growth phase, the duskward (westward) current dj_W was located tailward of the satellite location and moves earthward. 120 s before substorm onset, the oscillations of magnetic and electric fields and ion pressure with a period of 50-60 s appear. This oscillations are a signature of the *interchange-ballooning instability* which develops at this transition boundary and may trigger other instability, for example, a cross-field current instability [Roux et al., *J. Geophys. Res.*, 96, 17697, 1991; Liu, *J. Geophys. Res.*, 102, 4927, 1997], with a subsequent substorm onset.

In our case during sudden rapid local magnetic field line stretching (the Bz decrease), a short-time dawnward (eastward) current dj_E appears at 6 Re, earthward of the satellite location. Simultaneously the auroral arc appeared at the Sodankyla station and Loparskaya (westward of the spacecraft). During 30 s, this current moves tailward from the spacecraft with the velocity of 250 km/s. This direction of the current expansion, the absence of a fast earthward plasma flow, and the decrease of the total pressure before and at the dipolarization are the facts that consistent with the near-Earth initiation current disruption model [Lui et al., *J. Geophys. Res.*, 96, 11389, 1991] and may not be support the flow braking model [Haerendel, *Proceedings of the First International Conference on Substorms, Eur. Space Agency Spec. Publ.*, ESA SP-335, 417, 1992; Shiokawa et al., *Geophys. Res. Lett.*, 24, 1179, 1997] for the present substorm.

The work was partly supported by Presidium of Russian Academy of Sciences through Program 22.

Transformation and absorption of MHD oscillations in plane-stratified models of the Earth's magnetosphere

Kozlov, D.A., and Leonovich, A.S. (Institute of Solar-Terrestrial Physics, Siberian Branch, RAS, Irkutsk, Russia)

The process of resonant transformation of fast magnetosonic (FMS) waves originating from the solar wind in Alfvén and slow magnetosonic (SMS) oscillations in the 1D-inhomogeneous magnetosphere model is investigated. It is shown that absorption of the incident wave energy at the transition layer increases substantially when there is a resonant surface for slow magnetosonic oscillations. In the neighborhood of this resonant surface, the energy of an incident wave is totally absorbed, resulting in additional plasma heating. Numerical calculations have shown that the energy absorption coefficient for an incident fast magnetosonic wave in plasma with $\beta \sim 1$ exceeds its counterpart in cold plasma or in a plasma configuration with one resonant surface, for Alfvén waves only.

Spatial distribution of energy absorption rate of FMS oscillation flux penetrating into the magnetosphere from the solar wind is studied. The Kolmogorov spectrum is used in numerical calculations, which is typical of the waves in the transition layer between a shock wave and the magnetopause. The FMS wave energy absorption rate caused by magnetosonic resonance excitation is shown to be several orders of magnitude greater than that caused by Alfvén resonance excitation at the same surface. Magnitude of the Fourier harmonics exciting resonant Alfvén oscillations is much smaller than that of the harmonics driving lower-frequency magnetosonic resonance.

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Dynamics of the geomagnetic disturbances in the initial phase of the magnetic storm: Case study

Kozyreva, O.V. (Institute of Physics of the Earth RAS and Space Research Institute RAS, Moscow, Russia)

The spatial distribution of long-period Pc5 (2-7 mHz) geomagnetic pulsations has been investigated in the initial phase of magnetic storm

of April 5, 2010, based on the analysis of the global network of ground-based magnetometers. This storm was characterized by high dynamic pressure (up to 15 nPa) and the high solar wind speed (800 km/s). It is shown that Pc5 pulsations had a global character, i.e. they were observed in the large area of the longitude (from early morning until evening hours MLT), as well as in the latitude (from the polar to the equatorial ranges). It was found that the most intense pulsations were recorded in the morning sector (06-08 MLT) at high geomagnetic latitudes (67-69°), while simultaneously the afternoon Pc5 pulsations were observed at lower latitudes 63-64°. The amplitude of the pulsations in the morning sector was 3-4 times higher than in the afternoon. The Pc5 pulsations propagated from the noon meridian to the morning and afternoon sides. The spectral analysis of the Pc5 pulsations, observed in the morning magnetosphere (GOES 11 and 12) and on the ground, showed the coincidence of the frequency peaks in the spectra.

The study of the dynamics of the equatorial region during auroral substorm expansion phase

Krishtopov, A.A., and Dmitrieva, N.P. (St.Petersburg State University, St. Petersburg, Russia)

During the substorm explosive phase equatorward motion of the discrete aurora equatorial boundary observed simultaneously with a sharp auroral poleward boundary shift as well as equatorial drift of the individual auroral structures inside auroral bulge area.

In this paper we study the equatorial boundary and auroral structures dynamics after auroral breakup. Using Canadian all-sky cameras data we determine latitude-longitude position of the discrete oval boundary depending on time.

The calculated substorm current wedge size and its longitudinal position were compared with the position of the auroras active region. Extreme position of auroral structure traces and equatorward boundary was compared.

Effects of magnetic field generation by convective motions in the photosphere: Alfvén waves and chromospheric spicules

Kropotkin, A.P. (D.V. Skobel'syn Nuclear Physics Institute, Moscow State University, Moscow, Russia)

The basis is laid out for a theory relating various phenomena in the solar atmosphere: localized concentrations of magnetic field at the bases of coronal magnetic arches, chromospheric spicules, twisted coronal magnetic flux tubes, and flows of energy carried by Alfvén waves propagating upward into the corona. The structure of photospheric currents localized in the vicinity of supergranule boundaries and excited by convective motions is studied. These currents exist primarily in a "dynamo layer" of sharply enhanced transverse conductivity, which forms in the weakly ionized thermal photospheric plasma located in the solar gravitational field. The motions of the electrons and ions in this layer have appreciably different characters: the ions are collisionally driven by flows of neutral atoms, while the electrons drift in the crossed electric and magnetic fields. The electric field supporting the current arises due to polarization dividing the electrons and ions. This field also gives rise to Alfvén perturbations that propagate upward into the corona, together with their associated longitudinal currents. The momentum flux carried by these Alfvén waves should be transferred to the cool chromospheric gas, facilitating the vertical ejection of this gas in the form of spicules, as was first proposed in 1992 by Haerendel.

Energy conversion in space plasmas: role of nonlinear kinetic processes and structures

Kropotkin, A.P. (D.V. Skobel'syn Nuclear Physics Institute, Moscow State University, Moscow, Russia)

Dynamics of plasma systems in space involves processes of large-scale energy conversion. Sure, like in conventional gas dynamics, the conversion can occur on shocks. However, in magnetized plasma systems, there is a much wider range of possibilities. It gets especially wider in the collisionless plasma case. Here, the momentum balance in the nonlinear system with a current sheet (CS) can occur involving strong ion anisotropy, with appearance of double-stream ion distributions outside the CS. In the recent years this important opportunity

has been thoroughly examined by means of theory and by simulation with kinetic codes. Remarkably, the experimental results obtained recently at the magnetopause and at the magnetotail CS, reveal the corresponding pattern, though the authors of the experiments do not recognize it. The large-scale energy conversion which takes place at the CS, is an outstanding evidence of the magnetic reconnection. Such processes being revealed in the terrestrial environment, should occur also in other astrophysical objects, to which the model of collisionless plasma may be applied.

The influence of By IMF component on the connection between variations of atmospheric electric field in the central Antarctica and ionospheric potential

Kruglov, A.A. (St. Petersburg State University, St. Petersburg, Russia), Frank-Kamenetsky, A.V., Lukianova, R. Yu. (Arctic and Antarctic Research Institute, St.Petersburg, Russia), and Kotikov, A.L. (St.Petersburg branch of Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, St.Petersburg, Russia)

The solar wind generator contributes in a variable manner to the ionosphere-to-ground potential difference at sites in the Polar Regions. It averages $\sim 20\%$ 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 (ΔE_z) performed at Vostok Station ($\phi = 78.45^\circ S$; $\lambda = 106.87^\circ E$, elevation 3500 m) in Antarctica are compared with the value of electric potential above the station (U_v) derived from different statistical electric potential models for the high-latitude ionosphere. Observed positive correlation of ΔE_z with U_v both on an example of separate day, and on all set of fair-weather days. It is shown that the profile of a daily curve of correlation coefficient between ΔE_z and U_v smoothly changes from great values in the afternoon to smaller values at night. Features of a daily curve reflect possibilities of the adequate description equipotential lines structure by stationary convection models.

Depending on the transverse orientation of the IMF (B_y, B_z), correlation coefficient between ΔE_z and U_v change a complicated way, but the overall trend is to improve the relation from B_y0 to B_y0 . This

fact is explained by the asymmetry of the convection patterns with opposite signs B_y .

Separation of the flapping oscillations modes in the presence of noise

Kubyshkina, D.I. (St. Petersburg State University, St. Petersburg, Russia); Sormakov, D.A. (Arctic and Antarctic Research Institute, St. Petersburg, Russia); Semenov, V.S., Sergeev, V.A. (St. Petersburg State University, St. Petersburg, Russia)

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 $\sim 20\text{--}60$ km/s, amplitude $\sim 1\text{--}2 R_e$ and quasiperiod $\sim 2\text{--}10$ min. 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. Calculations were made for two different variants of initial disturbance to exclude its influence on the results. By numerical calculations we get theoretical parameters which good correlate with experimental values.

In the framework of this model the rotation of the vector of magnetic field in the plane $Z\text{--}Y$ as well as vector of plasma velocity is investigated to find differences between kink and sausage modes of the flapping oscillations. Were observed that rotation of the vectors does not depend on type of initial disturbance and 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 rotation of the velocity vector simultaneously observed on two spacecraft of Themis mission corresponds to the kink mode of the flapping oscillations.

Obtained mechanism of the modes separating were analyzed on ability to withstand noise. It was shown that behavior of the speed vector is more invariable then magnetic field's. By this fact we can explain why theoretical prediction of magnetic field vector rotation was not found out in the experimental data.

Also we analyzed behavior of the speed vector in case of combined

modes. The results obtained show that data on rotation of \mathbf{v} and \mathbf{B} vectors can give important information about modes and characteristics of the flapping waves.

Extremely quiet 2009 state of geomagnetic field as a reference level of the local geomagnetic disturbances

Levitin, A.E., Gromova, L.I., Gromov, S.V., and Dremukhina, L.A. (Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, Troitsk, Moscow region, Russia)

We present a new technology of calculating the external geomagnetic field hourly amplitudes applicable for any hour and any day of the whole survey period of any observatory proceeding from the ground based magnetometer measurements. The calculated values may be used to find the amplitudes of the most magneto-quiet hour (day, month, year) and the most magneto-disturbed one for the whole measurement period. These data allow to estimate and to draw maps of the recent geomagnetic activity and the activity during specific geophysical events in the past at any point on the Earth. For the description of the past and recent geomagnetic activity we consider this method more opportune than that of AE(AU, AL), Kp, Dst indices, out-of-date and not without drawback, since introduced more than half a century ago. A detailed description of the method is presented with examples, for estimation of the local geomagnetic activity, its seasonal variations and calculation of Dst variation during the magnetic storms.

Kp index and local high-latitude geomagnetic activity

Levitin, A.E., Gromova, L.I., Gromov, S.V., and Dremukhina, L.A. (Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, Troitsk, Moscow region, Russia)

Nowadays the geomagnetic activity seasonal variations are described using monthly data of the global Kp index averaged for several years. As is known, the peak area of the geomagnetic activity seasonal variations corresponds to the equinox periods (maximums), while the two minimums are found at the solstices. It is supposed that the

formation of activity areas in the solar regions between 10 and 30 degrees of the N and S geographical latitudes plays the major role in the equinoctial asymmetry of the geomagnetic activity occurrence. During an equinox the plane of the solar equator coincides with that of the Earth, and in this period the Earth is most vulnerable to the impact of the solar activity areas. We establish the correlation of the ground based magnetometer measurements used to derive Kp index and the data of the high latitude observatories used for AE-index calculating during magnetic storms. We consider inconsistent calculations on the base of Kp index, as far as it doesn't describe the global geomagnetic activity during magnetic storms, but it describes local high latitude magnetic disturbances in these periods when the polar oval shifts equatorwards and Kp-observatories indicate the increase of the auroral current system intensity. Magnetic storms have the maximum of occurrence near vernal and autumnal equinoxes, and it induces the peaks of the monthly Kp index in March-April and October-November. As we suppose, it would be more accurate to estimate the geomagnetic activity using the data of the magnetic observatories located at the different latitudes of the northern hemisphere from the equator to the polar cap. For data proceeding and calculating of the geomagnetic activity we apply a new technology that allows to give quantitative estimation of the current local geomagnetic activity and of the magnetic storm intensity.

Pre-onset dynamics of the global systems of convection, ionospheric and field-aligned currents

Lunyushkin, S.B., Mishin, V.M., and Mishin, V.V. (Institute of Solar-Terrestrial Physics, SB RAS, Irkutsk, Russia)

The dynamics of the systems of high-latitude ionospheric currents, plasma convection and field-aligned currents during the pre-onset period of substorm 27.08.2001 was calculated based on the magnetogram inversion technique (MIT). The pseudobreakup phase defined in the ionospheric currents which seems to start in the most distant tail of the magnetosphere and develop, one at the same time, others do not, on its entire length. It was found that at the end of the pre-onset period in night circumpolar region of the ionosphere (in the polar cap) there is the formation of a powerful vortex convection, rapidly expanding in the direction of the oval. The convective flow separates

from that crossing the polar cap boundary in the 21–02 MLT sector and moving to the southeast. The overall picture of convection in this area of night auroral oval is similar to the scheme published in recent articles by Nishimura et al., and the convection flow is similar to N-S streamer investigated in these Refs. It was also established that at the end of the pre-onset period increase of current and convection systems suddenly change to decay, inspite of the continued rapid growth of the magnetic flux in the tail lobes Ψ and input energy ε' .

The convection stream of ionospheric plasma from the polar cap to the auroral oval

Lunyushkin, S.B., Mishin, V.M., and Mishin, V.V. (Institute of Solar-Terrestrial Physics, SB RAS, Irkutsk, Russia)

Based on the global maps of the electric potential, calculated by the method of MIT we consider the dynamics of the convection stream of ionospheric plasma from the polar cap to the auroral oval in the 21–02 MLT sector immediately after the expansion phase onset of the 27.08.2001 substorm. Using an original method for determining the basic parameters of the ionospheric convection stream we calculated the velocity of the ionospheric plasma drifts associated with this stream, as well as the magnetic flux carried by the stream from the polar cap (open tail lobes) to the auroral oval (to the plasma sheet). The obtained estimates of drift velocity are consistent with the radar observations data. Assuming that the stream region in the ionosphere under investigation is projection of the magnetotail reconnection, we obtained simple relations, and based on them the plasma velocities in the magnetosphere, the characteristic dimensions of the field reconnection, the values of the reconnected magnetic flux and related additional power coming into the plasma layer were estimated.

Long-term study of VLF-LF radio wave propagation at mid-latitudes under transition from minimum to the raising solar activity in 2007–2012

Lyakhov, A.N., Yakymenko, K.N., Egoshin, A.A., Poklad, Yu.M., Kudryavcev, V.P., Kozlov, S.I., Ermak, V.M., and Zetzer, J.I. (Institute of Geospheres Dynamics RAS, Moscow, Russia)

Spatio-temporal analysis of the data of the European VLF-LF stations signals measured at “Mikhnevo” geophysical observatory (54.94N, 37.73W) is presented. The comparison between the measurements and EOS-Aura satellite data has shown that significant variations of the neutral atmosphere temperature profile cause the transit from unimodal probability distribution for the amplitude of VLF-LF signal to the bimodal one. The same splitting in LF range is observed under the appearance of additional maxima of water content at 40–60 km. Such a transition can be interpreted as dynamical bifurcation process. The same effects are observed in A118 SID station data with some new effects. Namely, the bimodality is observed only on eastward and westward paths, not on the northward. The numerical simulation using D-layer plasmachemical model confirms that the observed middle atmosphere variations can lead to the observed amplitude deviations. The presented results covered the range from October 2007 till nowadays allowing to study the transition of the lower ionosphere from the state undisturbed by the solar activity to the conditions of the moderate one with repeated solar flares. Spectral analysis of long-term measurements at Mikhnevo and at the A118 France SID station has shown that the time periods of disrupted diurnal dynamics of the signal amplitude correspond to the detection of planetary wave periods in the spectra. Statistically significant periods are 1.5–3, 4–7, 15 and 20 days, thus some of them are close to Rossby waves periods. Consequences and possibilities for the study of the solar-terrestrial physics are discussed.

Some properties of the secular changes of geomagnetic field at the observatory "Akademik Vernadsky"

Maksimenko, O.I., Melnyk, G.V., and Shenderovskaya, O.Ya. (Institute of Geophysics, Ukrainian Academy Sciences, Kiev, Ukraine)

The study of geophysical phenomena in the AIA requires as the control of the long-term trends in solar, magnetic activity and the concentration of electrons and greenhouse gas emissions but as the secular variations of the magnetic field components in the magnetically conjugate hemisphere also. Secular changes in the geomagnetic field, equal to $(\Delta H) = -17\%$ (39,8 nT/year) and $(\Delta Z) = 23\%$ (100.8 nT/year) with the corresponding altitude gradients (5–8) nT/km and (18–10) nT/km, and a weaker (5–6)% secular variation at low rates of change of 9.7 nT/year for H and 28.6 nT/year for the Z field components in the conjugate points of the AIA were determined using the IGRF/DGRF models in the range 1900 to 2010. Preliminary forecast zeroing of the more sensitive to external magnetic fields H component were obtained later than the Z component, which comes at 2440 with a 20 year difference from the AIA experimental data in reading from 1980 under the field trend deceleration in recent decades. There were marked the rate changes in the magnetic field with the different prevailing periods of ~ 11 , ~ 22 at the AIA and of $\sim (60-80)$ years in the conjugated latitudes; three stages of evolution with a positive rate of secular variation of the magnetic field in the $\sim 1940-1980$ that have like as well-known interval of the surface temperature stagnation in climatic temperature anomaly increase in both hemispheres in the twentieth century.

Role of longitudinal inhomogeneity on the structure of embedded current sheets in space plasma

Malova, H.V., Zelenyi, L.M. (Institute of Space Research RAS, Moscow, Russia), Popov, V.Yu. (Physics Department, Moscow State University, Moscow, Russia), Artemyev, A.V., and Petrukovich, A.A. (Institute of Space Research RAS, Moscow, Russia)

Current sheets in the Earth's magnetotail can accumulate and then release magnetic energy during substorms or plasma convection in the distant region of magnetotail. Near reconnection regions they can

reach minimum of their thicknesses about ion Larmor radii. Properties of thin current sheets are investigated in a frame 2D current sheet model taking into account a longitudinal inhomogeneity. It is shown that such current sheets have characteristic multiscale and embedded plasma structure. Thus electron and ion current layers are embedded inside more thicker plasma sheet. It is shown that transient ions and fast Boltzmann electrons support slightly inhomogeneous of bell-shape current density across current sheet. On the contrary, quasi-trapped ions essay to redistribute the total current density in such a way that it becomes thicker and split in earthward direction (where the concentration of quasi-trapped particles reaches its maximum value). The gradient of electron currents is directed in tailward direction correspondingly to the decrease of curvature radii of magnetic field lines and increase of electron curvature drift currents. As a result, the structure of current sheet is electron-dominated in the distant magnetotail region and is influenced by quasi-trapped ions in the earthward edge of current sheet. Applications to the Earth's magnetotail are discussed.

Variations of topside N(h)-profiles of the ionosphere during Space Weather events

Maltseva, O.A., Zhbankov, G.A., Mozhaeva, N.S., Nikitenko, T.V. (Institute of Physics, Southern Federal University, Rostov-on-Don, Russia)

Space Weather effects are well understood in the behavior of ionospheric parameters such as the critical frequency foF2, the maximum height hmF2, the total electron content TEC. Space Weather effects in the behavior of N (h)-profiles are less understood. This report proposes the use of a new model IRI2010 (IRI-Plas) to determine the variations of N (h)-profiles. Distinctive features of the model IRI-Plas are account of the plasmaspheric part, the adaptation of the model to the current values of foF2, hmF2, TEC. The report proposes an additional adaptation to the values of the plasma frequency f_{pe} on the heights of different satellites. Data are used: (1) a chain of ground ionosondes (Loparsk, Leningrad, Moscow, Rostov), (2) global TEC maps of JPL, (3) f_{pe} of satellites CHAMP and DMSP by the example of April 2001, including two strong disturbances (1-2.04, a minimum Dst = -228 nT, 11-12.04, the minimum Dst = -271 nT) and two weak

disturbances (18, 22-23.04) with a minimum of $Dst \sim -100$ nT. Variations were estimated as deviations from the median profiles. It was marked nine cases of travelling satellites over all the stations, which allows us to estimate the latitudinal profiles. This passage was near noon and midnight, and covered both positive disturbance (1-6.04) and negative (all other) disturbances. The strongest variations were found for profiles of station Leningrad, apparently as a result of its position near the projection of the "quiet" plasmopause. In the daytime, while enhancing the positive disturbance of concentration reached 5-15% at all altitudes, increasing with latitude. On April 12 at UT = 13 at Leningrad Station, deviations were 75% providing a deep minimum of the latitude dependence. On April 20 N (h)-profiles had 5-10% gain in the bottom side and a similar weakening of the - at the topside. On April 28 at the station Rostov, the lowest concentration N(h)-profiles was at the bottom and a 20% gain at the topside. At night, 1-2.04 at UT = 23-1 Leningrad station was in zone of a strong increase of the ionization (40%) with a concentration exceeding the concentration of the other stations at all altitudes. This provided the location of the station Moscow in the zone of trough. On April 6-7 at UT = 23-1, N (h)-profiles of Loparsk and Moscow were still in the area of the positive disturbance. At the station Leningrad, fne values were 1.5-2 times lower than at other stations. On April 14 profiles at all stations had negative deviations but the minimal of fne belonged to station Leningrad, i.e. the station was in the trough. On April 22 at UT = 23 N (h)-profiles of station, Moscow, having a maximum deviation of 60%, showed that Moscow is in the trough. On April 30 at UT = 21 profiles returned to the quiet state. This demonstrates the permanent restructuring of ionization and the change of sign of the latitudinal gradients. Similar variations were obtained for other regions and other disturbances. Using the adaptation of the IRI-Plas model to the data of fne of satellites, we can more accurately assess these gradients and the actual values of concentrations at all altitudes.

Non-typical ensemble of the quasi-periodic VLF waves: Case study of 18.12.2011 event

Manninen, J. (Sodankylä Geophysical Observatory, Finland); Kleimenova, N.G., Kozyreva, O.V. (Institute of Physics of the Earth RAS, Moscow, Russia; Space Research Institute RAS, Moscow, Russia)

For the first time, an unusual ensemble of different types of quasi-periodic (QP) VLF emissions in frequencies of 1–5 kHz, has been revealed at auroral latitudes ($L=5.3$) during the Finnish VLF campaign (December 2011) near obs. Sodankylä. The emissions were not associated with geomagnetic pulsations. Contrary to typical QP emissions, the spectral structure of the reported QP events represented a sequence of repeated discrete rising diffuse VLF signals, lasting about 2–3 min, with the changing in time repetition periods ranged from 1 to about 10 min. The VLF ensemble included the series of such QPs and an extended high-frequency (~ 3.0 – 4.5 kHz) hiss with simultaneous intensity enhancement. The considered emissions were observed in the night-time, while the typical QP occurring is the day-time. It is shown that fine structure of the QP bursts may consist of a combination of different frequency signals, which seem to be generated by different independent origins. The lower frequency signals appear to trigger the strong dispersive upper ones. The temporal dynamics of the spectral structure of the considered series of QPs is found to be significantly controlled by some disturbances in the solar wind and IMF. This finding is very important for future theoretical investigations because the generation mechanism of the revealed.

Nose and flanks magnetospheric MHD waveguide and its excitation mechanisms

Mazur, V.A., and Chuiko, D.A. (Institute of Solar-Terrestrial Physics, Irkutsk, Russia)

Magnetosphere's nose and flanks plasma and geomagnetic field inhomogeneity properties allow for existence of a MHD-waveguide for fast magnetosonic modes there. The oscillations are trapped in the direction across the waveguide due to the increase of Alfvén speed towards the Earth (across magnetic shells as well as along the field lines), and the magnetopause plasma parameters jump. The oscillations can freely propagate in the azimuthal direction along the wave-

uide, with comparatively small azimuthal inhomogeneity leading to their modification in such propagation process. The waveguide eigenmodes properties are theoretically investigated in this work in the framework of two-dimensionally inhomogeneous model, taking into account both the inhomogeneity across the magnetic shells and the weak azimuthal inhomogeneity. An important feature of such eigenmodes is the presence of a magnetic shell inside the magnetosphere for each of the eigenmodes (distinct for every eigenmode), on which we have Alfvén resonance — the sharp increase in the field of oscillations having the properties of the slow mode, and, thus, capable of reaching the Earth's surface via propagation along the field lines. Waves' energy dissipation takes place in the narrow vicinity of the Alfvén resonance across the corresponding magnetic shells.

The two main excitation mechanisms of the waveguide's oscillations are considered. Namely, the penetration of the solar wind's MHD waves and the KH instability on the magnetopause. The wave penetration conditions are more favorable in the nose area, whereas the instability role (as a result of the solar wind speed increase along the magnetopause) becomes more significant towards the flanks. For these reasons the waveguide modes are pumped by external oscillations in the nose and then amplified by the instability as they propagate towards the flanks. An analysis of the oscillation field evolution as it propagates through the waveguide is given. The analysis takes into account the solar wind's waves penetration, the KH amplification, the damping due to dissipation in the Alfvén resonance areas and leakage of the waves back to the solar wind. We conclude that the oscillations' amplitude increases from the nose, peaks at the morning and evening sectors, and decreases during further motion towards the tail. Herewith the spectrum density maximum shifts from the Pc3 to the Pc5 frequency range.

Magnetosheath magnetic field behavior when the interplanetary magnetic field is nearly collinear to the solar wind velocity

Mezentsev, A.V. (Siberian Federal University, Krasnoyarsk, Russia)

Magnetosheath magnetic field behavior is modelled on a basis of the method of small perturbations, when the interplanetary magnetic field (IMF) is nearly parallel to the solar wind velocity. The mag-

netic field disturbances in the magnetosheath are studied on the background of the stationary solar wind flow around the magnetosphere, when the IMF is strictly parallel to the solar wind velocity. Our calculations show that the angle between the velocity and magnetic field vectors increases significantly in a thin layer near the magnetopause. The thickness of this layer exceeds that of Hall layer for large Alfvén-Mach numbers (~ 10). The angle between the magnetic field and velocity vectors reaches its maximum at the equatorial plane. This is due to bending and stretching of the magnetic field lines near the magnetopause. This angle is a crucial factor for the Kelvin-Helmholtz (K-H) instability. An increasing of the angle leads to the corresponding increase of the growth rate of the K-H instability. The profiles of the angle are obtained for different distances from the subsolar point. The estimation of the layer thickness was derived from definition that the angle exceeds 1 rad. The analytical model results obtained in this work describe average characteristics of the plasma and magnetic field in the magnetosheath, and especially at the boundary of the magnetosphere in case of collinear IMF.

Model simulation of the dynamics of fine-scale irregularities in the ionospheric F2 layer

Mingalev, O.V., Mingaleva, G.I., Melnik, M.N., and Mingalev, V.S. (Polar Geophysical Institute, Apatity, Russia)

In the ionospheric F2 layer plasma, electron density irregularities are observed very often. These irregularities possess a wide range of spatial scales, ranging from a few Debye lengths to thousands of kilometers. Small-scale irregularities are predominately magnetic field aligned. The mechanisms responsible for the formation of small-scale irregularities may be not only natural but also artificial, in particular, fine-scale irregularities are produced by high-power high-frequency radio waves, pumped into the ionosphere.

In this work, a two-dimensional mathematical model, developed earlier in the Polar Geophysical Institute, is utilized to investigate the temporal history of the irregularity, created initially in the ionospheric plasma. The investigated irregularities are supposed to be geomagnetic field-aligned, with their cross-section being circular. The irregularities are considered which have initial cross-section size being equal to a few Debye lengths. The mathematical model is based on

numerical solution of the Vlasov-Poisson system of equations. The system of equations is numerically solved applying a macroparticle method. The temporal history of the irregularity, created initially in the ionospheric plasma, is calculated for two distinct on principle situations. The first situation corresponds to natural conditions, while the second situation corresponds to artificially disturbed conditions when high-power high-frequency radio waves, propagating along the magnetic field, affect on the ionospheric plasma.

The results of modeling indicate that the fine-scale irregularity, created initially in the ionospheric plasma, vanishes and recovers periodically, with its parameters fluctuating. In particular, the normalized potential energy of the plasma demonstrates periodic damped vibrations. High-power high-frequency radio waves, propagating along the magnetic field, ought to affect on the temporal history of the irregularity slightly. The time interval of about 15 vibration periods of the irregularity is sufficient for the irregularity to lose almost completely its initial structure, to be diffused, and to decay.

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Numerical simulation of the effect of artificial heating of the daytime high-latitude ionosphere on the meridional oblique HF radio wave propagation

Mingaleva, G.I., and Mingalev, V.S. (Polar Geophysical Institute, Apatity, Russia)

It is well known that propagation of HF radio waves is appreciably influenced by large-scale inhomogeneous structures in the electron concentration distribution in the vertical as well as horizontal directions at the levels of the Earth's ionosphere. Also, it is known that high-power high-frequency radio waves, pumped into the ionosphere, can result in the formation of large-scale electron temperature and density irregularities in the F region.

In this study, the mathematical model of the high-latitude ionosphere, which can be affected by powerful high-frequency radio waves, developed earlier in the Polar Geophysical Institute, is utilized to calculate three-dimensional distributions of the electron concentration in the high-latitude F-region ionosphere. The calculations were made for two cases. Firstly, we obtained the electron concentration distribu-

tion under natural conditions without a powerful high-frequency wave effect. Secondly, the distribution of the electron concentration was obtained on condition that the ionospheric high-frequency heating facility near Tromsø, Scandinavia, is operated, with the heater being located on the sunlit side of the Earth on the magnetic meridian of 15.00 MLT.

On the magnetic meridian, laid across the ionospheric heater, a point with magnetic latitude of 42° N was taken in the capacity of the position of the oblique incidence ionosonde transmitter. Utilizing both spatial distributions of the electron concentration separately, we calculated ray-path trajectories of HF radio waves, originated from the transmitting point in the magnetic meridian plane in the direction of the Magnetic pole for different values of the elevation angle and transmission frequency, using a ray-tracing computer program, developed earlier in the Polar Geophysical Institute. The results of modeling indicate that, under specific conditions, the electron density depletion, caused by artificial heating, can influence conspicuously on the meridional oblique HF propagation through the high-latitude ionosphere in the daytime.

This work was partly supported by the RFBR grant 10-01-00451.

Atmospheric application for the biggest SEP events

Mironova, I.A. (St. Petersburg State University, St. Petersburg, Russia)

The aim of the present work is investigation of a specific problem of solar activity influence upon atmospheric processes, viz. impact of extra-terrestrial energetic particles (galactic and solar) on the physical and chemical properties of the Earth atmosphere in polar region. By means of case studies of solar protons events with different energies of particles and their influence on various atmospheric parameters, it will aim to evaluate the possible effect of solar (SEP) and galactic (GCR) particles on polar microphysical processes. An important aspect is that the local meteorological parameters remain roughly constant during short SEP events and do not greatly distort the signal. In this way, an upper limit for the cosmic ray effect was identified for the extreme event of Jan-2005. Here it is shown extended analysis of all major ground level enhancements of SEP events for 1989–2006

looking for their possible signatures in atmospheric aerosol and clouds data, to assess the range of the effect magnitude.

Fading of the electric field, ionospheric and field-aligned currents before the substorm active phase onset

Mishin, V.V., Mishin, V.M., and Lunyushkin, S.B. (Institute of Solar-Terrestrial Physics SB RAS, Irkutsk, Russia)

We investigated the pre-onset and active phases of the 27.08.2001 substorm. Based on the magnetogram inversion technique we obtained time-series of maps of the distribution in the polar ionosphere of field-aligned current (FAC) density, the perpendicular current system, the electrical potential difference on the the polar cap boundary. We found that this difference (U_{pc}) increases rapidly during the first half of pre-onset phase, begins to decrease slowly in the second half, and the decline accelerated in the late phase called. Fading is also observed on the maps of the FACs and ionospheric currents in the narrow near-midnight oval sector, although the tail lobes magnetic flux and energy flux entering the ionosphere from the solar wind continuously grows during the pre-onset phase. In the early active phase the fading is replaced by a sharp increase in U_{pc} . At both stages (growth and decay) the different formations of the magnetosphere containing the plasmoid, FACs of the three Iijima-Potemra Regions, ionospheric currents, convection jets and the ring current, interacted with each other as elements of a united electric circuit of the global dynamo. We present a schematic diagram of the circuit. The variants of the interpretation of these changes in terms of circuit inductance L , that decelerates the growth of U_{pc} at the tail lengthening and accelerates at the transition to the dipolarization regime.

New data on the substorm energetics

Mishin, V.V., Mishin, V.M., and Saprionova, L.A. (The Institute of Solar-Terrestrial Physics, SB RAS, Irkutsk, Russia)

Time series of values of the energy flux ϵ' , entering the magnetosphere from the solar wind are calculated using the magnetogram inversion technique (MIT) and data from the high-latitude network of ground

magnetometers, together with data on solar wind parameters from the ACE satellite. A new method for computing the parameter ε' gave an opportunity to separate the contributions into ε' , created by magnetic fluxes, the "old" (existing in the tail lobes prior to substorm) and "new" (initiated during substorms). We found that these two contributions are of comparable magnitude. Due to additional contribution from the "old" tail lobes energy flux ε' increases in several times, and energy, stored during the growth phase, is sufficient to ensure the observed power of the expansion and recovery phases.

Preliminary results of the One-Whorl-Light-Whirl experiment

Močnik, K. (Space Research Institute, Austrian Academy of Sciences, Graz, Austria)

The experimental results of the "One-Whorl-Light-Whirl" are up to discussion by independent experts. We give a careful report on the preliminarily obtained figures, and we stress that nature of electromagnetic propagation seems to behave according to geometrical laws rather than according to more or less wilful hypotheses.

Long-term trends and variations of the Iberian climate: effect of atmospheric circulation, CO₂, volcanoes and geomagnetic and solar activity

Morozova, A.L., and Pais, M.A. (Centro de Geofísica da Universidade de Coimbra, Coimbra, Portugal)

Monthly series of temperatures parameters measured in the three Portuguese meteorological stations of Lisbon, Coimbra and Porto over more than 100 years were used to recognize the imprints of different forcings in West-Iberia climate. We focused our attention on four types of forcings: volcanic eruptions, anthropogenic greenhouse gases, global atmospheric circulation and solar and geomagnetic activity variations. Only long-term trends and variations with characteristic periods of decades have been studied.

Obtained results confirm the influence of the anthropogenic greenhouse gases, volcanic eruptions as well as solar and geomagnetic activ-

ities variations on the climate changes in this region. In particularly, the prevalence of CO₂ influence over other forcings (solar activity, circulation) has started only around 1950. It is also shown how the character of the response depends on the type of studied temperature parameter, on the time period and on the season.

Vertical sounding ionogram in the polar cap region

Moskaleva, E.V., and Zaalov, N.Y. (Department of Radio Physics, State University of St. Petersburg, St. Petersburg, Russia)

Signatures of enhanced electron density localized regions (patches and arcs) in the F region of the high latitude ionosphere are investigated. The polar patches drift from dayside of the Earth across the magnetic pole in accordance with convection flow patterns at speeds of a few hundred metres per second. Patches are typically of about 500 km in dawn to dusk direction but they range from 200 to 1000 km and exhibit electron-density enhancements of up a factor of 10 above background. In this paper the typical feature of the vertical ionogram, produced by local enhancements of electron density is investigated. The model of the ionosphere with irregularities (mid-latitude trough, auroral oval, polar cap patches and sun-aligned arcs) was developed in collaboration with University of Leicester (UK). Based on this model the vertical ionograms for different time and geophysical conditions were simulated. The typical shapes of traces of ionograms were classified by types. The results of simulation are very reminiscent of the main characteristics of the ionograms observed in high latitude. It is believed that the variations of parameters of the model may be employed to estimate the real parameters of the high latitude ionospheric inhomogeneities.

Relativistic electrons and ULF-activity dynamics during CIR- and CME-storms in May 2005

Myagkova, I.N. (Skobeltsyn Institute of Nuclear Physics Moscow State University, Russia), and Kozyreva O.V. (Institute of the Earth Physics RAS, Moscow, Russia)

The electron acceleration and ULF activity during two magnetic storms in May 2005 have been analyzed. The first magnetic storms

(May, 7–9) caused by the corotating interactive region and high speed stream of solar wind (CIR-storm) as well the second one (May 15-16) caused by the coronal mass ejecta (CME-storm). We have studied relativistic electron dynamics in the Outer Earth's Radiation Belt (OERB) based on CORONAS-F (1.5–3 MeV) and Universitetskiy-Tatiana (3.5 MeV) satellite measurements. These data have been compared with the ground and magnetosphere ULF (2–7 mHz) activity. The global maps of the ULF space-temporal distribution have been constructed. We have found that the relativistic electron flux measured by both satellites significantly decreased during the main phase of both CIR and CME geomagnetic storms. Then during the recovery phase of both geomagnetic storms (and even several days after that), the electron flux was pronouncedly increased, the electron's belt widened and the OERB formed much closer to the Earth. The possible role of ULF-waves in the OERB dynamics is discussed.

Interpretation of GOES and THEMIS spacecraft magnetic observations during substorm expansion phase using extended substorm current wedge model

Nikolaev, A.V., Sergeev, V.A., Tsyganenko, N.A. (St. Petersburg State University, St. Petersburg, Russia), and Singer, H. (Space Weather Prediction Center (NOAA), Boulder, USA), and Angelopoulos, V. (University of California, Los Angeles, USA)

The 3-dimensional current wedge system (SCW) is historically recognized as a main current system of magnetic substorm expansion phase and described as a cartoon-like sketch model SCW which consists of westward electrojet which is limited in longitude by upward and downward field-aligned currents on the west side and east side of auroral bulge terminations respectively. Using single-loop SCW quantitative model with realistic topology of field-aligned current lines we found systematic discrepancies between modeled and observed magnetic variations at geostationary distances. Such mismatch depends on (1) initial magnetic configuration at substorm onset, (2) expansion phase time, (3) spacecraft location and can be partly explained by R2-like current loop which is generated by fast earthward plasma flow heating region of quasi-dipole magnetic field at the inner edge of plasma sheet. According to simultaneous magnetic field observations on radially-distributed GOES and THEMIS spacecraft

in the night-side magnetosphere we have shown convincingly that equatorial segment of R2-like current loop develops in the region of geostationary orbit. Using inversion algorithm with realistic SCW model, supplemented by R2-like current system, we estimated linear and non-linear parameters for both R1 and R2-like current loops in case of two substorm events. Furthermore, statistical investigation of ratio Bz magnetic components on GOES spacecraft to Bz components on THEMIS spacecraft showed that equatorial part of R2-like current loop is located (1) closer to Earth with respect to geostationary orbit in case of strongly stretched magnetic field configuration and (2) further in the tail in case of quasi-dipole field topology.

Some new aspects of the storm of March 1989

Nikolaeva, V.D. (Saint-Petersburg State University, Saint-Petersburg, Russia; Arctic and Antarctic Research Institute, Saint-Petersburg, Russia), Shirochkov, A.V., Makarova L.N. (Arctic and Antarctic Research Institute, Saint-Petersburg, Russia), and Stupishina, O.M. (Saint-Petersburg State University, Saint-Petersburg, Russia)

Development and regime of energetic particles precipitation during well known storm of March 1989 is reconsidered here. Some new features of the event are presented in this paper. The solar proton event with simultaneous precipitation of the protons with energies more than 60, 30, 10, 4, 2, 1 MeV were measured in time interval between 2 and 12 UT of March 13. Intensity peaks of these fluxes were recorded at the same time (745 UT) when Quebec province energetic system was collapsed. Surprisingly enough riometers in the polar cap did not show any absorption. Precipitation of more soft particles ($E=30-30000$ eV) was studied by DMSP 8 and 9 satellites. Equatorward protrusion of the soft particles precipitation boundary reached such lower geomagnetic latitudes as 50° . We conclude that giant short-lived storm of March 1989 developed at the background of the continued magnetospheric substorm activity. It was shown that magnetospheric index PC was the only ground-based parameter capable to predict the beginning of the storm for at least five hours.

Solar magnetic fields as a clue to the solar wind and solar corona mystery

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

Data on the permanent solar wind (RSW) speeds measured on board Ulysses (SWOOPS) are analyzed, generalized and interpreted. A finding of a crucial importance extracted from Ulysses/SWOOPS observations is a discovery of clear-cut inverse coupling between the SW speeds and the solar magnetic fields (SMF) [*the stronger close MF the slower SW, and vice versa*] that we consider as a sign of deceleration of the primary high speed outflows by the SMFs near the solar surface. Insertion of SMF into consideration leads to the alternative paradigm of the SW: *decelerating instead of the acceleration*. From such a point of view both the solar corona and SW streams convert into the product of the interaction of with SMFs a primary high velocity mass outflow ejected from the photosphere. Such an interaction not only divide primary outflows into fast and slow SW streams but also create and heat the corona through the plasma capture and stoppage in the magnetic traps. Observational arguments are represented in favor of the idea proposed. In particular, it is shown that such primary fast outflow is real phenomenon instead of hypothesis and is observed as permanent SW flow with 700–800 km/s, associated with the regions on the solar surface where active region magnetic field are either absent or very weak. Similar phenomena, when extremely high velocities of a plasma stream cannot be described thermodynamically, and known “Strange’ Fermi Processes” is considered in a common sense in the frames of the fractal topology.

Disturbances of the geomagnetic field at Schumann frequencies on the ground and in the ionospheric F-layer

Nosikova, N., Surkov, V. (National Research Nuclear University “MEPhI”, Moscow, Russia), Yagova, N., Pilipenko, V., and Schekotov, A. (The Schmidt Institute of Physics of the Earth, Moscow, Russia)

Fluctuations of natural geomagnetic field in the frequency range 5–20 Hz are analyzed in the ionospheric F-layer and on the ground surface. It is shown that there are some features of Schumann resonances in the ionosphere, but it is not related to global thunderstorm activity

and the question about the source of these oscillations remains open. Morphological and physical properties of "Schumann" disturbances in the F-layer are analyzed and possible generation mechanisms for them are discussed.

Determination of artificially enhanced electron temperature in lower ionosphere by measurements of the HF electromagnetic wave absorption

Pashin, A.B., and Mochalov, A.A. (Polar Geophysical Institute, Apatity, Murmansk region, Russia)

More than 50 year history of experiments on ionosphere modification via electron heating by powerful ground based transmitter shows a lot of remarkable results. However at present time we have no direct measurement of primary modified parameter, namely enhanced electron temperature. Our knowledge on its value is based on theory, numerical modeling, or observation of disturbances being results of the temperature increasing. One of these measurements is amplitude of artificial low frequency emissions excited under modulated heating of D-region electrons. The generation of artificial magnetic pulsations — the emissions in frequency range around 1 Hz — shows their sporadic nature. Sometimes during experiments detection of the pulsations is finished without significant variations of parameters of the ionosphere. This peculiarity demonstrates incomplete of our knowledge on the emission excitation and it requires to elaborate more direct experimental method of the enhanced temperature estimation. Clear dependence of absorption of HF electromagnetic wave on electron temperature gives an opportunity to consider the measurements of the absorption value as a candidate for diagnostic of this parameter. Numerical modeling shows that the value of the additional absorption during the heating should be significant enough for the measurements and interpretations. The possibility to employ of the probe waves at different frequencies has an advantage, unknown parameters such as electron density and undisturbed electron temperature may be excluded from the solution. As a source of HF waves one may uses a cosmic radio noise or transmitter based on a satellite.

Earth rotation and solar wind

Petrov, S.D., and Trofimov, D.A. (Astronomical Institute, St. Petersburg State University, St. Petersburg)

A connection between solar activity and decadal Length of day variations is investigated. Statistical comparison of Length of day with various geomagnetic and Solar activity indices has been done for the last 140 years. A jump in Length of day (LOD) is found at the moment of the geomagnetic storm, the largest one for the last few decades, that happened in late October 2003, the so called Halloween storm. This change in rotational velocity of the Earth can not be explained by any known atmospheric or oceanic influences. Moreover, such jump in LOD is an unique one for the few recent years. It is supposed that this jump can be caused by transfer of angular momentum between Solar wind and the solid Earth. A possible mechanism of such a transfer is proposed.

High-frequency magnetic waves before substorm onsets as observed by Cluster

Petrukovich, A.A., Artemyev, A.V., Zelenyi, L.M. (Space Research Institute, Moscow, Russia), and Nakamura, R. (Space Research Institute, Graz, Austria)

A number of studies suggest high frequency (period ~ 1 min) waves as possible signatures and/or precursors of substorm onset in the magnetotail. Variants include kinetic ballooning/interchange waves of oblique drift kink modes. We review some Cluster observations of such events and estimate spatial gradients. These results suggest, that the most of observations corresponds to kink modes.

Large scale solar wind disturbances causing strong geomagnetic storms

Plotnikov, I.Ya., Barkova, E.S. (Institute of Cosmophysical Research and Aeronomy SB RAS, Yakutsk, Russia), Shadrina L.P. (Academy of Sciences of S(Ya)R, Yakutsk, Russia), and Starodubtsev S.A. (Institute of Cosmophysical Research and Aeronomy SB RAS, Yakutsk, Russia)

We present a statistical study of coronal mass ejections, interplanetary magnetic and electric field variations and also geomagnetic field variations during intense geomagnetic storms ($Dst \leq -150$ nT) for the time interval from 1963 to 2006. Under the consideration are the events with solar wind dynamic pressure $P_d \geq 0$ nPa and interplanetary electric field $E_y \geq 10$ mV/m. For the period we analyzed 122 geomagnetic storms and 90 ones are caused by passing of magnetic clouds of eight well-known categories (NES, SWN, SEN, NWS, WNE, ESW, ENW and WSE). By the way, SWN-type magnetic clouds are registered more often. It is found that the main phase of geomagnetic storm is caused mainly by a positive component E_y of the interplanetary electric field in the cloud's magnetosheath. Partial contributions of the electric fields of two neighbor's regions — magnetosheath and cloud can be due for the two-step main phase development of strong storms.

Is it possible to detect an Ionospheric Alfvén resonator on satellites?

Plyasov, A.A., Surkov, V.V., Nosikova, N.S., Ignatov, V.N. (National Research Nuclear University, Moscow Engineering Physics Institute, Moscow, Russia), Pilipenko, V.A. (Space Research Institute, Moscow, Russia), and Fedorov, E.N. (Institute of Physics of the Earth, Moscow, Russia)

We have theoretically estimated ULF spectra on the ground and at the ionosphere altitudes in the frequency range of the ionospheric Alfvén resonator (IAR). The IAR has been considered to be excited either by a separate intense lightning stroke or stochastic global thunderstorm activity. The IAR excitation during daytime and nighttime has been compared. The influence of the IAR eigenfrequency latitudinal inhomogeneity on the signatures of the spectral resonance

structure has been modeled. Results of calculations are compared with the power spectra recorded at low-orbiting satellites (Aureol-3, C/NOFS, CHAMP) and feasibility of the IAR response to the atmospheric lightning activity at low-orbiting satellites is indicated.

On the SYMH-index forecasting based on upstream interplanetary data

Popova, O.V., and Tsyganenko, N.A. (St. Petersburg State University, St. Petersburg, Russia)

In this work we describe an algorithm to calculate the SYM-H index variation, based on upstream interplanetary medium data. To reproduce the SYM-H index dynamics at the main phase of a storm, a simple analytical driver function has been defined, using the solar wind speed, density and southward component of the interplanetary magnetic field. The current model differs from earlier ones by a more general form of the differential equation, describing the SYM-H index dynamics as a result of competition between the source and loss terms in its righthand side, which provided a better replication of the storm peak intensity and its decay rate during the recovery phase. Best-fit values of the model parameters were derived by minimizing the rms deviation of the model index from its observed values by means of a simplex search in the space of nonlinear parameters, combined with calculating linear coefficients by the SVD method at each step. The model has been tested on a number of magnetic storm events, which allowed us to better understand the role of different external factors in the storm dynamics. The obtained results will be used in our future studies, with the goal to improve the reliability of the short-term forecasting of the SYM-H index behavior during space storm events.

ULF waves in the solar wind and on ground: 23rd solar cycle variations and impact on “killer” electrons

Potapov, A.S. (Institute of Solar-Terrestrial Physics SB RAS, Irkutsk, Russia), and Tsegmed, B. (Institute of Solar-Terrestrial Physics SB RAS, Irkutsk, Russia, also in: Research Centre for Astronomy and Geophysics MAN, Ulaan-Baator-51, Mongolia)

We analyzed 11-year variation in ultra-low frequency (ULF) activity measured in the solar wind and on ground during the 23rd sunspot cycle. Data from magnetometers and plasma sensors onboard the spacecraft ACE, as well as magnetic measurements at two mid-latitude diametrically opposite INTERMAGNET observatories were used. Cross-correlation analysis showed a good correspondence between ULF amplitude variations in two regions and between the solar wind speed and ULF intensity. ULF variations were compared with changes in relativistic electron flux (energy $E > 2$ MeV) at geosynchronous orbit, using measurements made by GOES satellites. Average value of relativistic electron flux at the decay and minimum phases of solar activity is one order higher than the flux during maximum sunspot activity. Of all solar wind parameters, only solar wind speed variation has significant correlation with changes in relativistic electron flux, taking the lead over the latter by two days. Variations in ULF amplitude advance changes in electron flux by three days. Results evidence in favor of a contribution of ULF waves to acceleration of the outer radiation belt electrons up to relativistic energy. The work was supported by RFBR grant 10-05-00661.

New data on the giant September 1859 magnetic storm: an analysis of Italian and Russian historic observations

Ptitsyna, N.G., Tyasto, M.I. (St.Petersburg Filial of Institute of Terrestrial Magnetism, Ionosphere and Radiowave Propagation RAS (SPb FIZMIRAN), St.Petersburg, Russia), and Altamore, A. (University Roma-Tre, Physical Department, Rome, Italy)

On 1 Sep 1859 near the center of the solar disk the first-ever registered flare was detected in enhanced continuum emission in optical wavelengths (white light) by Carrington and Hodson. Moreover, it is the first-ever registered solar-geomagnetic event, which marked the beginning of space weather science. The Carrington flare produced a

coronal mass ejection which after 17 hours triggered a giant geomagnetic storm. We present an analysis of this event performed on the basis of new historic geomagnetic data that we found in Italy (Rome) and geomagnetic data registered in Russia (St. Petersburg, Yekaterinburg, Barnaul, Nerchinsk). The value of the extreme magnetic disturbance registered on September 2, 1859 in Rome (~ 3000 nT) is the largest among the registered by other observatories. These observations are important in studying the Carrington solar-terrestrial event, since magnetic readings in almost all other world-wide observatories, were out of scale. Comparison of Russian and Italian data are in very good accordance. During the severe magnetic disturbance, which is associated with the Carrington flare, its current system showed the character of a strongly asymmetric circuit that connected the partial ring current in the equatorial atmosphere to the current jet in the auroral zone, which was much shifted to the south relatively to its usual location. It is supported by observation of a outstanding event in Rome – a spectacular aurora borealis in forms of streamers and columns of light.

Very intense magnetic storms in 19 c. and solar activity

Ptitsyna, N.G., Tyasto, M.I., and Hrapov, B.A. (St.Petersburg Filial of Institute of Terrestrial Magnetism, Ionosphere and Radiowave Propagation RAS (SPb FIZMIRAN), St.Petersburg, Russia)

Eruptive activity of the Sun produces a chain of extreme geophysical events, in particularly, severe geomagnetic storms that form an important component of space weather. In this work we present a catalogue and an analysis of very intense magnetic storms registered in 1841-1870 by the Russian network of geomagnetic observatories. This period covers solar cycles 8–11. We considered great geomagnetic storms with magnitudes that approximately correspond to $Dst < -200$ nT (or $Kp \geq 8$). For our collection of storms high solar activity plays a critical role in generating very intense storms in 1841-1870: only one peak in solar cycle which falls into years of maximal activity (or little earlier) is found. Our analysis shows two-fold increase of great storms in solar maxima (or little earlier) in comparison with periods of lower activity. Such distribution is characteristic for the storms which are associated with interplanetary magnetic clouds.

The characteristics of plasma and magnetic field at the sub-solar magnetopause in accordance with data of THEMIS mission

Pulinets, M.S., Riazantseva, M.O., Antonova, E.E., Kirpichev, I.P. (Skobeltsyn Institute of Nuclear Physics, Moscow State University, Moscow, Russia)

We analyze the crossings of the magnetopause near the subsolar point using FGM and ESA devices of THEMIS mission. Variations of the magnetic field near magnetopause measured by one of THEMIS satellites are compared with simultaneous measurements in the solar wind by another THEMIS satellite. 30 and 90 s averaging of magnetic field in the magnetosheath is produced. The results of averaging are compared with the results of measurement just after the magnetopause crossing. It is shown, that B_x component of the magnetic field near magnetopause is near to zero, which supports the possibility to consider the magnetopause as the tangential discontinuity. Comparatively good correlation of B_y component in the solar wind and near the magnetopause is observed. The correlation of B_z component near the magnetopause and IMF is practically absent. It is shown, that in many cases the sign of the B_z component of magnetic field near the subsolar point does not coincide with the sign of IMF B_z component. The results of the analysis create definite difficulties to simplified theories of magnetic reconnection of solar wind magnetic field at the magnetopause.

Evidence of periodicity of solar activity millions years ago

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

Unique palaeoclimatic data with annual time resolution was used for study of climatic variability in time interval from 50.000 till hundred million year ago. These palaeoclimatic data is based on biological (tree-ring width of fossil trees) and geological (varves) materials. The climatic periodicity revealed have correlation with fundamental solar activity cycles and climatic periodicities related to internal processes in the atmosphere-ocean system. The periodicities revealed are similar with analogous periodicities in modern time.

Role of atmospheric circulation in climate response to long-term solar activity variations

Raspopov, O.M. (SPbF IZMIRAN, St. Peterburg, Russia), and Dergachev, V.A. (Ioffe Physico-Technical Institute of RAS, St. Petersburg, Russia)

Analysis of the processes in the lower atmosphere that occur during enhancement and weakening in cosmic ray fluxes has revealed changes in the atmospheric circulation. This response of the atmosphere to external forcing indicates that in the case of long-term factors associated with solar activity analysis should include consideration of the response of the entire atmosphere-ocean system, including internal processes in this system. Simulation and experimental data have shown that atmospheric circulation gives rise to a regional response to solar activity variations.

Southern boundary of the ultra relativistic electron precipitation on May 12, 1987

Remenets, G.F., and Kustov, A.A. (Physics Department of St. Petersburg State University, Russia)

Phenomenon of the ultra relativistic electron precipitation was analyzed in a cycle of publications [1–4] since 1985 year. Today we know about these electrons that their energy is about 100 MeV and that they are capable to generate X- and gamma-rays of such intensity that a sporadic D-layer of electric conductivity at the altitudes of 10–40 km appears. This sporadic layer reflects a signal from an on ground monochromatic radio source of very low frequency (VLF) range. The effective height of radio wave reflection changes during a disturbance since normal undisturbed value ~ 60 km at daytime to ~ 30 km in the maximum of powerful disturbance (PwD's). For weaker disturbances (strong (StD's) and moderate disturbances (MdD's)) the effective height variation is less. These values were gotten due to the solution of the VLF inverse problem, in which according to the time variations of the amplitudes and the phases of 3 radio signals for the auroral radio pass the effective height and the reflection coefficient were found as functions of time. It was supposed that the spacious horizontal scale of a disturbance was greater than the length of the auroral radio pass (10.2, 12.1, 13.6 kHz with its 885 km length. The pointed

VLF inverse problem we shall call as an inverse problem of first kind. The presented report is devoted to an inverse VLF problem of second kind, in which we used the amplitude and phase variations of a radio signal (16 kHz) during the same disturbance for a long partly auroral radio pass (England – Kola peninsular, 2497 km) for the determination of the southern boundary of the ultra relativistic electron precipitation. From direct comparison of the phase variations for the pointed auroral and the partly auroral radio passes it was estimated that the long radio pass was disturbed only partly from the northern end and that the disturbed part was about 1/3 of its length [4]. But every disturbance is individual and it is necessary to have an algorithm for finding the position of a boundary between the disturbed and undisturbed parts of the radio pass for a given disturbance. In represented case it is a disturbance on May 12, 1987.

So let us imagine a model of a wave-guide, which consists of two homogeneous parts at every moment of a disturbance. The position of a boundary between these two parts is an object of search by the help of the inverse problem. The southern part of a wave-guide was modeled with the help of the middle latitude ionosphere, which was not disturbed. The northern part of the wave-guide was characterized by the changes in time of the electric properties of the sporadic D-layer of conductivity, which the VLF inverse problem of first kind had given. For such model we were able to calculate the relative changes of the amplitude and the phase variation for 16 kHz radio signal as function of time. These two functions we included into a functional G , which characterized the difference between the experimental and calculated magnitudes. Such functional G we minimized relative to a position of a boundary. In the case of our event to the position founded the latitude equal to $(65 \pm 1)^\circ$ N corresponded.

So we have solved a problem about the latitude of the southern boundary of ultra relativistic electron precipitation.

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Observation of hydrogen emission $H\alpha$ in Spitzbergen

Roldugin, A.V., Pilgaev, S.V., and Roldugin, V.C. (Polar Geophysical Institute, Apatity, Russia)

Main proton event in January 2012 occurred on 23 January, but in advance of this burst the moderate increase of proton flux 10 MeV–50 MeV as large as 2–3 /cm²·s·sr obtained on 22 January in GOES. That day in Barentsburg observatory intensive hydrogen emission $H\alpha$ was observed, and its variation coincided with the solar proton flux changes. At the time of proton maximum on 23 January this emission was absent. During the hydrogen emission appearance the WIND satellite data showed sharp increase of velocity and pressure of solar wind, and an augmentation of positive B_z , following cusp shift to more high latitude. We consider that the $H\alpha$ emission was caused by solar protons, penetrated through the cusp.

The event of riometer absorption caused by auroral protons

Roldugin, V.C., and Shkarbalyuk, M.E. (Polar Geophysical Institute, Apatity, Russia)

There are regular riometer observations in Lovozero ($\Phi = 64.4^\circ$, $\Lambda = 114.3^\circ$) with 30 MHz frequency after spring of 2011.

The event of riometer absorption on 5 May 2011 is considered. At the time of small magnetic positive bay about of 40 nT in Lovozero and in neighboring Scandinavian stations in the evening between 1630 and 1700 UT an absorption of cosmic noise about of 1.5 db occurred. A west auroral electrojet may be situated this time at more high latitude, and the small positive bay can not be caused by its spreading

currents. During this absorption Pc1 and Pc5 pulsations were observed in Lovozero and in Scandinavia. We hypothesize on the base of these facts that this riometer absorption was caused by energetic proton precipitation.

Effects of geomagnetic disturbances on power systems at the NW of Russia

Sakharov, Ya., Katkalov, Ju. (PGI KSC RAS, Apatity, Russia); Viljanen, A. (FMI, Finland); Selivanov, V., Kolobov, V. (Centre for Physical and Technological Problems of Energy in Northern Areas KSC RAS, Russia)

Geomagnetically induced currents (GIC) related with geomagnetic disturbances can lead to misoperation of inductive systems as power lines, signaling systems etc. Systems operating at high and middle latitudes are mostly vulnerable to impacts of GIC during strong geomagnetic storms. European research project EURISGIC (European Risk from Geomagnetically Induced Currents) is aimed to mitigate possible effects of GIC on power systems in Europe. Special system for GIC recording was installed at five transformer stations at the Kola Peninsula and Karelia. GIC recordings and geomagnetic variations are presented at *eurisgic.org* site in nearly real time. GIC measurements are in good agreement with results of the current modeling. This research has received funding from the European Community's Seventh Framework Programme (FP7/2007–2013) under grant agreement no 260330.

Variations of the magnetopause pressure in dependence on IMF orientation

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

It is usually assumed that the magnetopause pressure is completely determined by the solar wind dynamic pressure. However the solar wind parameters change in the magnetosheath. Our analytical study and numerical simulations show that the magnetopause pressure is smaller than the solar wind pressure, if the magnetic barrier does

not form upstream of the magnetopause, and it stays close to the solar wind pressure, if the magnetic barrier does exist. Existence of the magnetic barrier, in turn, depends on the IMF orientation. In particular, the magnetic barrier does not form for radial IMF, and the increase of magnetic field before the magnetopause is usually smaller for southward than for northward IMF. We compare results of the anisotropic and isotropic 3-D MHD simulations in the magnetosheath and find that the variations of the magnetopause pressure with IMF orientation become stronger, if the anisotropic model is applied.

A case study of the sharp change in the IAR characteristics

Semenova, N.V. (Polar Geophysical Institute, Apatity, Russia)

Resonance spectral structures (RSS) in the geomagnetic background noise in the range from 0.1 up to several Hz are commonly suggested to be a signature of the ionospheric Alfvén resonator (IAR). The RSS frequencies as well as spectral width (difference between neighboring frequencies) closely relate with upper ionosphere parameters. In particular, the spectral width increases when the electron density in F-region decreases. Typically, at given point, the RSS spectral width exhibits smooth diurnal variations reflecting the diurnal changes of the ionosphere overhead. An unusual sharp increase of the RSS spectral width was observed on 24 December 2005 in Barentsburg, Svalbard during a substorm, which developed equatorward of this station. The spectral width jumped from 0.8 Hz up to 2 Hz. At the same time, the ionosonde located in Longyearbyen (close to Barentsburg) showed stepwise decrease in the electron density, which is consistent with RSS behavior. To understand the reason of such dramatic changes we analyzed the available auroral and magnetic observations. Data of the auroral TV camera in Barentsburg showed that the increased spectral width was observed when the substorm auroral bulge approached the station as close as 100 km. This is also confirmed by the location of substorm-related westward electrojet calculated from the data of IMAGE magnetometer network. We conclude that observed features could be explained suggesting the existence of the “ionospheric cavity”, which locates just poleward of the auroral bulge. The existence of such cavity, which is consequence of the downward field-aligned current poleward of the aurora, has been earlier established with radar observations and confirmed with some other data.

Forbush decreases in the absence of geomagnetic storms

Shadrina, L.P. (Academy of Sciences of S(Ya)R, Yakutsk, Russia), Plotnikov, I.Ya., and Starodubtsev, S.A. (Institute of Cosmophysical Research and Aeronomy SB RAS, Yakutsk, Russia)

First class of Forbush-storm classification Forbush decreases in the absence of the magnetic storms are studied. For the time periods from 1997 to 2010 it were chosen 29 events of cosmic ray intensity decreases with the amplitude more then 2,5% during geomagnetically quiet periods. For the analysis of the aforementioned events data of interplanetary medium parameters magnetic clouds configurations, interplanetary magnetic and electric field directions were used. It is shown that the most of the analyzed events are connected with the Earth's passing through the flanks of the interplanetary disturbance. A conclusion was made, that these events are caused by absence of considerable positive values of interplanetary electric field component E_y , whereas Forbush decreases a caused by magnetic clouds passing.

Superstorm 06.04.2000: identification of hidden dependencies of the magnetic flux of the tail lobe of the values of electric field of the solar wind

Shapovalova, A.A., Karavaev, Y.A., Mishin, V.M., and Mishin, V.V. (Institute of Solar-Terrestrial Physics SB RAS, Irkutsk, Russia)

The question of linear or nonlinear dependence of the magnetic flux of the lobe tail, Ψ , on the parameters of the solar wind is actively discussed in the literature (e.g., Shukhtina et al., 2004, 2005; Lopez et al., 2009). The report made a comparative analysis of changes Ψ during the superstorm 06.04.2000 with the change of the solar wind parameters, the electric field, E_{sw} . The improved version of the magnetogram inversion technique (MIT) developed in SibIZMIR is used for processing of 120 ground-based magnetometer data. The maps of FACs density distribution in polar ionosphere have been calculated, and the time series of Ψ are obtained on this base. Further, on the basis of the original method, variation of the derivative $\frac{\delta\Psi}{\delta E_{sw}}$ during superstorm have been found. Marked by a pronounced saturation Ψ effect in continuous growth E_{sw} to 13 mV/m.

The midlatitude ionosphere during storm periods and afterwards

Shubin, V.N., Deminov, M.G., and Badin, V.I. (IZMIRAN RAS, Troitsk, Russia)

It is well-known that the changes in the thermospheric temperature and composition are first responsible for negative phases of storms occurring in the midlatitude ionosphere, namely, these changes result in the decrease in the critical frequency foF2 of the storm-time midlatitude F2 layer. The thermospheric temperature and composition depend on the history of the geomagnetic activity that is taken into account in modern empiric models of the thermosphere. Therefore, the storm-time foF2 changes also depend on this history through the weight-average (with a characteristic time T) geomagnetic index $ap(T)$. The statistical analysis of the foF2 data indicates that the characteristic time $T = 14$ hrs is optimum for taking into account the foF2 dependence on the geomagnetic activity observed at intense storms. During such periods, the foF2 changes are proportional to $Kp(T)$ squared, where $Kp(T) = 2.1 \ln(ap(T)/5 + 1)$. A simple empiric model using this relation for storm-time foF2 corrections reproduces the midlatitude foF2 dynamics observed during the periods of the high geomagnetic activity. Strong foF2 depletions are also observable within the first day succeeding the finish of the magnetic storm, when the geomagnetic activity is that of the background level. The preliminary statistical analysis of the phenomenon is presented. It seems that in the relaxation of thermospheric winds to undisturbed conditions, there are some peculiarities which persist when the midlatitude thermospheric temperature and composition have already reached the quiet level; these peculiarities can be among plausible reasons for the strong foF2 depletions succeeding magnetic storms.

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Solar wind and magnetotail conditions before substorm onset

Shukhtina, M.A., Dmitrieva, N.P., Kubyshkina, M.V., Sergeev, V.A. (St. Petersburg State University, St. Petersburg, Russia)

Conditions, leading to substorm onsets, is one of the key problems of magnetospheric physics. It is usually assumed that tail magnetic flux (F) is accumulated during the growth phase and then suddenly released during the expansion phase. However, it is not always the case. From 65 intense unloading events in 1995–1998 for which the tail magnetic flux could be calculated based on Geotail observations (following Shukhtina et al., 2009), clear F increase before onset (here onset is defined as sudden flux unloading) was observed only in 33 (type 1 “classic” events). In the rest 32 cases F stayed at nearly constant level during about 40 min before onset (type 2, “delayed onset” events). We call this 40-min interval the Preonset Period (PP).

A superposed epoch analysis for two event categories showed that substorms of type 1 began on quiet background, the “merging electric field” E_m on dayside magnetopause increasing from ~ 0.5 mV/m at $t = T_0 - 2$ h to 1.6 mV/m at $t = T_0$ (T_0 for the flux unloading time). On the contrary, for type 2 events E_m was stable during 2 hours before T_0 , with average value 1.3 mV/m (1.5 mV/m at T_0). Dynamic pressure was stable and almost equal (~ 2.8 nPa) for both types.

Analysis of Geotail (GT) data showed that general field line stretching (B_z decrease) and plasma sheet thinning (plasma beta decrease) is observed in both groups during PP, the F value at T_0 being lower for type 2 than for type 1. The flux transfer $-VxB$ in the plasma sheet during PP is small for events of type 1 (0.08 mV/m) but large for events of type 2 (0.26 mV/m, the average value for magnetospheric convection). Also, during this stage some activity have been detected for type 2 events (namely, transient dipolarizations at both GT and GOES and intensification of AL index), indicating that dissipative processes are already in operation at some moderate level. At the beginning of sudden unloading phase, plasma flow at ~ 23 Re is typically tailward for type 1 and earthward for type 2, indicating different location of midtail reconnection. Contrary to Geotail observations no additional field line stretching is observed at GOES spacecraft during PP.

We studied in detail two type 2 events, when simultaneous GT (at

~ 20 Re), THEMIS (at ~ 10 Re) and GOES data was available. Magnetic flux, calculated from GT measurements in the lobes, was nearly constant during 20/120 min before T_0 for the first/second event. In the case when ground auroral images were available, auroral activity of pseudobreak type was observed during the stable F period. In both cases all aforementioned features were detected during this period. Essentially different field and plasma behavior was observed on closely situated THEMIS spacecraft. It means that the conditions leading to substorm onset may be extremely localized.

Open magnetotail magnetic flux calculation based on tail observations inside 15 Re

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

Generalization of the earlier used algorithm of magnetic flux calculation is presented. The algorithm develops the Petrinec and Russell, 1996 (PR96) method of magnetotail radius RT calculation based on simultaneous magnetotail and solar wind observations. The algorithm is based on the pressure balance on the magnetopause and in the plasma sheet. Contrary to the model PR96 expression for RT as a function of IMF and solar wind dynamic pressure, it allows one to calculate the actual RT value and the tail magnetic flux as $F = \pi B_L R_T^2 / 2$ (B_L for the tail lobe magnetic field).

Till now we used the algorithm for magnetotail data tailward of -15 Re, where the tail approximation is fulfilled. In the present study we generalize the method for the region inside -15 Re, where the dipole field contribution is significant. To obtain the open F value the dipole field is subtracted from the total magnetic field .

We test the algorithm on a CCMC global simulation and on real magnetospheric/solar wind measurements. In the simulation we compare the F values, calculated by the algorithm, with F_D -the flux values obtained by direct integration through the magnetotail cross-section at $X = -15$ Re. The analysis shows good results ($cc > 0.9$, regression coefficients $\sim 0.8 - 0.9$, close F and F_D values) for measurements in the tail lobes at X down to -7 Re not far from the midnight meridian ($|y| < 7$ Re). The dipole contribution is significant even at -15 Re ($B_{dip} \sim 9$ nT at the equator). Taking it into account minimizes the difference between F and F_D .

Analysis of F values based on simultaneous Geotail (GT, $X \sim -28$ Re) and Interball (IT, moving in the lobes from -12 Re to -7 Re) observations during 6 hours for strongly tilted dipole gave the regression equation $F_{IT} = 0.6F_{GT} + 0.21$, $cc = 0.8$, $F_{IT} = 0.55$ GWb, $\langle F_{GT} \rangle = 0.57$ GWb.

Based on obtained results we hope to get in the future reliable F estimates using tail lobe spacecraft data as near as $X = -7$ Re.

The study of magnetic barrier dependence on direction and intensity of the interplanetary magnetic field

Slivka, K.Y., Semenov, V.S., and Dmitrieva, N.P. (St. Petersburg State University, St. Petersburg, Russia)

The magnetic barrier is the region with enhanced magnitude of magnetic field and depleted plasma. It is formed in the inner magnetosheath layer adjacent to the dayside magnetopause. There is a general point of view now that a magnetic barrier can persist only for the northward direction of interplanetary magnetic field (IMF) while it is absent for the southward direction. We make a special study to check appearance of magnetic barrier for different directions of IMF. To this end a data base consisting 45 events of low-latitude dayside magnetopause crossings by the THEMIS satellites with signatures of magnetic barrier, was created and analyzed. In order to study the variations of key plasma parameters and the magnetic field in the magnetopause and the adjacent magnetosheath in a systematic way, we used a superposed epoch analysis. It turns out that the magnetic barrier is the most pronounced for the northward IMF. For the southward IMF we still were able to find events with signatures of magnetic barrier although it was highly disturbed by the reconnection. Also we found out that direction of magnetic field in front of the bow shock corresponded to direction of magnetic field in front of the magnetopause.

Fractal approach to study the multiscale magnetospheric dynamics in the ULF range based on the Earth surface observations

Smirnova, N.A. (St. Petersburg State University, St. Petersburg, Russia), Isavnin, A.A. (St. Petersburg State University, St. Petersburg, Russia; The University of Helsinki, Helsinki, Finland), and Varlamov, A.A. (St. Petersburg State University, St. Petersburg, Russia)

Now it is recognized that the multiscale ultra-low-frequency (ULF, $f = 0.001 - 10$ Hz) phenomena play an important role in magnetosphere dynamics. Particularly they compile essential features of the magnetotail structure and substorm dynamics (see a review "Low Frequency Magnetic Fluctuations in the Earth' Plasma Sheet" by A.A. Petrukovich in *Non-equilibrium phenomena in plasmas*, Eds. A.S. Sharma, P.K. Kaw, Springer, 145–178, 2005). In recent years a new paradigm is developed to understand the magnetosphere dynamics in the frame of the complex stochastic systems behavior. The corresponding approach includes the notions of self-organized criticality, intermittency, scale-invariance, etc. So fractal analysis of the ULF phenomena, especially of ULF emissions, seems to be the most appropriate tool to study such complex magnetosphere dynamics. The ULF emissions can be registered both inside the magnetosphere and on the Earth's surface. Here the multipoint ground-based observations of the ULF emissions recorded in wide range of latitudes from equatorial region to the polar cusp area are considered. The chain of stations includes the 210 MM stations Guam ($\Phi_m = 4.6^\circ$ N), Moshiri ($\Phi_m = 37.6^\circ$ N), Paratunka ($\Phi_m = 46.3^\circ$ N), Magadan ($\Phi_m = 53.6^\circ$ N) and Chokurdakh ($\Phi_m = 64.7^\circ$ N), the Russian PGI stations Lovozero ($\Phi_m = 64^\circ$ N), Barentsburg ($\Phi_m = 76^\circ$ N) and the drifting station "Norhth Pole-30" ($\Phi_m = 76^\circ$ N). Fractal analysis of the ULF emissions has been fulfilled using PSD technique, Higuchi method and MF DFA approach. The obtained ULF emissions scaling characteristics (spectral exponents and fractal dimensions) have been analyzed depending on the station position, local time and magnetic activity. The difference in fractal dynamics of ULF emissions during quite and disturbed periods is demonstrated. It is shown how geomagnetic disturbance is manifested in fractal characteristics of ULF emissions. It is suggested that one of the revealed peculiarities such as a "kink" near $f = 0.03$ Hz in scaling curves at the high-latitude data can be attributed to the corresponding "kink" in power-law spectra of

magnetic fluctuations obtained with the Geotail spacecraft in the distant magnetotail. Based on the peculiarities revealed, the processes of self-organizations in the magnetosphere are discussed. It is finally argued that fractal properties of the ground-observed ULF emissions allow insight into the global and small-scale dynamics of the Earth's magnetosphere.

Modeling of the proton radial diffusion in the Earth's magnetosphere

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

The results of the numerical solution of the Fokker-Planck equation, describing radial diffusion of protons in the Earth's magnetosphere, are presented. Attention is restricted to equatorially mirroring protons in the energy range (1–750) keV, and comparison is made between theoretical predictions of proton energy spectra at L values between 1 and 6.6 and observations on board several satellites.

The proton ring current development during the magnetic storm

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

The development of the ring current protons in the inner magnetosphere during the magnetic storm is studied. The temporal and spatial evolution of the proton phase space densities in a dipole field are calculated using a two dimensional ring current model, considering radial and pitch angle diffusions, charge exchange and Coulomb losses. The simulation starts with a quiet time distribution. The model is tested by comparing calculated proton fluxes with Polar/MICS measurement during the magnetic storm on 21–22 October 1999.

Traveling ionospheric disturbances: data of meridional chain of ionosondes and model calculations

Stepanov, A.E., Filippov, L.D., and Sofronov, S.K. (Yu.G. Shafer Institute of Cosmophysical Research and Aeronomy, SB RAS, Yakutsk, Russia)

Traveling ionospheric disturbances (TIDs) — a special type of wave ionospheric disturbances, characterized by quasi-periodic variations of the electron density, and has a global character. They found only radiophysical methods, such as ionosondes of vertical and oblique sounding, incoherent scatter radar, GPS systems, etc. Yakut meridional chain of ionospheric stations, aligned from L \sim 3 to 6, is a convenient tool to study the parameters and characteristics of high-latitude TIDs.

In this report were analyzed data from ionosondes chain Yakutsk-Tixie Bay-Zhigansk and Norilsk in 2005. The statistics of registrations TIDs characteristic ionospheric features depending on geomagnetic conditions is presented. Calculated the phase velocities of the TIDs, its size and direction of propagation. Calculations of traveling ionospheric disturbances using a parabolic model of the ionosphere is also given.

On geomagnetic variations at middle latitudes from magnetospheric and ionospheric sources during strong magnetic storms

Sumaruk, Yu.P. (Institute of Geophysics NASU, Kiev, Ukraine)

Geomagnetic variations are generated by magnetospheric and ionospheric sources. Current systems of the magnetopause, magnetospheric ring current and currents in the magnetosphere tail present the magnetospheric sources. The auroral electrojets and its return currents to the middle latitudes and also Sq – dynamo currents present the ionospheric sources. At middle latitudes these sources generate the especially intricate geomagnetic variations during geomagnetic storms. We calculated middle latitude variations of the geomagnetic field which are generated by ionospheric and magnetospheric sources during eleven great magnetic storms. For zero-level the mean hourly values of Sq on five international quiet days for correspondent month

was chosen. Carried out analysis allowed to receive numerical values of the variations from different sources. It is shown that about eighty percentage, in average, of full variation during storms is generated by magnetospheric sources and only one fifth part of its has ionospheric sources.

A possibility of Schumann resonances observation at the ionospheric altitudes

Surkov, V.V., Nosikova, N.S., Plyasov, A.A. (National Research Nuclear University, Moscow Engineering Physics Institute, Moscow, Russia), and Pilipenko, V.A. (Space Research Institute, Moscow, Russia)

Schumann resonance power spectra excited by individual lightning discharges and by stochastic lightning discharges due to global thunderstorm activity are theoretically estimated both in the Earth-ionosphere waveguide and at the ionospheric altitudes. The dependence of resonance spectra on the daytime and nighttime ionospheric parameters and the inclination angle of geomagnetic field lines are investigated. The magnitudes of the ELF/ULF electric and magnetic power spectra at the ionospheric altitudes are shown to be strongly smaller than that at the ground surface especially at the daytime. The two opposite cases of polar and equatorial ionosphere are examined. The middle latitude region appears to be more favorable for onboard observation of the Schumann resonances. Results of our calculation were compared with the power spectra recorded at the C/NOFS satellite. The theoretical possibility of Schumann resonance observation at the low orbiting satellites is indicated.

The troposphere and ionosphere variations in the solar terminator region

Suslova, O., Karpov, I.V. (Im. Kant BFU, Kaliningrad, Russia), and Radievsky, A.V. (WD IZMIRAN, Kaliningrad, Russia)

The atmosphere and ionosphere observations were made simultaneously in the period January 2011 – March 2012 in Kaliningrad. The observations were made using two-wavelength atmospheric lidar and

stations receiving signals of navigation satellites GLONASS/GPS. The results of observations in the troposphere have shown that for 1 hour before sunrise, and within 1 hour after sunrise in the atmosphere were observed perturbations with typical periods of 10–20 min. The characteristic times of the identified variations in atmospheric and ionospheric parameters are close to the Brunt-Vaisala periods. Consequently, such variations are determined by IGW with small spatial scales. Such IGW propagate almost vertically, and can reach the ionosphere very fast. It is possible that in the solar terminator region at ionospheric heights may be observed IGW, generated at the troposphere. We can assume that IGW with small space scales and frequency close to the frequency of Brunt – Väisälä play an important role in the connection of the tropospheric and ionospheric processes.

Equatorial Pc3-4 waves observed in the upper ionosphere by CHAMP and on the ground

Syusyuckalov, S.A., Yagova, N.V. (Institute of Physics of the Earth, Moscow, Russia), Pilipenko, V.A. (Institute of Physics of the Earth, Space Research Institute, Moscow, Russia), Heilig, B. (Geomagnetic Observatory Tihany, Hungary), Luehr, H. (Solar-terrestrial Physics Center, Germany), Yumoto, K., and Uozumi, T. (Kyushu University, Japan)

We have searched for simultaneous ULF activity in the Pc3 band at the near-equatorial 210MM magnetic stations and low-orbiting CHAMP satellite during its passage over the dip equator.

The spatial structure of Pc3-4 waves throughout the Earth's surface is very inhomogeneous and demonstrates a localized amplitude enhancements at sub-auroral, middle, and equatorial latitudes. The fact of "equatorial enhancement of ULF waves" was noticed many decades ago, however, a possible mechanism of equatorial ULF enhancement is still unresolved problem. Several different mechanisms can be involved:

- enhancement of the ionospheric currents induced by ULF wave which spread into the equatorial region with elevated ionospheric Cowling conductance;
- direct penetration of ULF compressional wave energy towards the

near-equatorial region without conversion into Alfvén field line oscillations;

- fluctuations of the equatorial electrojet.

Most probably, combination of all these mechanisms takes place. To resolve them is a challenging goal. A real breakthrough in these studies can be achieved only with the comparison of simultaneous low-orbit satellite observations (CHAMP) and ground magnetometers (CPMN), which are located near the dip equator.

Spatio-temporal characteristics of thermal structures within dusty auroral dynamo layer

Timofeev, E.E. (Admiral Makarov State Maritime Academy, St. Petersburg, Russia), Shalimov, S.L. (Institute of Physics of the Earth RAS; Space Research Institute RAS, Moscow, Russia), Chkhetiani, O.G. (Space Research Institute RAS; Institute of Atmospheric Physics RAS, Moscow, Russia), Vallinkoski, M.K., Kangas, J. (Space Physics Department of the University of Oulu, Oulu, Finland)

In present study we analyze spatial and temporal variations of the ion (Ti) and electron (Te) temperatures measured by the EISCAT facility within the nighttime dynamo layer over Tromso during two auroral substorms on March 15 and 23, 1988. High-frequency fluctuations of the temperatures were smoothed out by sliding average method. Smoothed temperatures were studied as functions of the average ionospheric electric field (E) and electron density (Ne). It is found that: (1) On time scales from 3 to 20 minutes the ion temperature is in anti-phase with electron temperature: ion heating is accompanied by cooling of the electrons and vice versa. (2) On time scales of about 30 to 45 minutes the wavy anti-phase variations of Te and Ne were revealed. The scale of electron cooling is, in average, about twice of the ion heating scale. (3) For the E-field under the threshold of the FB-instability (15–20 mV/m) the thermal anomaly with temperature difference $(Ti-Te) > \sim 50K$ is systematically observed. (4) The value of the anomalous temperature difference $(Ti-Te)$ increases with decreasing of the E-field and increasing of the electron density, and can reach about 120 K. (5) For the E-field exceeding the FB-threshold and low Ne the thermal anomaly is replaced by classical picture when overheating of the electrons takes place $(Te-Ti > \sim 50 K)$ that is typical for the dust-free plasma dynamo layer. The above-mentioned

anomalous finding are interpreted in the frame of modern theory of strongly coupled dusty plasma. The estimates are compared with similar results of laboratory experiments with dusty plasmas. The suggested hierarchy of self-similar thermal structures is interpreted in the framework of nonlinear evolution of the Ekman type instability that can develop within the dynamo layer.

Investigation of the energetic particle participation during the substorm explosive phase

Timofeeva, S.A., and Sergeev, V.A. (Institute of Physics, St. Petersburg State University, St. Petersburg, Russia)

During the substorm explosive phase the magnetic field configuration is changing. In this connection, conditions of particle scattering in loss-cone and structure of the auroral precipitation change also. Therefore, by interpreting the precipitation picture (regions of wave-induced precipitation and regions of non-adiabatic current-sheet precipitation) before and after the substorm onset we can obtain information about the magnetic field reconfiguration.

In this paper we study the energetic particle dynamics in the several substorms observed on the ground in the Canadian sector. Using energetic particle data from this low-altitude spacecraft (NOAA series), crossing the dipolarization region, we compare precipitation structure before and after substorm onset to study their typical features.

It is shown that after the beginning of substorms increase in the fluxes of energetic particles, the isotropic boundaries shifts for electrons and protons observed. Also we can distinguish areas of dipolarization, injections, and define the type of particle scattering.

Based on our results we continue to develop the method for distance study of magnetic field structure changes proposed in (Sergeev and Kubyshkina, *J. Geomag. Geoelectr.*, 1996).

Properties of the magnetospheric backward wave oscillator inferred from CLUSTER measurements of VLF chorus elements

Titova, E. (Polar Geophysical Institute, Apatity, Russia), Demekhov, A. (Institute of Applied Physics, Nizhny Novgorod, Russia), Kozelov, B. (Polar Geophysical Institute, Apatity, Russia), Santolik, O., Marcusova, E. (IAP/CAS, Prague, Czech Republic), Rauch, J.-L., J.-G. Trotignon, J.-G. (LPCE/CNRS, Orleans, France), Gurnett, D., and Pickett, J. (University of Iowa, Iowa City, USA)

According to the backward wave oscillator (BWO) model, a sharp gradient (or step-like deformation) on the electron distribution function is the most important factor in chorus generation, but such a feature is very difficult to observe directly. The properties of the step in the BWO model determine the dimensionless parameter q quantifying the excess of the energetic electron flux above the absolute-instability threshold. This parameter, in turn, is related to the frequency sweep rate of chorus elements, which we obtained by using data from the WBD instrument onboard the CLUSTER satellites in the equatorial region for more than 7000 chorus elements. Then, using the CLUSTER data for the plasma density and magnetic field, we calculated q assuming the validity of the BWO theory and found that the q values depend only weakly on the density; the average values of $q \approx 7$ for the lower band chorus ($f/f_{ce} < 0.5$) and $q \approx 13$ for the upper band ($f/f_{ce} > 0.5$). These q values constitute a large excess over the generation threshold ($q > 3$) resulting from numerical simulation of discrete elements with rising frequency and are thus consistent with the simulations. Another important feature of the q parameter is the significant scatter of its values during each Cluster passage of the generation region. Using the obtained q values we estimate the relative height of the step in the electron distribution function to lie in the range from 0.01 to 0.3.

Comparison magnetospheric magnetic field models in context of cosmic ray cutoff rigidities

Tyasto, M.I., Danilova, O.F., Ptitsyna, N.G. (St. Petersburg Filial of IZMIRAN, St. Petersburg, Russia), and Sdobnov, V.E. (Institute of Solar-Terrestrial Physics SB RAS, Irkutsk, Russia)

Cosmic ray time variations of the magnetospheric origin are related to changes in geomagnetic cutoff rigidities. We have compared the cutoff rigidity changes obtained by the trajectory tracing method in the magnetic field of the Ts01 and Ts04 magnetosphere models with those obtained by the spectrographic global survey method based on the experimental cosmic ray data. Both magnetosphere models were developed on the basis of the same experimental data set. The calculations were performed for the strong stormy period in November 2003 for several stations with quiet cutoff rigidities covering the major part of the cutoffs influenced by the geomagnetic field. Comparison shows that the cutoff rigidities calculated by using the Ts01 and Ts04 models differ by 0.8–0.9 GV during the main phase of the storm.

Fractal diagnostics of solar wind parameters in flares of active region 11429

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

Solar wind flow structure is the important characteristic of new growing solar cycle. Phases of growth and maximum of 24-th solar cycle are connected with the transformations of fractal dimension values of solar wind parameters. It confirms the increase of sporadic phenomena in a new cycle, such as flares and another phenomena of solar activity - coronal mass ejections (CME), high wind streams and filament eruptions. The beginning of March 2012 is characterized by the strong growth of solar activity, especially power X and M flares in active region 11429. 24 cycle of solar activity (SA) stays now in a phase of an ended branch of growth and obvious transition to a phase of SA maximum.

Realizations of this transition are events of March, 2012 when emergence of quickly developing active region (AR) 11429 began the period of a powerful intensification of flare activity on a visible disk of

the Sun /http://www.lmsal.com/solarsoft/latest_events/. The valuable feature in this time was a formation of the complex of active regions from AR 11429 and AR 11430.

Reaching our planet, flare streams, coronal mass ejections (CME) and filaments eruptions affect on magnetosphere, being late rather ionosphere disturbance from arrival of solar cosmic rays. The arrival of powerful flare streams is shown in the magnetosphere as global and regional disturbances, magnetic storms and sub-storms in auroral latitudes.

The auroral activity is especially important and dynamic manifestation of SW action. Research of active events occurring in March, 2012 gives us the chance to compare and to analyse solar events in their impact on a magnetosphere and an ionosphere, using Wind data /http://cdaweb.gsfc.nasa.gov/cdaweb/istp_public/ and to identify the reasons of geomagnetic storms and their course in the considered period of March, 2012.

Fractal dimension calculations help us to evaluate the transformation of SW flow structure in near-Earth cosmic space. It gives the additional arguments at discussion about properties of SW streams, causing variations in magnetosphere and ionosphere of the Earth. Calculations of fractal dimension of plasma streams, reaching our planet, allow to reveal changes of structure of SW streams and to treat their subsequent influence on the Earth.

Strongly tilted current sheets in the Earth magnetotail

Vasko, I.Y., Artemyev, A.V., and Petrukovich, A.A. (Space Research Institute, Moscow, Russia)

We investigate strongly tilted current sheets in the Earth magnetotail. We analyze magnetic and electric field structure based on the statistics of 38 current sheets collected by Cluster mission in 2001, 2002 and 2004 years. Tilted current sheets are characterized by relatively large value of north-south component of the magnetic field. We calculate the adiabatic parameter of charged particle motion and show that protons are likely stochastic (their Larmor radius is about field line curvature radius), whereas electrons are strongly magnetized. Electrons carry the most part of electric current in the majority of these current sheets and there is significant field-aligned electron cur-

rent. We observe electric field normal to current sheets (dawn-dusk component) with magnitude around 1 mV/m. This field corresponds to three types of electrostatic potential profiles across current sheet: parabolic potentials with minimum in the neutral plane (U-shape profiles), parabolic potentials with maximum in the neutral plane and potentials without a distinct parabolic shape. We develop an analytical model describing parabolic potentials and compare it with observations. The effect of the dominance of electron current density is discussed.

The polar vortex evolution as a possible reason for the temporal variability of solar activity effects on the lower atmosphere circulation

Veretenenko, S.V., and Ogurtsov, M.G. (Ioffe Physical-Technical Institute, Russian Academy of Sciences, St.Petersburg, Russia)

In this work we continue studying possible reasons for the temporal variability of long-term effects of solar activity (SA) and galactic cosmic ray (GCR) variations on the lower atmosphere circulation. It was revealed that the detected earlier 60-year oscillations of the amplitude and sign of SA/GCR effects on the troposphere pressure at high and middle latitudes (Veretenenko and Ogurtsov, *Adv. Space Res.*, 2012) are closely related to the state of a cyclonic vortex forming in the polar stratosphere. A roughly 60-year periodicity was found in the vortex strength affecting the evolution of the large-scale atmospheric circulation and the character of SA/GCR effects. It was shown that the sign reversals of the correlations between tropospheric pressure and SA/GCR variations coincide with the transitions between the different states of the vortex, with most pronounced SA/GCR influences on extratropical baric systems being observed when the vortex is strong. The results obtained suggest that the evolution of the stratospheric polar vortex plays an important part in the mechanism of solar-atmospheric links.

Variations of extratropical cyclonic activity in the Northern and Southern hemispheres associated with energetic Solar Proton Events

Veretenenko, S.V. (Ioffe Physical-Technical Institute, Russian Academy of Sciences, St. Petersburg, Russia), and Thejll, P. (Danish Meteorological Institute, Copenhagen, Denmark)

Influence of energetic Solar Proton Events (SPE), with energies above 90 MeV, on the development of cyclonic processes at middle latitudes of the Northern and Southern hemispheres was studied, the NCEP/NCAR reanalysis data being used. The study revealed a noticeable intensification of extratropical cyclonic activity associated with these events, the detected effects being most significant in the Northern hemisphere for the SPEs observed in October-March and in the Southern hemisphere for the SPEs observed in April-September. It was found that the largest cyclone deepening in the Northern hemisphere takes place in the North Atlantic near the south-eastern coasts of Greenland, this area being characterized by high temperature contrasts and a low geomagnetic cutoff rigidity. In the Southern hemisphere most appreciable cyclone intensification associated with SPEs occurs in the Southern Ocean near the Antarctica coasts next to the South Magnetic Pole, this region being characterized by a low geomagnetic cutoff rigidity and high temperature contrasts, too. The results obtained suggest an importance of ionization changes produced by cosmic ray variations for a mechanism of solar activity effects on extratropical cyclonic activity.

Inferring sector structure of the interplanetary magnetic field in the second half of the 19th century

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

Time series of satellite data exceed more than four decades. It allows finding some rules of solar-terrestrial physics, but is not enough for solar physics with well-known 11-year period of solar activity. That is why it is so important to reconstruct solar parameters in the past. In our work we infer sector structure of the interplanetary magnetic field (IMF). This structure is formed by IMF directions — away or toward the Sun. The possibility for reconstruction of the IMF sector

structure was found by Svalgaard and Mansurov in 1968 and 1969 with discovery of the Svalgaard–Mansurov effect. In accordance with this rule opposite IMF directions lead to opposite sign of the geomagnetic variations at polar stations and, thus, can be inferred. Based on this rule we proposed our own method of inferring IMF polarities. Success rate of the method varies from 78 to 94% depending on used set of stations. In this work we analyzed geomagnetic variations in Helsinki in the second half of the 19th century. Detailed results are presented on the poster.

The formation of the electric fields and currents in the Harang discontinuity during growth phase of the substorm

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

This work is focused on the formation of the electric fields and currents in the Harang discontinuity. The charge separation in this region of the magnetosphere is the result of various protons and electrons drift in the inhomogeneous magnetic field. The cold electrons move with velocity of the electric drift, while the hot ions move with velocity of electric and gradient drift. The gradient drift is directed along the lines of the equal magnetic field. Within the research the magnetic field model with the tailward magnetic fields lines has been used. In the magnetosphere model the hot ions have velocity component directed away from Earth to the evening sector of the magnetosphere at the distance of 10 Re. As the result, the negative charge, electric fields and currents have been appearing in this region with the typical distribution of these electric fields and currents for the Harang discontinuity. The tailward magnetic fields lines lead to a significant increase of the magnetic flux tubes volume and significantly affect the intensity of the currents flowing in this area.

Nonlinear electrostatic structures in the magnetospheric plasmas

Volosevich, A.V. (Mogilev State University, 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 nonlinear evolutionary equations 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 $R = L1/L2$ (where $L1$ and $L2$ are 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.

Generalized theory of the Farley Buneman instability and its approach to experiments in the auroral ionosphere

Volosevich, A.V. (Mogilev State University, Belarus), and Zarnitsky, Yu.F. (Private scientist, 52/30 Atzmaut str., Ashdod, 77452, Israel)

Linear and nonlinear theories of the excitation of modified two-stream or Farley-Buneman (FB) instability in the auroral ionosphere are investigated. From the magnetohydrodynamic (MHD) and kinetic systems of equations the generalized theoretical models for the low-frequency waves (wave's frequency is much less than ion-neutral collision frequency) and high-frequency waves (wave's frequency is much more than ion-neutral collision frequency) for the real physical conditions on altitude of an ionosphere of 100–120 km are obtained. On the basis of the considered generalized linear theory the dispersive equations and speeds of phase for low-frequency and high-frequency

waves are calculated. Also the main physical mechanisms of stabilization of the FB instability are considered: (a) the attenuation Landau on ions in kinetic model or viscosity in MHD models; (b) a deviation from a condition of quasi-neutrality of plasma ; (c) the nonlinear interaction the low-frequency waves with the high-frequency waves This theoretical results are compared to the experimental data of the auroral scattering of the radio waves.

Global distribution of auroral luminosity inferred from the Auroral Precipitation Model

Vorobjev, V.G., Yagodkina, O.I., Katkalov, Yu.V., and Kirillov, A.S. (Polar Geophysical Institute, Apatity, Murmansk region, Russia)

Auroral Precipitation Model (APM) which is placed now on the PGI website <http://apm.pgia.ru/> was used to calculate the global distribution of auroral luminosity in visible and UVI spectral ranges. Integral intensities of the N₂ LBH(L) band near 170.0nm, 1NG N₂⁺ at 391.4 nm, (OI) 557.7 nm (the transition ¹S → ¹D in atomic oxygen), and the 1PG N₂ band near 669.0 nm have been calculated. To calculate (OI) 557.7 nm intensity the production of O(¹S) in the electron energy transfer process N₂(A³Σ_u⁺)+O(³P), the dissociative recombination, auroral electron impact and the production of electronically excited N₂ by auroral electron impact were taken into account. A good agreement was revealed by comparison of the LBH(L) global distribution observed by the IMAGE spacecraft and calculated from APM.

Dynamics of the auroral precipitation zones during solar wind recurrent streams

Yagodkina, O.I., and Despirak, I.V. (Polar Geophysical Institute, Apatity, Russia)

The dynamics of the spatial localization of the different auroral precipitations zones during solar wind recurrent streams was studied by DMSP satellites data. The examination was implemented depending on the geomagnetic disturbance level, expressed by the AL- and Dst indices. Three precipitation zones were determined: (1) DAZ zone,

coinciding with the diffuse auroral glow zone; (2) AOP zone, coinciding with the statical discrete auroral forms oval; (3) the band of soft diffuse precipitations SDP, enveloping the poleward boundary of the AOP zone. The solar wind parameters were defined by OMNI data base. Recurrent streams (RS) and CIR- regions (the regions of interaction RS with undisturbed solar wind) were defined. The spatial localization of auroral precipitation zones was obtained during three recurrent streams, on October 06–08, 2002, on October 14–16, 2002 and on March 10–16, 1998. We determined the poleward and equatorward boundaries of auroral oval, the variations in size and strength of the auroral oval during passage of solar wind recurrent stream. The different precipitation structure during the specified events was discussed.

Global distribution of ion precipitation and height integrated ionospheric conductivities

Yagodkina, O.I., Vorobjev, V.G., and Katkalov Yu.V. (Polar Geophysical Institute, Apatity, Russia)

The model of global distribution of precipitating ions was developed on the base of DMSP F6 and 7 spacecraft observations. This model allows us to calculate the average energy and energy flux of ions in different regions of precipitation in depend on a magnetic activity level expressed in AL and Dst indexes. A comparison of electron and ion characteristics were carried out in different MLT sectors. It was shown that being not so significant the ion deposit in the global precipitation power is more pronounced in the dusk and around the clock during magnetic quietness. Calculated values of ion energy flux and ion energy were compared with the DMSP spacecraft observations during two magnetic storms on February 06–16, 1986 and March 11–21, 1989 and have shown rather well conformity. A global distribution of height integrated Hall and Pedersen ionospheric conductivities inferred from both electron and ion precipitation models are presented for low and high magnetic activity levels.

Pc2-3 pulsations in the ionospheric F-layer, on the ground and in the magnetosphere: comparison of CHAMP, MM100 and GOES observations

Yagova, N.V., Fedorov, E.N. (Schmidt Institute of Physics of the Earth, RAS, Moscow, Russia), Heilig, B. (Tihany Geophysical Observatory ELGI, Tihany, Hungary)

Pc2-3 Pulsations are studied at the meridional magnetometer chain MM110, in the F-layer of the ionosphere at CHAMP satellite and at the geostationary orbit. Ionospheric pulsations are characterized by high, in comparison with ground measurements, contribution of high (≥ 0.1 Hz) frequencies. The cross-spectral analysis of CHAMP, GOES and ground data has shown that the observed disturbances are pulsations, but not the result of satellite pass through spatial structures in the ionosphere. Although the amplitudes of geomagnetic disturbances in this frequency range is low on the ground surface, a clear maximum in spectral coherence between CHAMP and MM100 signal is often seen simultaneously with Pc2-3 at CHAMP. The polarization of pulsations supports their Alfvén nature. An effective ionospheric screening at small transversal scales leads to low amplitudes of these pulsations on the ground.

Sub-oval proton aurora spots: Mapping relatively to plasma-pause

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

Sub-oval proton auroras discovered from IMAGE spacecraft correlate with EMIC waves (geomagnetic pulsations of the Pc1 range). This means the common source of the waves and proton precipitation is the ion-cyclotron (IC) instability developing in the vicinity of the equatorial plane. Different forms of the proton auroras reflect different regimes of the IC instability and different conditions in the near-Earth equatorial magnetosphere. To understand what are the conditions for generation of the sub-oval proton aurora one may map the aurora onto equatorial plane and compare with position of some important magnetospheric boundaries. In this report we perform a comparison between the projection of so-called "proton aurora spots" with location of plasmopause. The latter is determined using the plasmopause

formation model based on quasi-interchange instability mechanism. The comparison suggests that often the proton aurora spot source is situated in the vicinity of the plasmopause or cold plasma gradient inside the plasmopause. In some events the proton aurora spots map well outside the plasmopause. We assume that in latter case the IC instability develops when the westward drifting energetic protons interact with the cold plasma tubes detached from plasmasphere.

Location of the ion-cyclotron instability region relatively to plasmopause during magnetospheric compressions

Yahnin, A., Yahnina, T., Popova, T. (Polar Geophysical Institute, Apatity, Russia); Frey, H. (Space Sciences Laboratory, University of California, Berkeley, California, USA); and Pierrard, V. (Belgian Institute for Space Aeronomy, Brussels, Belgium)

Compression of the magnetosphere by a jump of the solar wind dynamic pressure produces, among other consequences, a large-scale dayside precipitation of energetic protons responsible for sub-oval proton aurora flashes. These flashes are related to a sudden appearance of geomagnetic pulsations in the Pc1 range. Both proton precipitation (proton aurora) and Pc1 manifest the development of the ion-cyclotron instability in the equatorial plane of the magnetosphere. To explore the magnetospheric domain where the instability develops we combined the projection of the equatorial edge of the proton aurora flashes observed by the IMAGE spacecraft and plasmopause location. The latter was determined using the plasmopause model. It was shown that during magnetospheric compression an ion-cyclotron interaction mostly occurs outside plasmasphere. It was also found that the location of the Earthward edge of the ion-cyclotron instability region as well as the distance between this edge and plasmopause depends on preceding geomagnetic activity. During stronger geomagnetic activity the ion-cyclotron instability region tends to locate closer to the Earth and plasmopause.

Unusual sub-oval proton aurora occurred on 10 and 11 November 2004: Image of plasmopause

Yahnin, A., Yahnina, T. (Polar Geophysical Institute, Apatity, Russia); and Soraas, F. (University of Bergen, Norway)

During interval of 01-03 UT on 10 November 2004 an unusual "proton aurora" (emission of the excited hydrogen atoms generated by precipitating magnetospheric protons after charge-exchange with atmospheric constituents) was observed from the IMAGE spacecraft well equatorward of the auroral oval. This was a narrow arc of "proton" luminosity situated at $L = 2.5$ and $MLT = 23 - 06$. Localized precipitation of energetic (E30 keV) protons was observed by the NOAA POES satellite above the arc. At the end of considered interval the arc broke into separate spots. For this case the plasmopause position was found using the model, which is based on the quasi-interchange mechanism of the plasmopause formation and depends on the history of magnetospheric electric field variations. This position fairly well agrees with the location of the proton arc. During interval of 06-09 UT on 11 November 2004 an arc-like structure formed from several proton aurora spots was also observed. In the morning sector this structure was at $L=2.5$, and it jumps to $L=4$ in the pre-noon sector. This agrees with the form of the modeled plasmopause, which exhibits a pre-noon "shoulder". As known, sub-oval proton auroras are the result of interaction of the ring current protons with ion-cyclotron waves. Relationship between the arc-like proton aurora structures and plasmopause agrees with suggestion that favorable conditions for the ion-cyclotron instability occur at the cold plasma gradient (plasmopause). This means that observation of sub-oval proton auroras can be used for monitoring the plasmopause.

Dynamics of the localized precipitation of energetic protons during geomagnetic storm

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

Localized precipitation of energetic (E30 keV) protons (LPEP), which is observed equatorward of isotropy boundary, is the result of interaction between ring current protons and ion-cyclotron waves, and mark the field lines where the interaction exists. The ion-cyclotron

waves also precipitate relativistic electrons from the radiation belt. Thus, LPEPs can be used for monitoring and investigation of the ring current / radiation belt losses. Using data from three low-orbiting NOAA POES satellites we considered the dynamics of LPEPs during a strong magnetic storm (Dst = -473 nT at 19 UT on 20 November 2003). The highest proton flux was observed during the main and early recovery phases. The flux decreased monotonically in a course of the recovery phase. During the main phase and half a day after the Dst minimum, LPEPs of type 2 (those associated with low energy (E20 keV) proton precipitation) were generally observed. They occupied almost all MLTs and were located at low latitudes. Distinct transition from LPEPs of type 2 to LPEPs of type 1 (containing only 30 keV protons) appeared in a day after Dst minimum. During the early recovery phase LPEPs were concentrated in the morning sector. Later, they were observed mainly around noon and shifted to higher latitudes. We modeled plasmopause position at different stages of the storm and found that most LPEPs tend to locate in the vicinity of plasmopause. However, at the end of the recovery phase some LPEPs appeared on the dayside at high latitudes well outside the plasmopause. We conclude that the intense cyclotron interaction of waves and particles during magnetic storm occurs at the cold plasma gradients. At later stage of the storm recovery the interaction seems to be not related with plasmopause. Probably, it is due to increased transversal anisotropy of hot protons at higher latitudes on the dayside, which results from drift shell splitting of particles having different pitch-angles and drifting from night side to dayside in non-dipole magnetic field.

Long-lasting proton aurora on the dayside

*Yahnina, T.A., and Yahnin, A.G. (Polar Geophysical Institute, Ap-
atity, Russia)*

From the analysis of the IMAGE FUV instrument images we found a new (not described yet) type of sub-oval proton aurora on the dayside. This aurora occurs during relatively quiet geomagnetic conditions and at relatively high latitudes in close relation with ground observations of geomagnetic pulsations Pc1. The later means that both auroras and pulsations are the result of the IC instability of the near-Earth plasma. Comparison with measurements onboard LANL spacecraft

shows that the instability does not relate with the enhanced cold plasma, that is, the instability develops outside plasmasphere. The lack of the cold plasma explains the fact that related Pc1 frequency is always above equatorial gyrofrequency of He⁺ at latitude of the proton auroras. We conclude that this aurora is the result of the increased anisotropy of energetic ring current protons drifting around the Earth. The anisotropy increases in the day sector due to effect of the drift shell splitting.

Verification of empirical and theoretical models of the lower ionosphere under the minimum of solar activity and under the solar X-ray flares

Yakymenko, K.N., and Lyakhov, A.N. (Institute of Geospheres Dynamics RAS, Moscow, Russia)

Verification of empirical (IRI, Danilov-Smirnova and Long-Wave Prediction Model) and theoretical (24-component model of the D-layer and middle atmosphere developed in the Institute of Geospheres Dynamics RAS) models was evaluated by means of the Long-wave Prediction Capability (LWPC) code. Experimental data were presented by the absolute calibrated measurements of the electric field strength from European VLF-LF transmitters at "Mikhnevo" geophysical observatory (IDG RAS, Moscow Region) as well as by relative magnetic measurements at the A118 sudden ionosphere disturbances monitor station at France. The measurements and validation cover the range from 18 to 77 kHz, thus allowing the probing of the whole lower ionosphere.

The given data cover the range from October 2007 up to nowadays. Verification was evaluated for the permutation of seasons and sunlit conditions (day, night and two scenarios of the pass through the terminator, namely from night to day and the opposite one). Validation under the solar X-ray flares uses the principally new technique for the calculation of ionization rates in the middle atmosphere by the solar X-rays.

The results are presented that qualitatively the IRI empirical model is the most suitable for the undisturbed conditions. Validation under the solar flares proves that it is necessary to improve the schemes of the ionization and recombination processes of the middle atmosphere

chemistry as well as include the dynamical and wave processes into the theoretical model explicitly.

We also discuss the principal possibility to study some aspects of the solar-terrestrial physics by means of the regional and world-wide VLF-LF monitoring.

Simulation of magnetic surges to the poles during the solar cycles 21–23

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

The method of reconstruction of poleward magnetic field surges from sunspot impulses in terms of point density distribution is performed. Difference of latitudinal positions between distributions of leading and trailing spots is defined by means of latitudinal segregation, derived from tilt angle. Algebraic difference between distributions of leading and trailing spots defines unbalanced surplus. Due to time-latitude geometry of distributions, the surplus from leading spots is weaker with respect to the same for trailing spots. Modelling is performed without parameter of effective diffusion. That is why there is no annihilation of old polarity through the equator. That is a key difference from the classical dynamo mechanism, which is nonworking in presence of only the meridional flow without supergranular diffusion. We suggest that the diffusion role is to decay active regions and decrease poleward magnetic streams. In other words diffusion is effective on less than supergranular scale. In our approach the meridional flow plays the pole of transport to drift unbalanced flux of both trailing and leading polarities toward solar poles. Relative orientations of impulses, their latitudinal location, and shape and intensity as well meridional flow velocity define appearing of old polarity surges or its absence.

Disturbances of plasma parameters at geostationary orbit accompanied by deep early decrease in subauroral F2 layer critical frequency: Yakutsk observatory (62.02°N, 129.72°E), May–June, 2003

Zolotukhina, N.A., Polekh, N.M., and Chelpanov, M.A. (Institute of Solar-Terrestrial Physics, Irkutsk, Russia)

Variations in the F2 layer critical frequency observed at Yakutsk subauroral ionospheric station in May-June 2003 are analyzed. Twenty days are selected according to following criteria: 1 – the diurnal foF2 maximum followed by foF2 decrease occurred earlier than that in quiet days; 2 – the minimal foF2 ≤ 3 MHz. For these days variations in the magnetospheric convection field and plasma parameters at geostationary orbit are studied. Data used were obtained aboard geosynchronous LANL 1994 satellite 16° to the east of the ionospheric station. It is shown that in 10 cases a deep early decrease in foF2 developed in the days of enhancement magnetospheric convection, increase in magnetospheric ion and electron temperatures and lowering of their temperature anisotropy up to zero and negative values. In these cases the beginning of a sharp decrease in foF2 coincided within half an hour with a start of electron temperature increase at geostationary orbit. In two cases a deep early decrease in foF2 was observed during the main phase and at maxima of moderate magnetic storms after magnetospheric convection field reducing and decrease in magnetospheric electron temperature. The results confirm the existence of a causal relation between an expansion of the plasma sheet towards the Earth, a progress of the main ionospheric trough towards the equator and a sharp decrease in the critical frequency of the subauroral F2 layer revealed earlier from the ground-based and low-altitude satellite data.

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Dayside auroras and auroral precipitation

Zverev, V.L., Vorobjev, V.G. (*Polar Geophysical Institute, Apatity, Russia*); Feldstein, Y.I. (*Institute of Terrestrial Magnetism, Ionosphere and Propagation of Radio Waves, Troitsk, Russia*)

The optical observations from Barentsburg ($\Phi' = 75.2^\circ$, MLT = UT + 2.4), and simultaneous precipitating particles observations with DMSP F12–F16 spacecraft for 23 events during 2000–2005 years were used for the investigation of correlation of the dayside auroras and precipitating particle structure. Several events were examined in detail when spacecraft orbits intersect auroral forms, observed with the meridional scanning photometer (MSP), or passed within the field of view of the all-sky TV-camera. The results of examination indicated that in most events the highest latitudes along the trajectories were limited by latitudes of LLBL region, At this events positions of dayside discrete auroral forms are connected with the precipitating particles of LLBL regions, identifying that the source of arcs generation is on the closed geomagnetic field lines. There were some events when precipitating particles were identified on APL Internet pages as cusp regions. Differential spectra of precipitating particles of LLBL and cusp regions in these events are very similar: with a spectral peak in the ions of about $0.9 \div 1$ keV, and an average electron energy of $100 \div 300$ eV. For instance: on January 06, 2001 at 08:38:40 UT (LLBL) the energy flux of electrons (JE) was $7.71e+10$ eV cm⁻²s⁻¹sr⁻¹ and average energy (Avg E) $1.16e+02$ eV; energy flux of ions (JE) was $1.88e+10$ eVcm⁻²s⁻¹sr⁻¹ and average energy (Avg E) $7.91e+02$ eV. At 08:39:10 UT (cusp) the energy flux of electrons (JE) was $6.71e+10$ eV cm⁻²s⁻¹sr⁻¹ and average energy (Avg E) $9.57e+01$ eV; energy flux of ions (JE) was $3.53e+10$ eV cm⁻²s⁻¹sr⁻¹ and average energy (Avg E) $7.37e+02$ eV.

Author Index

Afremov Leond

Far-Eastern Federal University, 690950, Vladivostok, Russia
e-mail: afremovl@mail.dvgu.ru,
25, 26

Alva-Valdivia Luis Manuel

Universidad Nacional Autónoma de México, México, Mexico
e-mail: lalva@geofisica.unam.mx,
26

Amariutei Olga

Finnish Meteorological Institute, Erik Palmenin aukio 1, FI-00560, Helsinki, Finland
e-mail:
olga.amariutei@fmi.fi, **141**

Artamonova Irina

St.Petersburg State University, Earth's Physics Department, Ulyanovskaya str. 1, 198504, St.Petersburg, Russia
e-mail: artirin@yandex.ru, **141**

Assinovskaya Bela

Geophysical Services RAS seismic station Pulkovo, Pulkovskoye shosse 65, 196141, St. Petersburg, Russia
e-mail: belaa@gao.spb.ru, **86**

Astapenko Valentin

Belarussian Research Geological Exploration Institute, Kuprevich str., 7, 220141, Minsk, Belarus
e-mail:

astapenko@geology.org.by, **9**

Avakyan Sergei

All-Russian Scientific Center

S.I. Vavilov State Optical Institute; Central (at Pulkovo) Astronomical Observatory of RAS, St. Petersburg, Russia
e-mail: avak2@mail.ru, **142, 143**

Babak Valeriya

S.I. Subbotin Institute of Geophysics NAS of Ukraine, 32, Academician Palladin Ave., 03142, Kiev, Ukraine
e-mail: Baba4onok@bigmir.net, **112**

Badin Vladimir

Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation RAS, Troitsk, Moscow Region, 142190, Russia
e-mail: badin@izmiran.ru, **144, 159, 228**

Bagaeva Marina

Saratov State University, Astrakhanskaya, 83, 410012, Saratov, Russia
e-mail: bagaevami@rambler.ru, **27**

Balikhin Michael

University of Sheffield, Sheffield, Great Britain
e-mail: m.balikhin@gmail.com, **145**

Barabash Vladimir

Institute of Ionosphere, Institute of Ionosphere, Ukraine, Kharkiv, Krasnoznamennaya st. 16, 61002, Kharkiv, Ukraine
e-mail: Barabash_VV@ukr.net,

- 145**
Batalev Vladislav
Bishkek-49 Research station,
720049, Bishkek, Kyrgyzstan
e-mail: batalev@gdirc.ru, **9**,
10
- Belakhovsky Vladimir
Polar Geophysical Institute,
Academgorodok, 26a, 184209,
Apatity, Russia
e-mail: belakhov@mail.ru, **147**,
148
- Belashev Boris
Institute of geology of Kare-
lian Research Centre of RAS,
Pushkinskaya st. 11, 185910,
Petrozavodsk, Russia
e-mail: belashev@krc.karelia.ru,
29
- Belokon Valery
Far Eastern Federal Univer-
sity, 8, Sukhanova str., 690950,
Vladivostok, Russia
e-mail: belokon@sns.dvfu.ru,
30
- Beloushko Konstantin
Murmansk State Technical Uni-
versity, Sportivnaya st., 13,
183010, Murmansk, Russia
e-mail: beloushko@mail.ru,
148
- Benevolenskaya Elena
Pulkovo Astronomical Obser-
vatory, Pulkovskoe sh.65, 196140,
St. Petersburg, Russia
e-mail: benevolenskaya@mail.ru,
5
- Bessarab Fedor
Western Department of IZMI-
RAN, Kaliningrad, Pobedy
av., 41, Kaliningrad, Russia
e-mail: bessarabf@gmail.com,
149, **182**
- Blagoveshchenskaya Elena
SPbF IZMIRAN, Universitet-
skaya nab., 5, 199034,
St.Petersburg, Russia
e-mail: elblag77@gmail.com,
113
- Bolshakov Vyacheslav
Moscow State University, Moscow,
Russia
e-mail: vabolshakov@mail.ru,
31, **150**
- Bondareva Tatiana
St.Petersburg State Univer-
sity, Ulianovskaya 1, 198504,
St. Petersburg, Russia
e-mail: b.ndareva@gmail.com,
150
- Borisova Tatiana
Arctic and Antarctic Research
Institute, Bering Str., 38,
St.Petersburg, Russia
e-mail: borisova@aari.ru, **151**
- Botova Maria
Murmansk State Technical Uni-
versity, Sportivnyay St., 13,
183010, Murmansk, Russia
e-mail: botovamg@gmail.com,
152
- Chauhan Vishal
Department of Physics, Fac-
ulty of Engineering and Tech-
nology, R.B.S. College, Bich-
puri, Agra-283105, India
e-mail:
vishalparam84@gmail.com, **114**
- Chelpanov Maksim
Institute of Solar-Terrestrial
Physics, Irkutsk, Russia
e-mail: max_chel@list.ru, **254**

- Cherneva Nina
Institute of Cosmophysical Research and Radio Wave Propagation, Kamchatka, 684034 Kamchatka region, Elizovskiy district, Paratunka, Mirnaya str., 7, Russia
e-mail: nina@ikir.ru, **115, 154**
- Cherniak Iurii
West Department of IZMIRAN, Kaliningrad, Russia
e-mail: tcherniak@ukr.net, **115**
- Chernogor Leonid
V. Karazin Kharkiv National University, Kharkiv, 4 Svoboda Square, 61022, Ukraine
e-mail: Leonid.F.Chernogor@univer.kharkov.ua, **156, 157**
- Chernyaev Ivan
St.Petersburg State University, St. Petersburg, Russia
e-mail: ivan.a.chernyaev@gmail.com, **159**
- Chuiiko Daniil
Institute of Solar-Terrestrial Physics, Irkutsk, Russia
e-mail: ninesmartcats@yahoo.com, **204**
- Danukalov Konstantin
Institute of Geology USC RAS, Ufa, Russia
e-mail: danukalov@mail.ru, **28**
- Demekhov Andrei
Institute of Applied Physics RAS, Nizhny Novgorod, 46 Ulyanov st., 603950, Nizhny Novgorod, Russia
e-mail: andrei@appl.sci-nnov.ru, **160**
- Demina Irina
SPbF IZMIRAN, Mendeleevskaya, 1, 199034, St. Petersburg, Russia
e-mail: dim@izmiran.spb.ru, **31**
- Denisenko Valery
Institute of Computational Modelling, Krasnoyarsk, Russia
e-mail: denisen@icm.krasn.ru, **116, 117**
- Dergachev Valentin
Ioffe Physical-Technical Institute of RAS, Politekhnikeskaya str., 26, 194021, St.Petersburg, Russia
e-mail: v.dergachev@mail.ioffe.ru, **32**
- Despirak Irina
Polar Geophysical Institute, Apatity, Akademgorodok 26a, 184209, Apatity, Russia
e-mail: despirak@gmail.com, **246**
- Dolotov Andrey
Borok Geophysical Observatory, Institute of Physics of the Earth RAS, Borok, Yaroslavl region, Russia, 152742, Borok, Russia
e-mail: adolotov@bk.ru, **37**
- Dovbnaya Boris
Borok Geophysical Observatory, IPHE RAS, Yaroslavl region, 152742, Borok, Russia
e-mail: dovbnaya@inbox.ru, **163**
- Dubyagin Stepan
St.Petersburg State University, St. Petersburg, Russia

- e-mail: stepan@geo.phys.spbu.ru, **164**
Dvorova Ariadna
Geological Institute RAS,
Pyzhevsky, 7, Moscow, Russia
e-mail: a_dvorova@mail.ru, **33**
Dyadechkin Sergey
Finnish Meteorological Institute (FMI), Helsinki, Finland
e-mail: Sergey.Dyadechkin@fmi.fi, **165**
Eftaxias Konstantinos
National and Kapodistrian University of Athens, Dept. of Physics, Panepistimiopolis, GR-15784, Zografos, Athens, Greece, tel.: +302107276733, e-mail: ceftax@phys.uoa.gr, **118**
Erkaev Nikolai
Institute of Computational Modelling, Krasnoyarsk, Russia
e-mail: erkaev@icm.krasn.ru, **166**
Ermakova Elena
Radiophysical Research Institute, B. Pecherskaya str. 25/12a, 603950, Nizhny Novgorod, Russia
e-mail: l.ermakova@nirfi.sci-nnov.ru, **167**
Fabian Karl
Geological Survey of Norway, Trondheim, Norway
e-mail: karl.fabian@ngu.no, **33**
Fetisova Anna
Moscow State University, Moscow, Russia
e-mail: anna-fetis@ya.ru, **34**
Fokin Ilya
Institute of Physics of the Earth RAS, Moscow, Russia
e-mail: fokin.ilya@gmail.com, **87**
Fukuma Koji
Doshisha University, Tatara-Miyakodani 1-3, 610-0394, Kyotoanabe, Japan
e-mail: kfukuma@mail.doshisha.ac.jp, **35**
Ganushkina Natalia
Finnish Meteorological Institute, Helsinki, Finland, POBox 503, FIN-00101, Helsinki, Finland
e-mail: Natalia.Ganushkina@fmi.fi, **168**
Gendler Tatiana
Institute of Physics of the Earth RAS, B. Gruzinskaya, 10, Moscow, 123995, Russia
e-mail: gendler06@mail.ru, **42**
Gilmanova Dilyara
Kazan (Volga Region) Federal University, 4/5 Kremlyovskaya St., 420008, Kazan, Russia
e-mail: Di-Gilmanova@yandex.ru, **36**
Gizatullina Zulfiya
Kazan Federal (Volga Region) University, Kazan, Russia
e-mail: Zulechka_@bk.ru, **59**
Gladysheva Olga
Ioffe Physical-Technical Institute of RAS, Politekhnicheskaya 26, 194021, St. Pe-

- tersburg, Russia
e-mail: Olga.Gladysheva@mail.ioffe.ru, **119**
- Gnibidenko Zinaida
Trofimuk Petroleum Institute
Geology and Geophysics of
Siberian Branch of RAS, av.
Academician Koptuyge, 3 ,
630090, Novosibirsk, Russia
e-mail: gnibidenkozn@ipgg.nsc.ru, **36**
- Gordeev Evgeny
St.Petersburg State University, St. Petersburg, Russia
e-mail: evgeniy_gordeev@yahoo.com, **169**
- Gorshkov Victor
Central (Pulkovo's) astronomical
observatory of RAS, St.
Petersburg, St. Petersburg,
Russia
e-mail: vigor@gao.spb.ru, **88**
- Gravirov Valentin
Institute of Earthquake Prediction Theory and Mathematical Geophysics, Moscow
117997, Russia
e-mail: gravirov@rambler.ru, **89**
- Grib Sergey
Central (Pulkovo) Astronomical Observatory, 196140, St. Petersburg, Russia
e-mail: sagrib@gmail.com, **169**
- Gromova Lujdmila
Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation RAS,
Troitsk, Moscow Region, Russia
e-mail: gromova@izmiran.ru, **197**
- Gurary Garry
Geological Institute RAS,
Pyzhevsky per. 7, 119017,
Moscow, Russia
e-mail: palmagmax@mail.ru, **38**
- Guskova Elena
SPbF IZMIRAN, Muchnoy
per. 2, 191023, St.-Petersburg,
Russia
e-mail: oleg@or6074.spb.edu, **39**
- Guzhikov Andrey
Saratov State University, Astrakhanskaya, 83, 410012, Saratov, Russia
e-mail: aguzhikov@yandex.ru, **39**
- Hachay Olga
Institute of Geophysics UB
RAS, Amunsen str.100, 620016,
Ekaterinburg, Russia
e-mail: olgakhachay@yandex.ru, **120**
- Honkonen Ilja
Finnish Meteorological Institute, P.O.Box 503, 00101, Helsinki, Finland
e-mail: ilja.honkonen@fmi.fi, **170**
- Ievenko Igor
Yu. G. Shafer Institute of Cosmophysical Research and Aeronomy, Yakutsk, 31 Lenin Ave., 677980, Russia
e-mail: ievenko@ikfia.ysn.ru, **171, 172**

- Il'chenko Vadim
Geological Institute of the Kola
Science Centre of RAS, Apatity, Russia
e-mail: vadim@geoksc.apatity.ru, **89, 90**
- Iosifidi Alexandr
All-Russia Petroleum Research
Exploration Institute, Liteyny
ave. no. 39, 191014, Saint-Petersburg, Russia
e-mail: iosifidi@km.ru, **40**
- Isavnin Alexey
University of Helsinki, Helsinki, Finland
e-mail: alexey.isavnin@helsinki.fi, **173**
- Ismaguilov Valery
St.Petersburg Department of IZMIRAN, St. Petersburg, Russia
e-mail: ivs@izmiran.spb.ru, **124**
- Ivanov Sergey
Institute of Terrestrial Magnetism, Ionosphere and Radiowave Propagation, Mendeleevskaya, 1, St. Petersburg, Russia
e-mail: sergei.a.ivanov@mail.ru, **41**
- Ivanova Irina
Arctic and Antarctic Research Institute, St. Petersburg, Saint-Petersburg, Russia
e-mail: reapply@yandex.ru, **174**
- Kalegaev Vladimir
Skobeltsyn Institute of Nuclear Physics, Moscow State University, Moscow, Russia
e-mail: klg@dec1.sinp.msu.ru, **174**
- Kanunikov Igor
St. Petersburg State University, St. Petersburg, Russia
e-mail: igorkan@mail.ru, **175**
- Karimov Farshed
Institute of Geology, Earthquake Engineering and Seismology AS RTajikistan, Ajini str., 267, 734063, Dushanbe, Tajikistan
e-mail: seismtadj@rambler.ru, **43, 121**
- Karpov Mikhail
Murmansk State Technical University, Murmansk, Russia
e-mail: mikhailkarpov@hotmail.com, **122**
- Katkalov Juri
Polar Geophysical Institute, Apatity, Russia
e-mail: work@katkalov.com, **177**
- Kazansky Alexey
Trofimuk Institute of Petroleum Geology and Geophysics SB RAS, Academic Koptyug ave., 3, 630090, Novosibirsk, Russia
e-mail: kazanskyay@ipgg.nsc.ru, **44**
- Kharitonov Andrey
Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation RAS (IZMIRAN), Moscow region, Troitsk, 142190, Russia
e-mail: ahariton@izmiran.ru, galina@izmiran.ru, **123, 178, 179**
- Kharytonova Sofia

- Institute of Ionosphere, Kharkiv, Ukraine
e-mail: sophiaharytonova@gmail.com, **155**
- Khramov Alexey
All-Russia Petroleum Research Exploration Institute, Liteyny ave. no. 39, 191014, St.Petersburg, Russia
e-mail: vtomsha@mail.ru, **45**
- Kiselev Yurii
St.Petersburg State University, Ul'yanovskaya str., 1, Petergof, St. Petersburg, 198504, Russia
e-mail: kiselev@jk6907.spb.edu, **96**
- Kislov Konstantin
Institute of Earthquake Prediction Theory and Mathematical Geophysics (IEPT RAS), Belovezhskaya ul. 17-19, 121353, Moscow, Russia
e-mail: kvkislov@yandex.ru, **92**
- Kislov Roman
Space Research Institute, Moscow, Russia
e-mail: kr-rk@bk.ru, **180**
- Klain Boris
Institute of Physics of the Earth RAS, Moscow, Borok Geophysical Observatory, Borok, Yaroslavl, Nekouz, 152742, Russia
e-mail: klain@borok.yar.ru, **163, 164**
- Klebanova Yulia
Institute of Solar-Terrestrial Physics, Siberian Branch of RAS, Irkutsk, Russia
e-mail: malozemova81@mail.ru, **180**
- Kleimenova Natalia
Institute of Physics of the Earth RAS, Moscow, 10, B.Gruzinskaya, 123995, Moscow, Russia
e-mail: kleimen@ifz.ru, **181**
- Klymkovych Tamara
Carpathian Branch of Subbotins Geophysical Institute, 3-b, Naukova St., 79060, Lviv, Ukraine
e-mail: tamara@cb-igph.lviv.ua, **123**
- Kodama Kenneth
Lehigh University, Department of Earth and Environmental Sciences, 1 West Packer Ave, 18015, Bethlehem, USA
e-mail: kpk0@lehigh.edu, **46**
- Koleva Rositza
Space Research and Technologies Institute, Bulgarian Academy of Sciences, Acad. G. Bonchev, Block 1, 1113, Sofia, Bulgaria
e-mail: rkoleva@stil.bas.bg, **183**
- Kolotkov Dmitry
Sarov Institute for Physics and Technology National Research Nuclear Institute, Sarov, Russia
e-mail: molotok300@gmail.com, **184**
- Kopnin Sergey
Institute for Dynamics of Geospheres RAS, Leninsky pr. 38, bld. 1, 119334, Moscow, Russia
e-mail: serg_kopnin@mail.ru,

- 184, 185**
Korneyko Anastasiya
Moscow State University, Moscow, Russia
e-mail: worldofnastasiya@mail.ru, **48**
- Kornilov Ilya
Polar Geophysical Institute, Apatity, Polar Geophysical Institute, Academgorodok Str., 26A, 184209, Apatity, Russia
e-mail: kornilov@pgia.ru, **186**
- Kornilova Tatyana
Polar Geophysical Institute, Apatity, Polar Geophysical Institute, Academgorodok Str., 26A, 184209, Apatity, Russia
e-mail: kornilova@pgia.ru, **187**
- Korovinskiy Daniil
Space Research Institute, Austrian Academy of Sciences, Graz, Austria
e-mail: daniil.korovinskiy@gmail.com, **187**
- Kosareva Lina
Kazan (Volga Region) Federal University, 4/5 Kremlyovskaya St., 420008, Kazan, Russia
e-mail: Lina.Kosareva@ksu.ru, **49**
- Kotik Dmitry
Radiophysical Research Institute, B. Pecherskaya str., 25/12a, 603950, Nizhny Novgorod, Russia
e-mail: dmitry.kotik@nirfi.sci-nnov.ru, **188**
- Kotov Dmitry
Institute of Ionosphere, Kharkiv, Ukraine
e-mail: dmitrykotoff@gmail.com, **162**
- Kovalevsky Joseph
Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation RAS, Troitsk, Moscow region, 142190, Russia
e-mail: jkoval@izmiran.ru, **189**
- Kovtun Aida
St.Petersburg State University, St. Petersburg, Russia
e-mail: aakovtun@mail.ru, **11, 12**
- Kozelov Boris
Polar Geophysical Institute, Apatity, Murmansk region, Russia
e-mail: Boris.Kozelov@gmail.com, **190, 191**
- Kozlov Daniil
Institute of Solar-Terrestrial Physics, Irkutsk, Russia
e-mail: kozlov-da@iszf.irk.ru, **192**
- Kozlova Alexandra
St. Petersburg State University, St.Petersburg, Russia
e-mail: fev83@rambler.ru, **13**
- Kozyreva Daria
Moscow State University, Moscow, Russia
e-mail: kozdasha@mail.ru, **49**
- Kozyreva Olga
Institute of Physics of the Earth RAS, Moscow, B.Gruzinskaya, 10, 123995, Moscow, Russia
e-mail: kozyreva@ifz.ru, **177, 192, 204**
- Krishtopov Anton

- St.Petersburg State University, 198504, St. Petersburg, Russia
e-mail: antonybruin@gmail.com, **193**
- Kropotkin Alexey
D.V. Skobeltsyn Nuclear Physics Institute, Moscow State University, 119991, Moscow, Russia
e-mail: apkrop@dec1.sinp.msu.ru, **194**
- Kruglov Aleksandr
St.Petersburg State University, 7-9, Universitetskaya nab., 199034, St.Petersburg, Russia
e-mail: kruglov@aari.ru, **195**
- Kubyshkina Daria
St.Petersburg State University, St.Petersburg, Russia
e-mail: kubyshkina.darya@gmail.com, **196**
- Kurazhkovskii Alexandr
Institute of Physics of the Earth RAS, Moscow; Borok Geophysical Observatory, Borok, Yaroslavl, Nekouz, 152742, Russia
e-mail: ksasha@borok.yar.ru, **50**
- Kushnir Anton
S.I.Subbotin Institute of Geophysics, NAS of Ukraine, 32 Palladin Avenue, 03680, Kyiv, Ukraine
e-mail: Antonn@ukr.net, **14**
- Kuskov Oleg
Vernadsky Institute of Geochemistry and Analytical Chemistry, Kosygin Str. 19, 119991, Moscow, Russia
e-mail: ol_kuskov@mail.ru, **92**
- Larionov Igor
Institute of Cosmophysical Research and Radio Wave Propagation FEB RAS, Kamchatka, Kamchatsky kray, Elizovsky raion, s.Paratunka, Mirnaya 7, 684034, Russia
e-mail: igor@ikir.ru, **93**
- Lementueva Rita
Institute of Physics of the Earth RAS, Moscow, Russia
e-mail: treussov@ifz.ru, **94**
- Levicheva Aleksandra
Trofimuk Institute of Petroleum Geology and Geophysics SB RAS, Koptyug. 3, 630090, Novosibirsk, Russia
e-mail: Levicheva-aleksa@mail.ru, **51**
- Levitin Anatoly
Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation RAS, Troitsk, Moscow region, Russia
e-mail: levitin@izmiran.ru, **197**
- Liubchich Andris
Polar Geophysical Institute, Apatity, Akademgorodok 26a, 184209, Apatity, Russia
e-mail: lubchich@pgia.ru, **161**
- Lunyushkin Sergey
Institute of Solar-Terrestrial Physics, SB RAS, Irkutsk, Russia
e-mail: lunyushkin@iszf.irk.ru, **146, 198, 199**
- Lyakhov Andrey
Institute of Geospheres Dynamics RAS, Moscow, Leninskij pr-kt 38, korp.1, 119334,

- Moscow, Russia
e-mail:
alyakhov@idg.chph.ras.ru, **200**
- Lyashenko Mikhail
Institute of Ionosphere, NAS
and MESYS of Ukraine, Kras-
noznamenaya str., 16, 61002,
Kharkov, Ukraine
e-mail: mlyashenko@ya.ru, **154**
- Maksymchuk Valentyn
Carpathian Branch of Sub-
botins Geophysical Institute,
3-b, Naukova St., 79060, Lviv,
Ukraine
e-mail:
vmaksymchuk@cb-igph.lviv.ua,
126
- Malakhov Mikhail
Shilo North-East Interdisci-
plinary Scientific Research In-
stitute FEB RAS, Magadan,
Russia
e-mail: malakhov@neisri.ru,
52
- Malakhova Galina
Shilo North-East Interdisci-
plinary Scientific Research In-
stitute FEB RAS, Magadan,
Russia
e-mail: malakhov@neisri.ru,
53
- Malova Helmi
Skobeltsyn Institute of Nu-
clear Physics, Moscow State
University, Moscow, Russia
e-mail: hmalova@yandex.ru,
201
- Malysheva Liudmila
Institute of Physics of the Earth
RAS, Moscow, B.Gruzinskaya,
10, 123995, Moscow, Russia
e-mail: mlm60@yandex.ru, **182**
- Matasova Galina
Trofimuk Institute of Petroleum
Geology and Geophysics SB
RAS, Koptug ave, 3, 630090,
Novosibirsk, Russia
e-mail: matasovagg@ipgg.nsc.ru,
54
- McEnroe Suzanne
Dept. Geology and Mineral
Engineering, NTNU, Sem Sæ-
lands veg 1, N-7491, 7041,
Trondheim, Norway
e-mail:
suzanne.mcenroe@ntnu.no, **55**
- Melnyk Galina
Institute of Geophysics by S.I.
Subbotina, Ukrainian Academy
of Sciences, Kiev, Ukraine
e-mail: oimkv@list.ru, **201**
- Mezentsev Alexander
Siberian Federal University,
Krasnoyarsk, Russia
e-mail: 2412298@rambler.ru,
205
- Mihailova Victoria
All-Russia Petroleum Research
Exploration Institute, Liteyny
ave. no. 39, 191014, St.Petersburg,
Russia
e-mail: vtomsha@mail.ru, **56**
- Mingalev Victor
Polar Geophysical Institute,
Apatity, Russia
e-mail: mingalev@pgia.ru, **206**
- Mingaleva Galina
Polar Geophysical Institute,
Apatity, Russia
e-mail: mingalev@pgia.ru, **207**
- Minyuk Pavel
North-East Interdisciplinary

- Scientific Research Institute
FEB RAS, 16, Portovaya st.,
685000, Magadan, Russia
e-mail: minyuk@neisri.ru, **57,**
58
- Mironova Irina
St.Petersburg State University,
Ulyanovskaya 1, 198504,
St.Petersburg, Russia
e-mail: irini.mironova@gmail.com,
208
- Mishin Vladimir
Institute of Solar-Terrestrial
Physics, Irkutsk, Russia
e-mail: vladm@iszf.irk.ru, **209**
- Močnik Karl
Space Research Institute, Austrian
Academy of Sciences,
Schmiedlstrasse 6, 8042, Graz,
Austria
e-mail: karl.mocnik@oeaw.ac.at,
210
- Moroz Yuri
Institute of Volcanology and
Seismology FEB RAS, Piipa,9,
683006, Petropavlovsk-Kamchatsky,
Russia
e-mail: moroz@irk.ru, **14**
- Morozova Anna
Centro de Geofísica da Universidade
de Coimbra, Coimbra, Portugal,
Av. Dr. Dias da Silva, 3000-134,
Coimbra, Portugal
e-mail:
annamorozovauc@gmail.com,
210
- Moskaleva Elena
St.Petersburg State University,
St.Petersburg, Russia
e-mail: moelvi@mail.ru, **211**
- Moskovskaya Lyudmila
SPbF IZMIRAN, St. Petersburg,
Russia
e-mail: lf_mosc@mail.ru, **127,**
128
- Mozhaeva Natalia
Institute of Physics, Southern
Federal University, Stachki,
194, 344090, Rostov-on-Don,
Russia
e-mail: mozh_75@mail.ru, **202**
- Munirova Lira
Geophysical Survey Russian
Academy of Sciences, Seismic
station Pulkovo, Pulkovskoe
shosse 65 / 12, 196140, St.
Petersburg, Russia
e-mail: munirova@hotmail.com,
95
- Myagkova Irina
Skobel'syn Institute of Nuclear
Physics, Moscow State
University, SINP MSU, 1(2),
Leninskie gory, GSP-1, 119991,
Moscow, Russia
e-mail: irina@srd.sinp.msu.ru,
211
- Namgaladze Alexander
Murmansk State Technical University,
Sportivnaya St., 13,
183010, Murmansk, Russia
e-mail: Namgaladze@yandex.ru,
129, 131
- Namozov Ilyas
St.Petersburg State University,
Saint-Petersburg, Russia
e-mail: i.namozov@list.ru, **15**
- Nikolaev Alexander
St.Petersburg State University,
St.-Petersburg, Russia
e-mail: demosfen.spb@gmail.com,

- 212**
Nikolaeva Vera
St.Petersburg State University, Ulianovskaya Street, 3, Petrodvorets, 198504, St. Petersburg, Russia
e-mail: vera_nik@list.ru, **213**
- Nikolskaya Kommunela
Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation RAS, Troitsk, Moscow region, Russia
e-mail: knikol@izmiran.ru, **214**
- Nosikova Natalia
National Research Nuclear University "MEPhI", 31, Kashirskoe road, 115409, Moscow, Russia
e-mail: natanosik@yandex.ru, **214, 217, 235**
- Novikov Victor
Joint Institute for High Temperatures RAS, Moscow, 13, bld.2, Izhorskaya str., 125412, Moscow, Russia
e-mail: novikov@ihed.ras.ru, **125, 130, 137**
- Orlov Sergey
Geological Institute RAS, Moscow, Russia
e-mail: nogik@mail.ru, **60**
- Ozel Oguz
Istanbul University, Engineering Faculty, Avcilar Campus, 34320, Istanbul, Turkey
e-mail: oguzozel@istanbul.edu.tr, **97**
- Panasenko Sergii
Institute of Ionosphere, Kharkiv, Krasnoznamenaya st., 16, Kharkiv, Ukraine
e-mail: s_p2004@mail.ru, **153**
- Parnikov Stanislav
Yu. G. Shafer Institute of Cosmophysical Research and Aeronomy, 31 Lenin Ave., 677980, Yakutsk, Russia
e-mail: parnikov_s.g@ikfia.ysn.ru, **172**
- Pashin Anatoly
Polar Geophysical Institute, Academgorodok 26a, Polar Geophysical Institute, 184209, Apatity, Murmansk region, Russia
e-mail: pashin@pgia.ru, **215**
- Pavlenkova Ninel
Institute of Physics of the Earth RAS, Moscow, B.Gruzinskaja 10, 123242, Moscow, Russia
e-mail: ninapav@mail.ru, **98, 99**
- Peskov Alexey
Kosygin Institute of Tectonics and Geophysics, FEB RAS, Kim-Yu-Chena, 65, 680000, Khabarovsk, Russia
e-mail: lesha-ogr-31@mail.ru, **61**
- Petrishchev Maxim
SPbF IZMIRAN, Muchnoi, 2, p.b. 88, 191023, St. Petersburg, Russia
e-mail: ms_petr@mail.ru, **16**
- Petrov Igor
St.Petersburg State University, St.Petersburg, Russia
e-mail: petrov39@mail.ru, **62, 63**
- Petrova Larissa
St.Petersburg State University, St.Petersburg, Russia

- sity, St.Petersburg, Russia
e-mail: gull1722@mail.ru, **100**
- Petrukovich Anatoly
Space Research Institute, Moscow,
Russia
e-mail: apetruko@iki.rssi.ru,
216
- Pilipenko Olga
Institute of Physics of the Earth
RAS, Bolshaya Gruzinskaya,
10, 123995, Moscow, Russia
e-mail: pilipenko@ifz.ru, **64,**
68
- Plotkin Valery
Institute of Petroleum Geol-
ogy and Geophysics SB RAS,
Novosibirsk, 3, Akademika Kopy-
tyuga Prosp., 630090, Novosi-
birsk, Russia
e-mail: plotkinvv@ipgg.nsc.ru,
17
- Polets Anastasia
Institute of Marine Geology
& Geophysics (IMGG) FEB
RAS, Russia, Nauki str. 1 b,
693002, Yuzhno-Sakhalinsk,
Russia
e-mail: polec84@mail.ru, **101**
- Popov Victor
All-Russia Petroleum Research
Exploration Institute, Liteyny
ave. no. 39, 191014, St.Petersburg,
Russia
e-mail: v_v_popov@yahoo.co.uk,
64-66
- Popova Olga
St. Petersburg State Uni-
versity, St. Petersburg, Russia
e-mail: olgapovspb@gmail.com,
218
- Potapov Alexander
Institute of Solar-Terrestrial
Physics, Irkutsk, 126A Ler-
montov street, 664033, Irkutsk,
Russia
e-mail: potapov@iszf.irk.ru,
219
- Potirakis Stylianos
Department of Electronics,
Technological Education In-
stitute (TEI) of Piraeus, 250
Thivon & P. Ralli, GR-12244,
Aigaleo, Athens, Greece, tel.:
+302105381550,
e-mail: spoti@teipir.gr, **118**
- Prostyakov Kirill
St.Petersburg State Univer-
sity, St. Petersburg, Russia
e-mail:
kprostyakov@gmail.com, **91**
- Ptitsyna Natalia
St.Petersburg Filial of Insti-
tute of Terrestrial Magnetism,
Ionosphere and Radio, St. Pe-
tersburg, Russia
e-mail:
nataliaptitsyna@yandex.ru, **219,**
220
- Pulinets Maria
Moscow State University, Moscow,
Russia
e-mail: cotopaxy@gmail.com,
221
- Pushkarev Pavel
Moscow State University, Lenin-
skie Gory 1, MSU, Faculty
of Geology, 119991, Moscow,
Russia
e-mail: pavel.pushkarev@list.ru,
17
- Pushkarev Yury
Institute of Precambrian Ge-

- ology and Geochronology, embankment Makarova 2, 199034, St. Petersburg, Russia
e-mail: ydcanon@rambler.ru, **67**
- Raspopov Oleg
St. Petersburg Filial of IZMI-RAN, St. Petersburg, Russia
e-mail: oleg@or6074.spb.edu, **69, 221, 222**
- Remenets Georgy
St. Petersburg State University, St. Petersburg, Russia
e-mail: nayada-meskalero@yandex.ru, **222**
- Rokityansky Igor
Institute of Geophysics, National Academy of Sciences of Ukraine, Palladin av. 32, 03680, Kiev, Ukraine
e-mail: rokityansky@gmail.com, **18**
- Roldugin Valentin
Polar Geophysical Institute, Apatity, Russia
e-mail: rold_val@pgia.ru, **224**
- Sakharov Yaroslav
Polar Geophysical Institute, Apatity, Russia
e-mail: work@katkalov.com, **225**
- Sal'naya Natal'ya
All-Russia Petroleum Research Exploration Institute, Liteyny ave. no. 39, 191014, St. Petersburg, Russia
e-mail: natasavi@inbox.ru, **70**
- Saltsberg Alexandra
St. Petersburg State University, St. Petersburg, Russia
e-mail: alexandrasalzberg@gmail.com, **19**
- Samsonov Andrey
St. Petersburg State University, St. Petersburg, Russia
e-mail: andre.samsonov@gmail.com, **225**
- Sapozhnikov Aleksei
St. Petersburg State University, St. Petersburg, Russia
e-mail: vermucht@gmail.com, **71, 72**
- Semenova Nadezhda
Polar Geophysical Institute, Apatity, Akademgorodok, 26a, 184209, Apatity, Russia
e-mail: semenova@pgia.ru, **226**
- Shadrina Lyudmila
Institute of Cosmophysical Research and Aeronomy, Yakutsk, Russia
e-mail: lushadr@mail.ru, **217, 227**
- Shagimuratov Irk
West Department of IZMI-RAN, Kaliningrad, Russia
e-mail: shagimuratov@mail.ru, **132**
- Shapovalova Alyona
Institute of Solar-Terrestrial Physics SB RAS, Irkutsk, Russia
e-mail: alena@iszf.irk.ru, **176, 227**
- Sharov Nikolay
Institute of Geology Karelian Research Centre RAS, Pushkinskaya str. 11, 185910, Petrozavodsk, Russia

- e-mail: klimava@gmail.com, **102**
- Shcheglova Snezhana
Sobolev Institute of Geology and Mineralogy, Novosibirsk, Russia
e-mail: smekalka12@mail.ru, **73**
- Shcherbakov Valeriy
Borok Geophysical Observatory of Schmidt Institute of Physics of the Earth, Borok, Russia
e-mail: shcherb@borok.yar.ru, **74, 75**
- Shishkina Maria
Institute of Physics of the Earth RAS, Moscow, Leninskie Gory, 1 (poste restant), 119234, Moscow, Russia
e-mail: maryrose17@yandex.ru, **103**
- Sholpo Marina
SPbF IZMIRAN, RAS, St. Petersburg, Russia
e-mail: msholpo@mail.ru, **133**
- Shukhtina Mariya
St.Petersburg State University, St. Petersburg, Russia
e-mail: mshukht@geo.phys.spbu.ru, **229, 230**
- Simakov Alexander
St.Petersburg State University, Universitetskaya nab. 7-9, 199034, St.Petersburg, Russia
e-mail: sandhill@mail.ru, **20**
- Singh O.P.
Faculty of Engineering and Technology, R.B.S. College, Bichpuri, Agra-283105, Department of Physics, Faculty of Engineering and Technology, R.B.S. College, 283105, Agra, India
e-mail: opsasd@gmail.com, **134**
- Singh Raj
Dept. of Physics, Institute of Applied Sciences, GLA University, Mathura, 281406, India
e-mail: rpsinghmathura@gmail.com, **135**
- Singh Vikram
Department of Physics, Es-han College of Engineering, Farah, NH-2, 281122, Mathura, India
e-mail: vikram_sks@rediffmail.com, **135**
- Slivka Kirill
St.Petersburg State University, St. Petersburg, Russia
e-mail: bank1r@inbox.ru, **231**
- Smirnova Natalia
St.Petersburg State University, St. Petersburg, Russia
e-mail: nsmir@geo.phys.spbu.ru, **136, 232**
- Smolin Sergey
Siberian Federal University, av. Svobodny 79, 660041, Krasnoyarsk, Russia
e-mail: smolin@krasu.ru, **233**
- Sokoloff Dmitry
Moscow State University, Moscow, Russia
e-mail: sokoloff.dd@gmail.com, **76**
- Sokolova Elena
Research Centre Institute of

- Physics of the Earth, RAS,
Troitsk, Moscow region, Rus-
sia
e-mail: sokol_l@mail.ru, **21**
- Solyanikov Yaroslav
Silo North-East Interdisciplinary
Scientific Research Institute
FEB RAS, Portovaya st. 16,
685000, Magadan, Russia
e-mail: yaroslav1982@mail.ru,
76
- Starchenko Sergey
Institute of Terrestrial Mag-
netism, Ionosphere and Ra-
dio Wave Propagation RAS,
Troitsk, Moscow region, Russia
e-mail: sstarchenko@mail.ru,
77
- Stepanov Alexander
Institute of Cosmophysical Re-
search and Aeronomy, Yakutsk,
Russia
e-mail: a_e_stepanov@ikfia.ysn.ru,
234
- Stepanova Marina
Institute of Physics of the Earth
RAS, Bolshaya Gruzinskaya
10, 123995, Moscow, Russia
e-mail: mars@sumail.ru, **104**
- Stupina Anna
Institute of Tectonics and Geo-
physics named after Yu. A.
Kosygin, 65, Kim Yu Chen,
680000, Khabarovsk, Russia
e-mail: itig@itig.as.khb.ru, **78**
- Sumaruk Yuri
Institute of Geophysics Na-
tional Academy of Sciences
of Ukraine, Palladin av. 32,
03680, Kiev, Ukraine
e-mail: sumaruk_yuri@mail.ru,
234
- Suslova Olga
Im. Kant Baltic Federal Uni-
versity, ul. A. Nevskogo 14,
236041, Kaliningrad, Russia
e-mail: ivkarpov@inbox.ru,
235
- Sycheva Natalia
Borok Geophysical Observa-
tory of Schmidt Institute of
Physics of the Earth, Borok,
Russia
e-mail: seminar@borok.yar.ru,
74
- Syusyuckalov Sergey
Schmidt Institute of Physics
of the Earth RAS, Bolshaya
Gruzinskaya, 10, 123995, Moscow,
Russia
e-mail:
sergei.syusyuckalov@yandex.ru,
236
- Tereshyn Artem
Institute of Geophysics, Na-
tional Academy of Sciences
of Ukraine, Palladin av. 32,
03680, Kiev, Ukraine
e-mail: ter_artemk@mail.ru,
18
- Tikhotskiy Sergey
Institute of Physics of the Earth
RAS, Moscow, Bol. Gruzinskaya
str., 10, 123995, Moscow, Russia
e-mail: sat@ifz.ru, **105**
- Timofeev Eugeny
Admiral Makarov State Mar-
itime Academy, St. Peters-
burg, Russia
e-mail:
Evgeny.timofeev47@gmail.com,
237

Timofeeva Sonya
St.Petersburg State University, St. Petersburg, Russia
e-mail: bruslinka@mail.ru, **238**

Titova Elena
Polar Geophysical Institute, Apatity, Russia
e-mail: lena.titova@gmail.com, **239**

Trofimov Dmitrii
St.Petersburg State University, St. Petersburg, Russia
e-mail: dm.trofimov@gmail.com, **216**

Tselmovich Vladimir
Geophysical Observatory "Borok" IPE RAS, Borok, Nekouzskij region, Yaroslavl, 152742, Russia
e-mail: tselm@mail.ru, **78, 79**

Tsirel Vadim
Enterprise "Geologorazvedka", 11, Knipovich str., block 2, 192019, St.Petersburg, Russia
e-mail: geolraz@geolraz.com, **80**

Tyasto Marta
St. Petersburg Filial of IZMIRAN, St. Petersburg, Russia
e-mail: mtyasto@mail.ru, **240**

Usoltseva Olga
Institute of Geosphere Dynamics of Russian Academy of Sciences, Leninsky prospekt,38, housing 1, 119334, Moscow, Russia
e-mail: kriukova@mail.ru, **105**

Uvarov Vladimir
Institute of Cosmophysical Research and Wave Propagation FEB RAS, v. Paratunka,

Mirnaya str. 7, Kamchatka, 684034, Russia
e-mail: uvarovvng@yandex.ru, **137**

Vagin Stanislav
St.Petersburg State University, St. Petersburg, Russia
e-mail: stvagin@gmail.com, **22**

Val'chuk Tatiana
Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation RAS, Troitsk of Moscow region, 142190, Russia
e-mail: valchuk@izmiran.ru, **240**

Vasko Ivan
Space Research Institute, Moscow, Russia
e-mail: vaskoij@yandex.ru, **241**

Veretenenko Svetlana
Ioffe Physical-Technical Institute, Russian Academy of Sciences, Polytekhnicheskaya st., 26, 194021, St.Petersburg, Russia
e-mail: s.veretenenko@mail.ioffe.ru, **141, 242, 243**

Veselovskiy Roman
Moscow State University, Moscow, Russia
e-mail: roman.veselovskiy@ya.ru, **81**

Vinberg Fedor
Institute of Earthquake Prediction Theory and Mathematical Geophysics, Moscow, Russia

- e-mail: winberg@mitp.ru, **106**
Vokhmyanin Mikhail
St.Petersburg State University, St.Petersburg, Russia
e-mail:
vohmyaninmv@gmail.com, **243**
- Volkov Mikhail
Murmansk State Technical University, Murmansk, Russia
e-mail: mavol2006@yahoo.com, **244**
- Volosevich Alexandra
Mogilev State University, Kosmonavtov str., 1, Mogilev, Belarus
e-mail: avolos@rambler.ru, **245**
- Walker Simon
ACSE, University of Sheffield, Mappin Streetuni, S1 3JD, Sheffield, Great Britain
e-mail:
simon.walker@sheffield.ac.uk, **138**
- Yagodkina Oksana
Polar Geophysical Institute, Apatity, Akademgorodok, 26a, 184209, Apatity, Murmansk region, Russia
e-mail: yagodkina@pgia.ru, **246, 247**
- Yagova Nadezda
Institute of Physics of the Earth RAS, Moscow, B. Gruzinskaya, 10, 123995, Moscow, Russia
e-mail: nyagova@yandex.ru, **248**
- Yahnin Alexander
Polar Geophysical Institute, Apatity, Akademgorodok, 26a, 184209, Apatity, Russia
e-mail: yahnin@gmail.com, **248-250**
- Yahnina Tatiana
Polar Geophysical Institute, Apatity, Fersman str, 54-13, 184209, Apatity, Russia
e-mail: tyahnina@gmail.com, **250, 251**
- Yakymenko Kateryna
Institute of Geospheres Dynamics RAS, Moscow, Leninskij pr-kt 38, korp.1, 119334, Moscow, Russia
e-mail:
yakimenkokn@gmail.com, **252**
- Yanovskaya Tatiana
St.Petersburg State University, St.Petersburg, Petrodvoretz, Ul'yanovskaya, 1, 198504, Sankt-Petersburg, Russia
e-mail: yanovs@yandex.ru, **5, 107, 108**
- Yegorova Tamara
Institute of Geophysics, National Academy of Sciences of Ukraine, Pr. Palladina 32, 03680, Kiev, Ukraine
e-mail: egorova@igph.kiev.ua, **109, 110**
- Yudin Sergey
St.Petersburg State University, St. Petersburg, Russia
e-mail: serg79@nm.ru, **82**
- Zakharenkova Irina
West Department of IZMIRAN, Kaliningrad, Russia
e-mail: zakharenkova@mail.ru, **139**
- Zemtsov Victor
Institute of Geology, Karelian Research Centre, RAS,

- Petrozavodsk, Russia
e-mail: zemtsov@krc.karelia.ru,
83
- Zhamaletdinov Abdoulkhay
Geological Institute of the Kola
Science Centre of RAS,
Apatity, Russia
e-mail: abd.zham@mail.ru,
23, 24
- Zhidkov Grigoriy
Geophysical observatory "Borok",
Yaroslavskaya oblast, Nekouzskiy
region, Borok, 152742, Russia
e-mail: grigor@borok.yar.ru,
75
- Znak Pavel
St.Petersburg State Univer-
sity, St.Petersburg, Russia
e-mail: znak.pavel@gmail.com,
111
- Zolotov Oleg
Murmansk State Technical Uni-
versity, Sportivnaya St.,13,
183010, Murmansk, Russia
e-mail: ZolotovO@gmail.com,
140
- Zolotova Nadezhda
St.Petersburg State Univer-
sity, Petrodvorets, Ulyanovskaya
ul., 1, 198504, St. Peters-
burg, Russia
e-mail: ned@geo.phys.spbu.ru,
253
- Zotov Oleg
Borok Geophysical Observa-
tory, Schmidt Institute of Physics
of the Earth RAS, Borok, Yaroslavl
oblast, Russia
e-mail: ozotov@inbox.ru, **119**
- Zubov Alexander
Institute of Volcanology and
Seismology FED RAS,
Petropavlovsk-Kamchatsky, Russia
e-mail: zubov@kscnet.ru, **84**
- Zverev Vladimir
Polar Geophysical Institute,
Apatity, Russia
e-mail: zverev@pgia.ru, **255**
- Zvereva Tatiana
Institute of Terrestrial Mag-
netism, Ionosphere and Ra-
dio Wave Propagation RAS,
IZMIRAN, 142190, Troitsk,
Moscow region, Russia
e-mail: zvereva@izmiran.ru,
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