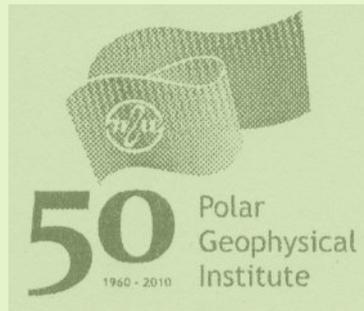


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PHYSICS OF AURORAL PHENOMENA

33rd Annual Seminar

2 – 5 March 2010

Abstracts



Apatity

2010

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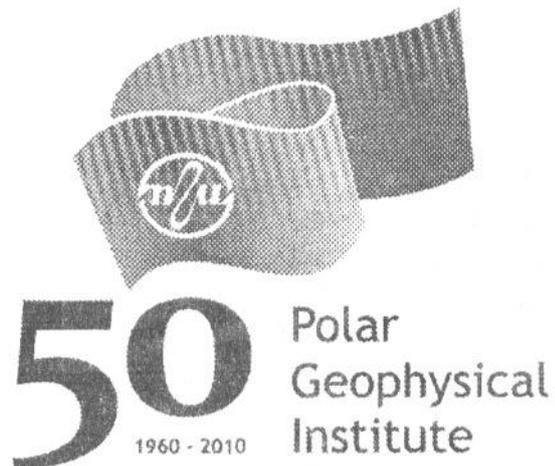
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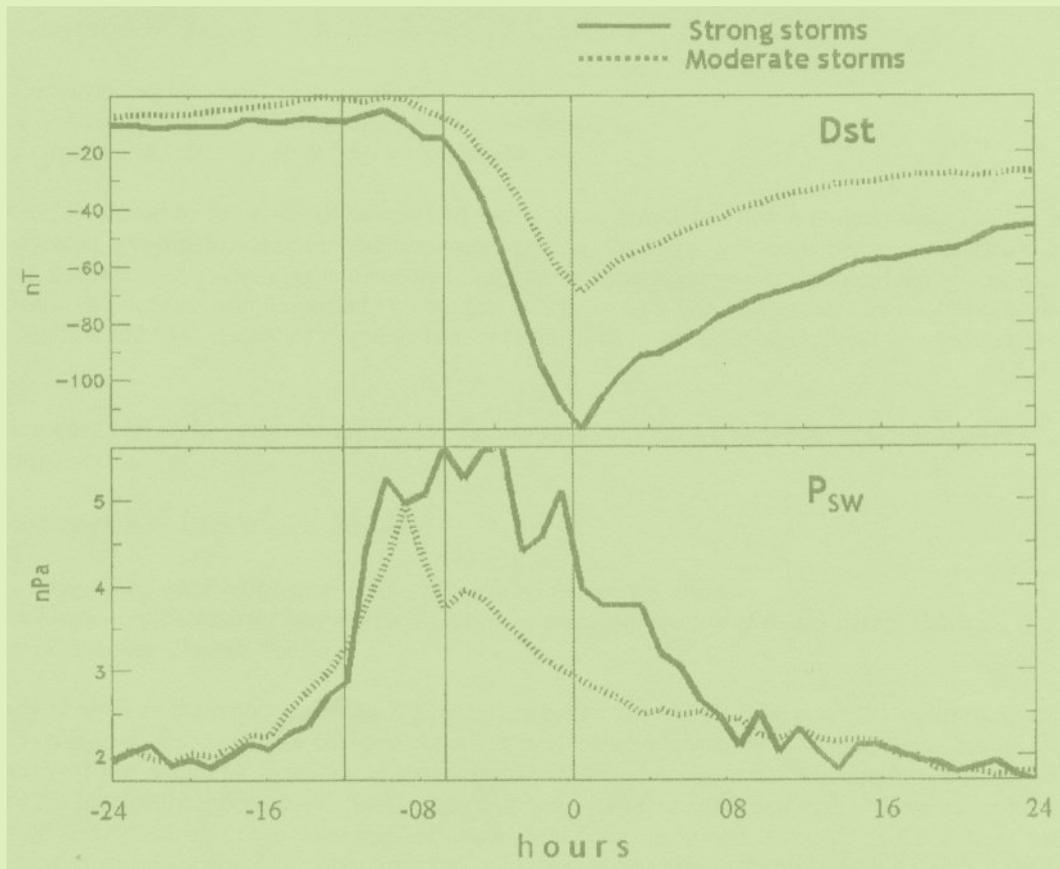
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Geomagnetic Storms and Substorms



Three-dimensional nonsteady magnetic reconnection signatures study

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The signatures associated with the three-dimensional nonsteady magnetic reconnection process in the thin current sheet have been investigated. The rigorous foundation of the reconnection presence criterion is obtained in the frame of the theoretical model. In two-dimensional case the relations between the parameters of reconnection (which are the magnetic flux and the coordinates of the X-point), and the integrals of the magnetic field and plasma velocity components over time and profiles are calculated. In three-dimensional case there is estimated the system of equations contained relations between the reconnections parameters (the magnetic flux and the coordinates and length of the X-line), and the integrals of the magnetic field and plasma velocity components over time.

As a result, a new method of evaluating the reconnected flux and coordinates of the reconnection side in the Earth's magnetotail is developed.

Stability of the thin current sheet in Earth's magnetotail

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This work is devoted to the study of stability of thin current sheets in Earth's magnetotail. Tearing mode of thin current sheet is investigated in linear and nonlinear regimes. Contrary to various recent paradigms it is shown that thin current sheets with embedding can become unstable in some parameter range and tearing islands will develop. The influence of current sheet embedding on the free energy margin is investigated. The nonlinear regime of tearing mode is studied and spatial scale of magnetic islands resulted from tearing development is estimated.

Kp index correction in order to eliminate excess impact of high latitude magnetospheric disturbances

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This study focuses on the development of Kp-index correction algorithms. The present algorithm for calculating the index Kp dynamics of spatial-time changes in the magnetosphere-ionosphere current systems arising from a change of topology of the magnetic field during magnetospheric disturbances are not accommodated. Errors of present planetary Kp index during periods of strong magnetospheric disturbances is occurred. During storm-time the size and position of the boundaries of the polar cap and the auroral zone are varied. Network of Kp stations partially in the polar region may be included. At this time the index value for local substorm activity rather than a planetary geomagnetic match. For example in 2004 the influence substorm activity on the values of Kp station magnetometer is demonstrated. It was found that 30% of the mid-and high-latitude observatory magnetograms the influence of the full magnetospheric disturbance source is contain. As a result the values of Kp-index are overestimated. Algorithm for calculating an corrected index of planetary geomagnetic activity on the use of purified magnetograms from excessive influence of the auroral electrojet is based.

Developing an algorithm of correction Kp-index as follows scheme is executed. For all Kp-stations corresponding high-latitude observatory is determined. Results of correlation analysis of magnetic disturbances on each pair of stations (with a correlation coefficient greater than 0.5) Kp-station magnetogram which requiring treatment is marked. The technology of proposed treatment includes the decomposition of correlated signals in the Fourier series and removed from the purified signal harmonics which correlate with the harmonics of high-latitude signal. New purified revised signal phasing out of the remaining harmonics. Then a formal algorithm for calculating Kp-index on the corrected magnetogram is applied. As a result the correct Kp index with the elimination of excessive influence of the polar electrojet is obtained.

Comparison of corrected and presented Kp-index showed that during periods of strong magnetospheric disturbances in 60% cases the planetary Kp index 0.7 points average in the digital index scale adds. Thus, the use proposed

correct Kp-index to avoid excessive influence of the polar sources and the planetary geomagnetic disturbance more reliably to estimate.

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Multiple equatorward-moving auroral traces and multiple injection-lets at geostationary orbit

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Motivated by recent comparisons of transient equatorward-moving auroral traces with short injections detected by Themis spacecraft we analyse TV observations of couple auroral substorm events (each showing a number of equatorward traces) together with energetic particle observations made by couple LANL spacecraft (located in nearby MLT sectors) to understand - if there exists a distinct correspondence between two phenomena and/or -which factors may influence their coherent appearance.

The auroral proton precipitation quite near the breakup

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Dynamics of the proton fluxes close to the substorm breakup was investigated using the high sensitivity ground based optical spectrometer at the Apatity and allsky cameras at the Lovozero and Apatity. The typical phenomena sequence consists of: (a) the proton flux intensity decrease just before the breakup; (b) the breakup itself; (c) the proton flux intensity short time increase just after the breakup. The sequence duration is a few minutes. The intensity of the hydrogen H α emission was used as the proton flux measure. Some variations of the precipitation proton energy spectra, inferred from the optical data, are discussed.

Effect of IMF sectoral structure on the magnetic storm development

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According to satellite and ground observations during the period 1995-2005 the dependence of the zonal geomagnetic indices (AE, Kp and Dst) from the azimuthal component of IMF (By) during weak and moderate magnetic storms are studied. It is shown that during the main phase of magnetic storms and the minimum Dst, the value of AE and Kp indices increases with increasing of IMF By positive values. In contrast of Kp and AE indices, the such relationship between Dst index and IMF By is not observed. Possible reasons are discussed.

This work was supported by the Presidium of the Russian Academy of Sciences (program 16, pan 3), by the RFBR grant № 09-05-98546 and also supported by the SB RAS project № 69.

Variations of aurora emissions during substorms at Spitsbergen archipelago

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We analyzed the variations of the green 557.7 and red 630.0 nm emission intensities during substorms observed with photometer and TV all-sky camera at observatory Barentsburg, Spitsbergen archipelago during 2005/2006, 2007/2008, and 2009/2010 winter seasons. In addition, the substorm onset time and poleward propagation of substorm were verified by ground-based data of the IMAGE magnetometers network. It is shown that sometimes during substorm poleward expansion, at front of the most poleward substorm arcs registered by the all-sky camera, a region of red emission exists. The width of this region is estimated as about 100 km. We suppose that this region

could be related with downward current poleward of the substorm auroras. In our view, this red emission can be provoked by energetic protons, precipitating within the region of the downward current. It is also shown that the precipitation of most energetic electrons occurs at the polar edge of the auroral bulge, while inside the bulge the precipitation of less energetic electrons is observed.

Relation between electrodynamic and optical scaling in the auroral breakup region

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While turbulence that develops in the near Earth plasma sheet at substorm expansion onset is primarily an electrodynamic turbulence, it has majorly been studied by its optical manifestations. This is because, unlike spacecraft measurements, optical observations provide instant 2D turbulent pictures. Auroral variations in the breakup region are known to exhibit scaling properties. In the present study, they are demonstrated for scales > 50 km by using UVI images from the *Polar* and *Dynamics Explorer 1* satellites and applying an advanced wavelet transform method to derive spatial scaling index (subscript 'A' means 'auroral'). It is shown that α_A undergoes a change in the course of substorm, varying from values less than unity at the beginning of substorm activation to ~ 1.5 at the early breakup stage, further increasing up to ~ 2 at expansion maximum, and then subsiding at the recovery phase. To explain the observed scaling in the breakup aurora, we try to relate it to the scaling of underlying electrodynamic quantities. For this purpose, we synthesize 2D self-similar distributions with known scaling index α_E (subscript 'E' means 'electric field') that mimic turbulent electric fields imposed from the magnetosphere on the site of further breakup onset. Index α_E is taken either $5/3$ or 2.6 , depending on whether turbulization in the near tail is assumed to be driven by locally formed plasma shear flow or by bursty bulk flows launched from the near-Earth neutral line. For a simplest model of magnetosphere-ionosphere coupling, we show that the relation between α_E and α_A can qualitatively be understood.

Examination of ionospheric potential sources utilizing global MHD modeling

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Using global MHD modeling we separated the contributions to ionospheric potential (Φ_{ion}) from dayside and nightside sources. Dayside source was parametrized by dayside reconnection potential (Φ_d) and the nightside source by cross-tail potential (Φ_n) in the middle tail ($X=-(25:15)Re$). There is a good agreement between measured ionospheric potential and predicted by fitting $\Phi_{fit} = \alpha\Phi_d + \beta\Phi_n + \Phi_v$, where Φ_v – viscose-like potential. We found that period of major nightside source contribution to Φ_{ion} ($\sim 25-30\%$) corresponds to substorm expansion phase. Time delays of ionospheric potential response to Φ_d is ~ 10 min and to Φ_n is < 5 min. Contribution of viscose-like interaction to Φ_{ion} is about 7 kV.

Substorm onset triggering by the IMF directional discontinuities

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We analyzed the time aspects of the substorm onset triggering by the IMF Bz turning. Using the magnetic and plasma data from Wind, ACE, Geotail, Themis B and Themis C spacecrafts 30 solar wind directional discontinuities (DD) with S-N Bz turning were selected. The multi-spacecraft method was used to define DD orientation and estimate the propagation time of the DD fronts. The reference time for the magnetospheric response is the moment of DD arrival to the bow shock nose (t_{bs}). Concerning this time we determined two characteristic moments: the global magnetospheric electric field response (as the PC-index decrease start time t_{pe}) and the substorm onset (as the start of the midlatitude positive bay t_0). The uncertainty of the arrival time estimate does not exceed 3 min. Ground magnetic variations start time was determined with accuracy of 2 minutes. It was shown that: firstly, the start of the convection electric field decrease (t_{pe}) regularly was late concerning the substorm onset (t_0); secondly, the time delay of the expansion onset ($t_0 - t_{bs}$) depends clearly on the DD orientation.

The results show that the substorm onset is caused by the disturbance launched by DD interaction with magnetosphere at the first contact point, but not by the convection electric field decrease.

Penetration dynamics of the ring current into the plasmasphere during substorms by the observation of diffuse aurora and SAR arc

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Observations of the diffuse aurora (DA) and stable auroral red (SAR) arc are the informative investigation method of magnetosphere-ionosphere coupling in the vicinity of plasmopause and inner boundary of the plasma sheet during magnetospheric disturbances. SAR arcs are the consequence of interaction of the outer plasmasphere (plasmopause) with energetic ions of the ring current. The DA is caused by the low-energy electron precipitation from the plasma sheet. During substorms we observe the intensity increase of DA and its equatorward extension up to the plasmopause projection, which is mapped by the SAR arc occurring at that time. (Ievenko et al, *Adv. Space Res.*, 2008).

In this work we present the new study results of the DA and SAR arc dynamics based on spectrophotometric observations at the Yakutsk meridian (199° E geomagnetic longitude). For individual events the relationship of equatorward extension of the DA in the 557,7 nm emission to the magnetospheric convection intensification after the turn of IMF B_z to the south is shown. The longitudinal dynamics of SAR arc formation during the substorm expansion phase is investigated. The relationship of SAR arc dynamics to the substorm injection by the geosynchronous measurements is analyzed. It is shown that the interval of latitudes where SAR arcs are observed during weak and moderate storms is a statistical map of the outer plasmasphere region, into which the developing ring current penetrates and damps during substorms.

Polar cap electric field shielding effect during SMC before the 20 Nov 2003 onset superstorm

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The Iijima-Potemra's Region 0 of field-aligned currents (FACs) are known to produce electrical shielding of the ionospheric polar cap (p.c.), like Region 2 FACs shield the mid-latitude ionosphere. These results support a magnetospheric model with open magnetic tail, which exists during quiet conditions and changes during substorm. The published data were obtained for substorms. In the present paper, we have described the above shielding effect using data of the 20 Nov 2003 storm in the interval (04:30-06:45) UT, when SMC mode of disturbance was observed. The results are discussed in the framework of the above new magnetospheric model.

Web Application for Empirical Model of Auroral Precipitation

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We developed a web application for modeling auroral precipitation zones at different levels of geomagnetic activity. Regression equations that relate latitudinal position of precipitation zones with the level of geomagnetic activity are used. The boundaries of precipitation zones are determined from statistical analysis of DMSP satellite observations [Vorobjev and Yagodkina, 2005, 2007]. The global distribution of auroral precipitation zones (in coordinates Geom.Lat.-MLT) is obtained for given values of the AL and DST indexes.

Our web application enables to put a custom observational point on simulated precipitation zones for given geographical coordinates and UT. A custom point can be set both manually and through Google Maps service.

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Behavior of ionospheric parameters at mid-latitude stations during sequence of geomagnetic storms on September 9-14, 2005

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On September 9, 2005 the weak geomagnetic storm was observed. The same day there was a solar flare, which was one of 10 most powerful flares registered for all history. On September 10, 2005 a weak geomagnetic storm was observed which then was replaced by a strong magnetic storm on September 11, 2005. This storm proceeded down to September 15, 2005. In the given study the ionospheric effects of geomagnetic storm sequence on September 9-14, 2005 are considered. There are presented the numerical calculation results of ionospheric parameter behavior during geomagnetic storms obtained with use of the Global Self-consistent Model of the Thermosphere, Ionosphere and Protonosphere (GSM TIP) (Namgaladze et al., 1988; Klimenko et al., 2006), developed in WD IZMIRAN. As initial conditions the values of all ionospheric parameters calculated for quiet conditions at 09:00 UT on September 9, 2005 have been chosen. At simulation of the storm conditions the potential difference through polar caps and amplitude of field aligned currents of the second region were set as function from *AE*-index of geomagnetic activity (Feshchenko and Maltsev, 2003; Cheng et al., 2008). The energy and flux of high-energy electrons were set according to Zhang and Paxton (2008). The displacement of field aligned currents of the second region to the lower latitudes was set as by Sojka et al., 1994. At the storm sudden commencement the time delay of the second region field aligned current variations, equal of 30 min. relative to the variations of the potential difference through polar caps was considered (Cheng et al., 2008). It is analyzed the obtained calculation results for the number of ionospheric stations. The comparison of these results with experimental data obtained at stations Irkutsk, Yakutsk, Millstone Hill and Arecibo is carried out.

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Multi-point investigations of magnetosphere response to a magnetic cloud during solar cycle minimum

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On 22 November 1997 a magnetic cloud reached the earth magnetosphere and produced a two-step magnetic storm with Dst reaching –108 nT. The sheath region reached the Earth at ~ 9:50 UT and a pulse in SW dynamic pressure hit the magnetopause. INTERBALL-1 was in the tail at ~ -10.6 R_E, heading towards perigee. It registered the increased two times magnetic flux about 1.5 – 2 min later. GEOTAIL was positioned at ~ -20 R_E in the plasma sheet near the dawn flank and 2.5 minutes after that observed first denser plasma and then experienced several magnetopause crossings. In the course of the storm several substorms developed with AL down to –1400 nT. In the Northern hemisphere INTERBALL-2 made several scans through the region of the dusk field-aligned currents. We

analyse the magnetospheric processes taking place during the storm and compare the observations with the results from Tsyganenko'96 and Tsyganenko'2004 storm models.

Physical processes interrelationships during main phases (MPs) of geomagnetospheric storms (GMSs), associated with BZ-component of interplanetary magnetic field (IMF), on evidence of cluster analysis

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The goal of our work is to study of the physical processes interrelationships during geomagnetospheric storms (GMSs) main phases (MPs) of investigated intensities ($D_{st}^{min} = -37 \div -226$ nT) with using cluster analysis realized in the form of the "nearest neighbour" method. The scale two-dimensional D_{st} - B_Z clusterization of 31 MPs has to select the weak (WS), moderate (MS), intense (IS), and very intense (VIS) storms MPs (the samples) associated with B_Z -component of IMF. It is worth noting that large and prolonged southward IMF is a necessary and sufficient condition for magnetic storm initiation [Maltsev, 2004]. The content physical analysis of the obtained MPs samples is carried out on the base of correlativity clustering of 32 interconnected physical processes (IPPs) characterizing every MPs. It has been found that the MPs of all samples have common part ($CP = [D_{st}] + [B_Z] + (B_Y) + B$) of tight IPPs structure, and in turn the MPs of every sample has own common IPPs structure. Hence theirs MPs are characterized by different physical development depending on the D_{st} scale. The availability of CP testifies that the MPs magnetospheric activity [D_{st}]= $D_{st} + DR + Q + U_T$ (where $Q = dDR/dt + DR/6$) of all scales is defined mainly by the [B_Z] and (B_Y) groupings, and B - IMF, i.e. by B_Z and B_Y IMF component and related with them derived functions (V -velocity and B_S -south component of IMF). In this case, the relationships $D_{st}(V^2B_S)$ and $D_{st}(VB_S)$ or $Q(V^2B_S)$ and $Q(VB_S)$ are most tightly coupled. In three MPs samples the B_X and B_T IMF component the velocity V play essential role. As for the Akasofu parameter ϵ , its role less appreciable, but the relationships $D_{st}(\epsilon)$ and $Q(\epsilon)$ are in existence. The D_{st} index (or Q function) and AL index have essential relationship in between only during WS, MS, and partly IS MPs; after that as the $|D_{st}|$ index drastically grows, the AL index gradually levels off. It was found that the most relevant coupling function for development of the AL index is the V^2B_S and VB_S functions, but only during WS, MS, and partly IS MPs.

Electromagnetic energy flux into the Earth's magnetosphere during 06.04.2000 superstorm

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The estimates of the Poynting flux ϵ have obtained by three methods under the data of the 06.04.2000 superstorm with the steps 5 minutes. Two methods are using the equations $\epsilon' = \Psi^2 V_{SW}/(\mu_0 \cdot S_T)$, $\epsilon^* = \Psi \cdot \langle B_L \rangle \cdot V_{SW}/\mu_0$, and the third method is based on the well-known global MHD model GUMICS. The results of three methods were compared with the estimates of the substorm power Q , which were obtained by the fourth independent method. The comparing of the results of the four methods are discussed.

Dynamics of the closed tail length during substorm and superstorm

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Two independent methods have been used to calculate with the steps 5 minutes the values L , of Earth's closed magnetotail length.

The results of the both methods are have consistently shown the closed tail lengthening during substorm loading and dramatic decreasing of the L values during substorm unloading phase in the expected limits from ~ 300 to $\sim 20 R_E$.

The new magnetospheric model of substorm current wedge (SCW): comparison between predicted and observed magnetic effects on GOES spacecraft

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The magnetic disturbances observed by the GOES spacecraft during substorm are contributed by different processes such as substorm current wedge (SCW), partial-ring current (DRP), R2 current systems, global reconfigurations etc, whose current systems are only tentatively known. To explore which part of magnetospheric magnetic effects during substorms are produced by the SCW in magnetosphere's tail, we estimate linear and non-linear parameters of standard substorm current wedge (based on interpretation of midlatitude magnetic observations using inversion algorithm) and apply these parameters to the new magnetospheric model of SCW (N.A. Tsyganenko 2009, not yet published). We compare predicted and observed magnetic disturbances on the nightside part of geosynchronous orbit and obtained their average ratio to be $l_{prm} = \delta B_{obs}/\delta B_{mod} = 1.9$ (CC=0.85), indicating that standard SCW model should be considerably modified. However, the interpretation results were found to depend on inclusion of partial-ring current (DRP), inversion algorithm parameters and unusual details of particular events such as double SCW features.

Ionospheric disturbances generated during magnetic storms in the auroral zone

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The measurements of total electron content (TEC) by international GPS network and a method for TEC variation mapping developed by authors were applied to investigate spatial-temporal parameters of ionospheric disturbances generated during magnetic storms in the auroral zone. A comparative analysis of the spatial distributions of TEC perturbations in the geographical and geomagnetic reference systems was made. The deviation from the equatorward propagation direction of large-scale traveling ionospheric disturbances (LS TID) registered during magnetic storms was discussed. This deviation is well-known phenomenon. However the deviation reasons are not clear. LS TID motion along the geomagnetic meridian may be one of the reasons. To check up this hypothesis we made a simulation of point motion in the geographical and geomagnetic reference systems. As shown, if the point travels along the geomagnetic meridian, its velocity has two components in the geographical reference system: along the geographical meridian (meridional component) and along the geographical parallel (zonal component). Values of meridional and zonal components vary with longitude and latitude. This work was supported by the Russian Foundation for Basic Research (grant 08-05-00658).

On latitude-stability of Pi2 domain from the evidence of “BEAR” magnetic pulsations data

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Stability of Pi2 generation domain is set by comparison of local extremes of vertical component in narrowband filtered Pi2 magnetic pulsations being obtained at high-latitude network during “BEAR” experiment, with their local sources positions which were defined in terms of generalized gradient technique for filtered horizontal Pi2 field components. Locations of these features are in a good coincidence for a single source of pulsations.

As a possible reason of this stability the self-focusing of Lengmuir waves is considered, that is associated with an energetic particles expansion at the inner radiation belts and with Kelvin-Helmholtz instability growth with efficient role of Stokes correction for waves' dispersion. It is marked also that on average a Pi2 period their oscillations are corresponded to 3D-current system behavior, but there are some features of their sources dynamic which are not confined to a simple resonant model of Pi2 excitation.

OBSERVATIONS OF CORONAL AURORA ABOVE BABILON (MESOPOTANIA, 32ON) IN 593 BC: MYTH OR REALITY?

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

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

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

Software-computer complex for Space Weather predicting

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Neural network software-computer complex to search for non-linear causal relationships in the problems of solar-terrestrial physics is developed. The main objective of the program is to ensure neural network numerical experiments for search of non-linear connections between geomagnetic indices and the parameters of a near-Earth space. Work program algorithm of an artificial neural network (ANN) include back propagation Elman network, feed forward network, fuzzy logic network and Kohonen layer classification network. The interface of application allows to change neural network architecture (the number of hidden layers, the number of neurons in the layer, the input and target data, and the number of cycles of training).

The beginning of the training process with selection of ANN input and target data in main window of the program is consists. The result of network work is the plot with results of testing. For simplification the setting of repeating experiments the application allows last trained neural network to use. In this case training is not done: from a previously saved file parameters of experiment are loaded. Previously trained network as a filter for input parameters get through and output parameters with the test event are compared. The open modular architecture of application with the purpose to solve various tasks to modify it is allows. As any other modular application software complex designed works with sets of database. For sure of the greater flexibility of the program work with a database in the form of files is stipulated. The created complex for 30 simultaneously processing streams of events in the input data is designed. Database minute numeric data for 30 geomagnetic storms in the period from 2000 to 2003 is contains. In this set of parameters of the Solar wind, interplanetary magnetic field (from spacecraft "ACE") and geomagnetic indices (Dst, SYM, ASY, AU, AL) are included. These data from the site at <http://cdaweb.gsfc.nasa.gov> are received. Is it necessary discrete data can be modified using the spline.

This tool for solving a wide range of tasks can be applied. It is the study of the general trends of nonlinear connections between the different parameters determining the causal relationships in the system «interplanetary space – magnetosphere - ionosphere» would be useful. It has already in different studies applied. Example studies: search the nonlinear connection the auroral electrojet activity between Solar wind parameters and interplanetary magnetic field, restoration and prediction of geomagnetic activity index, restoration and the forecast maximum observed frequencies on the traces of oblique HF ionospheric sounding with perturbation heliogeophysical parameters.

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Space weather impact on ground technological systems

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During magnetic disturbances rapid variations of ionosphere currents are accompanied by a geoelectric field, which drives so-called geomagnetically induced currents (GIC) in power systems and other technological networks. Generally GIC are a problem to the system. At the risk zone are power lines and cable automatic systems placed in North-West of Russia. We review effects of geomagnetic disturbances on power lines and railway automatic systems for period 2002 – 2008.

Mechanisms of substorm growth and expansion onset as revealed with ideal ground-spacecraft THEMIS coverage

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Ideal coverage of ground network and Themis spacecraft (with continuous neutral sheet control) on March 29, 2009 supported by event-specific adaptive magnetospheric modeling allow to reconstruct the growth phase and transition to the substorm expansion during an isolated substorm with greater reliability than it was possible before. The growth phase develops under external forcing but damped plasma sheet convection, during its last 15min very thin current sheet grows explosively whereas the total current saturates and shifts Earthward. Just before the onset the spacecraft at $r \sim 11R_E$ resolve the embedded TCS with half-thickness $\sim 0.15R_E$ and current density $\sim 20nA/m^2$, whereas total magnetic field in the neutral sheet was below 2nT at that location. In this event the expansion onset was initiated in the current sheet further tailward of 11-14 R_E distance probed by Themis spacecraft. We show detailed time sequence at

11 R_E as observed by a group of 4 spacecraft, which first see a gradual growth of Earthward flow and total pressure in front of Earthward DBF, evidencing against the outward-propagating rarefaction wave as BBF origin. It is followed by a sharp reduction of total pressure (up to 50%) and of lobe magnetic field, these current reduction signatures have been actually caused by the arrival of plasma bubble, the fast-flowing accelerated plasma with strongly reduced density and (initially) low electron temperature which evidence the reconnection of distant flux tubes the.

Distinct auroral breakup started near the ionospheric footpoint of the tail neutral sheet ~ 2 minutes after onset initiation in the tail, consistent with Alfvén wave travel time estimate. Excellent ground optical observations combined with DMSP observations provide a large-scale context confirming that breakup started on closed field lines, as usually in the equatorward half of the oval. This even provides a complete and definite choice against the breakup initiation on dipole-like field lines and in favor of reconnection as basic substorm onset process.

The nature of the pole expansion of the auroral electrojet under different conditions in the solar wind during periods of strong magnetic storms

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According to the global geomagnetic observations data in six meridional chains the regularities of poleward expansion of auroral electrojet localization region during periods of extra-magnetic storms 30-31.10.03, 20-21.11.03, 07-10.11.04 with $Dst \approx 300-400$ nT are analyzed.

The following results are obtained:

1. It is shown that the expansion of electrojet to the pole occurs at different geophysical conditions: a) during a sharp growth of solar wind velocity and dynamic pressure (P_d) at negative values of IMF B_z -component; b) during turning of IMF B_z -component from the south to the north, c) during periods of negative IMF B_z , but in the absence of significant variations of P_d and changes of IMF B_z direction.

2. It is found that in all cases the electrojet poleward expansion up to latitudes of the polar cap due to the extension of particles precipitation region and increased ionospheric conductivity from the low and auroral latitudes is occurred but not due to the movement of narrow electrojet region along the meridian as is the case in the of substorm.

It is discussed in the report the possible reasons of the poleward electrojet expansion under different geophysical conditions.

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Strengthening effect of the magnetic field due to the precipitation of charged particles

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

Morning – evening asymmetry of auroral precipitation during magnetic storms

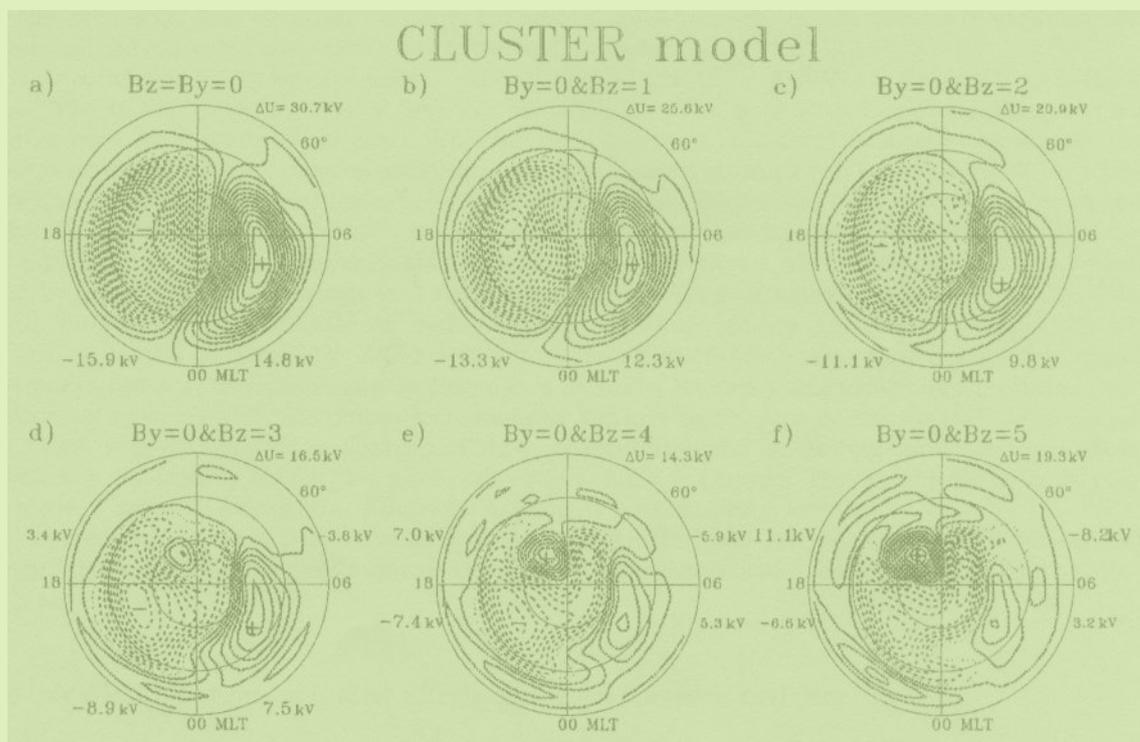
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Dynamics of the electron precipitation boundaries during magnetic storms on 10-11 January, 1997, 21-22 October, 2001 and 15-16 July, 2000 were investigated. The magnetic storms with a minimum in Dst of -80 nT, -200 nT and -300 nT respectively were driven by interplanetary magnetic clouds. Locations of auroral precipitation boundaries from DMSP F10-15 spacecraft observations were compared to those obtained by means of empirical model by [Vorobjev and Yagodkina, 2007]. In this model the auroral precipitation regions were determined by the statistical treatment of DMSP observations according to the geomagnetic activity level expressed by the AL- and Dst indices. A good agreement between observed and calculated data in different MLT sectors allowed us to use the VY-model to examine the dynamics of auroral precipitation boundaries in streaming operation. Long-lasting, steady depression of the Dst index was typical for all magnetic storm events. The significant latitudinal displacement of the diffuse auroral zone (DAZ) and the auroral oval precipitation region (AOP) along with the increase of magnetic activity was observed. During magnetic storms the width of the evening sector (18-21 MLT) DAZ precipitation does not change significantly while in the morning sector (06-09 MLT) the width of the DAZ increase up to $\sim 5^\circ$ of latitude. The opposite pattern displays the AOP region: weak widening of the precipitation in the morning and about 5° expansion of the structured precipitation in the evening. The width of the DAZ and AOP regions depends on Dst variations course. The planetary pattern of auroral precipitation shows morning – evening asymmetry in all storm events under investigation.

References:

Vorobjev V.G., Yagodkina O.I. Auroral precipitation dynamics during strong magnetic storms. *Geomagnetism and aeronomy*, 2007, V. 47, No.2, pp. 185-192.

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Nonlinear connection of auroral electrojets activity with Solar wind and interplanetary magnetic field parameters

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The establishment of nonlinear influence of Solar wind (PSW) and interplanetary magnetic field (IMF) parameters on ring current and auroral electrojets current systems within geomagnetic storms intervals is carried out. The periods of geomagnetic disturbances determined by Dst index dynamics. For research the main phases of magnetic storms have been selected only. Display of PSW and IMF in ring current and auroral current systems was analyzed with use of a nonlinear correlations method calculated by neural network. Under the parameters of near-Earth space means velocity V and concentration N of Solar wind as well as components B_y and B_z of interplanetary magnetic field. Under parameters of geomagnetic activity indices implied SYM and ASY which accordingly describe the current systems intensity of symmetric and asymmetric ring current as well as AU and AL indices describe eastward and westward electrojet intensity.

In all series of conducted neural network experiments as training sequence PSW and INF values are used, and as test sequence – intensity values of magnetospheric and ionospheric currents indices. For training parameters characteristic forestalling times which have been established by search of linear correlations were entered and they made 80 minutes taking into account a transfer time for carrying of PSW and INF to magnetosphere boundary. Statistical evaluation of non-linear correlation level was performed on the basis of statistical weights calculation for each pair of indices. The statistical weight is the ratio of good recovery events number (correlation coefficient between real and recovered sequences > 0.5) to the total events number.

Nonlinear correlation search between pairs of parameters N-AU, N-AL, V-AU, V-AL, B_y -AU, B_y -AL, B_z -AU, B_z -AL, N-SYM, N-ASY, V-SYM, V-ASY, B_y -ASY, B_y -ASY, B_z -SYM, B_z -ASY is carried out. Results of nonlinear neural network experiments are to establish influence degree of considered parameters on auroral electrojets development during the main phase of geomagnetic storms. Greatest influences on these electrojets have Solar wind velocity, IMF B_z component and less a Solar wind concentration. Influence of B_y components is weak. Statistical weights for the westward (AL) electrojet mostly higher than for the eastward (AU) electrojet. This could mean that at main phase of magnetic storms westward electrojet is highly developed when eastward electrojet. Probably it is caused by intensification of currents in a tail plasma sheet within geomagnetic disturbed intervals. Solar wind concentration has greater influence on eastward electrojet while velocity has greater influence on westward electrojet. It can be connected by different nature of auroral electrojets – westward electrojet is connected to substorm explosive processes and eastward electrojet is caused by stationary magnetosphere convection.

The strongest agent which determ ring current symmetric and asymmetric parts intensity is IMF component B_z . This is consistent with the known manifestation of B_z component dynamics in the ring current behavior. Solar wind concentration and velocity did not have a noticeable effect on the ring current. This may be due to the fact that at the main phase of magnetic storms up to 80% of the ring current are ionospheric ions.

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The solar wind B_z -events and their effects on the geomagnetic activity

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Southern vertical component of the Interplanetary Magnetic Field (IMF $B_z < 0$) is usually regarded as a predictor of the magnetospheric electromagnetic state disturbance. If equal to IMF $B_z < -5$ nT for 3 hours consecutively, this component indicates the occurrence of a magnetic storm and its development. So far, this criteria is commonly accepted. As a result, a geomagnetic forecast turns out to be reduced to the IMF B_z variation forecast, insufficiently reliable, for the indistinct role of the solar activity in the generating IMF B_z sign and sign change during the solar wind moving from the Sun to the Earth. The geomagnetic activity caused by solar plasma ejections depends on the Earth's moving trajectory through the body of a solar plasma ejection. Meanwhile the Earth's should cross the ejection area during interval when amplitude of IMF B_z is great but positive and these conditions do not cause a magnetic storm generation. We have examined hourly average $|B_z|$ measured by satellites in near space and found B_z -events when $|B_z| > 5$ nT during 4-hour interval. A number of events when the Earth, while crossing a solar

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ejection, experiences positive and negative Bz-events during a year are compared. Moreover, the results of statistical analysis of the influence of Bz-events on the geomagnetic activity.

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Models of the geomagnetic field and magnetometer measurements of Cluster FGM in the magnetospheric tail

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Four identical spacecraft, Cluster 1-4, were launched in summer 2000 into a high-inclination polar elliptical orbit with perigee at around 4 Re and apogee near 19 Re geocentric distance, and an orbital period of about 57 hours. The Electron Drift Instrument (EDI) on board Cluster measured the 2-D plasma drift perpendicular to the local magnetic field. The EDI drift data were mapped along the magnetic field lines into the upper ionosphere (~400 km) by use of the Tsyganenko-2001 (T01) geomagnetic field model. They provided the basis for statistical ionospheric convection pattern at high latitudes for various orientations of the interplanetary magnetic field (IMF) and constituted in this way a magnetospheric convection model. For estimating the correctness of the model assumptions, the T01 model values of the geomagnetic field were compared with the flux gate magnetometer (FGM) measurements on board Cluster. The Cluster FGM data are not part of the T01 data base and can therefore be used for an independent verification of the T01 model. The results of the drift vector mapping by use of the T01 model were compared with analogous mappings, which made use of the Paraboloid Model (PM) of the geomagnetic field. A similar comparison of Cluster FGM data with T01 model values was performed by Woodfield et al. (2007) from perigee up to a geocentric distance of 8 Re. They confirmed the general agreement between the model values and the satellite data with differences up to about ~20 nT. Here, we show a corresponding comparison between observed (Cluster) and modeled (T01 and PM) magnetic field values for the magnetospheric tail region between 8 Re and 15 Re.

This work is supported by Deutsche Forschungsgemeinschaft (DFG), RFFI grant 08-05-00896 and the Norwegian Research Council.

Discrete Structures in the Magnetotail Lobes and in the Lobe-Plasma Sheet Interface

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The survey of INTERBALL-1 measurements in the near (up to $-27 R_E$) lobes encountered several types of discrete plasma structures. In the present work we discuss the plasma structures of various durations with quasi-isotropic velocity distributions, resembling the plasma of the plasma sheet (PS). Previous studies performed on the basis of INTERBALL-1 observations revealed that the spatial distribution of such structures along the south-north direction depends on the direction of the interplanetary magnetic field. These transient observations of PS-like plasma may be caused by the large-scale disturbances of the boundary of already expanded PS. Multipoint CLUSTER observations allow to study spatial geometry of these structures. Such analysis gives us the opportunity to reveal whether the observation of PS-like plasma in the lobe is related with stable plasma filaments drifting towards the neutral sheet or it is associated with a sudden disturbance of PS boundary, possibly a result of the development of PS boundary instability.

Interaction between different magnetospheric regions during substorm

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

Relationship between energetic and thermal ions at $L < 6.7$

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Up to now it is not well known how the energetic ion population is related to the thermal plasma. Sometimes the spectra of these populations can be represented by single kappa distribution function. For disturbed periods the ion spectral shapes typically are more complicated and present a superposition of different forms. The Maxwellian form is the most able to describe the shape near knee. The differential intensity spectra at higher energies follow nearly a power law and are displaced sometimes in a parallel fashion with changing thermal energy of ambient plasma. Often it is difficultly conclusively decided whether the energetic particle population is an integral part of the hot plasma or has different origin.

We examine the differential energy spectra of ions with the energies 0.1-3200 keV using the CRRES data in the nightside magnetosphere when geomagnetic activity was at $AE > 100$ nT level. The CRRES was located near the equatorial plane and crossed the radiation belt and the inner part of the plasma sheet at $L \sim 3 - 6.7$. We consider the fluxes of ions with pitch-angles $\sim 90^\circ$ (J_{perp}) and $< 45^\circ$ (J_{para}).

We find that the overall ion J_{perp} spectra are smooth and present a superposition of kappa and Maxwellian forms. The main effect of increasing geomagnetic activity is heating of the plasma sheet. However the spectral parameters EO and α change independently for the high-energy and low-energy portions of the spectra. The spectral parameter EO changes from ~ 1.5 keV (~ 7 keV) to ~ 9 keV (12 keV) for the high-energy (low-energy) portion of the spectra with increasing K_p from 3- to 4+.

In the region of the energies > 70 keV, the observed J_{perp} changes are nearly adiabatic one. In the region $L < 4.5$ we find the anisotropic distribution with $J_{\text{perp}} > J_{\text{para}}$. In the more distant region the distribution with $J_{\text{perp}} < J_{\text{para}}$ is observed. The transit between J_{perp} and J_{para} moves from 220 keV (on $L \sim 4.7$) to lower energy (45 keV on $L \sim 5.3$) with the increasing L . The decreasing of the transit energy with the increasing L can be explained by the nonadiabatic scattering mechanism.

In the region of the energies < 70 keV, the observed J_{perp} changes are consistent with the quasi-adiabatic changes ($W/Bq = \text{const}$, where $q \sim 0.4-0.5$). The spectral changes are associated with the protons penetrating into the inner magnetosphere from plasma sheet and having the signatures of the nose structures. In this region we find the distribution with $J_{\text{perp}} > J_{\text{para}}$. However the overall spectra for J_{para} have abrupt intensity changes at energies 28-40 keV between the distributions J_{para} of the energetic ion and those at the thermal plasma.

We compare our preliminary results with other observations and discuss consequences of the observed magnetospheric dynamics of ions.

Calculation of the magnetopause stand-off distance

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The magnetopause stand-off distance (R_{sd}) is an important input parameter of the modern magnetospheric magnetic field models. The R_{sd} calculating can be based either on the dynamic *balance* of the *solar winds plasma's pressure* and that of the *Earth's magnetic field* or can rely on statistics of the dayside magnetopause location deduced from

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the satellite measurements. Choosing the first option, it's necessary to calculate the near-Earth's magnetic field taking into account the instant spatial-temporal distribution of the basic magnetosphere current systems. However in this case, a reliable conclusion is hardly achievable. In the other way, the analytical relations between Rsd and parameters of the solar wind and interplanetary magnetic field fixed by patrol satellites should be applied. But a) the Rsd set was computed shifting the satellite crossings of the dayside magnetopause to the initial point of the geometrical shape that describes the magnetospheric boundary; b) in the process only quiet or especially strongly disturbed conditions in the interplanetary environment took into account. The calculations of the magnetopause stand-off distance carried out in both ways have been compared with the satellite measurements executed in immediate proximity of the magnetosphere subsolar point.

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Models of the electric field and current systems in the high latitude ionosphere: splendours and miseries

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The models applied nowadays to describe electric field and current systems in the high-altitude ionosphere, are based on the *magnetogram inversion technique* or on the processing of radar and satellite measurements. In any case, to find a statistical relationship between the electric field (E) and the currents (J) in a each cell of the high-latitude ionosphere with solar wind parameters (density and velocity of the Solar wind plasma and the components of the interplanetary magnetic field vector) it's necessary to include processing measurement E and J according to some basic assumptions. Undoubtedly, the inevitable effect that such assumptions produce on the accuracy of certain model, is significant, on a par with the quality of the data taken into account. Our report presents a review of the postulates of the kind, their compliance and divergence from the reality, and its effect on the reliability and the accuracy of a model.

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Effects in the magnetosphere caused by active experiment in high latitude ionosphere, 16.02.2003. Satellite observations

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In this work, results of analysis of the EISCAT experiment of artificial modification of the ionosphere carried out on heating facility located in Tromso, Norway in 16.02.2003 are presented. The transmitter operated on frequency of 4.04 MHz with a 10 minutes period of square modulation. The experiment time had been chosen so that it coincided with the time of Cluster satellites flying over disturbed region. To confirm this, their orbits were projected along magnetic field lines to the height of ionosphere using Tsyganenko model (T96). The work purpose is experimental proof of the influence of the heating to the processes of ionospheric-magnetospheric interaction. For analysis, next Cluster's instruments are chosen: EFW – Electric Field and Wave, FGM – Fluxgate Magnetometer and CIS – Cluster Ion Spectrometer. The effect of the heating is supposed to be small and nonstationary at height of satellites orbits so different methods of spectral analysis were used namely Fourier, wavelet and EMD (Empirical Mode Decomposition) analysis. The mentioned methods applied to satellite data show different not always coincided results, but in most cases, it was possible to detect a signal at frequency of modulation of transmitter (0.0017 Hz). As a result of processing of all data it is possible to draw a conclusion that in the given experiment it was possible to reveal effect of work of the transmitter at height of satellites orbit level.

Distribution function of the transient ions in the thin current sheet

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Numerical self-consistent model of high-temperature collisionless magnetotail thin current sheets (TCSs) based on macro-particle method has been used for investigation of the distribution function of the transient ions for

symmetric 1D configurations of the TCSs with normal component of the magnetic field. It is shown that outside of the TCS the distribution function is approximately gyrotropic, and in the center of the TCS is essentially nongyrotropic.

The traveling convection vortex on 2 December 2007 over Arctic

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The traveling convection vortex (TCV) was observed on 2 December 2007 at 1100 UT in Arctic between geomagnetic longitudes 14° E - 115° E and geomagnetic latitudes 65 °-75°. The amplitude of the vortex was equal to 10 - 30 nT. The vortex started on the east Canada as Pc5 parcel and then moved in west - east direction with big velocity of about 5° per min. At the geostationary LANL A2 spacecraft, which was situated at the geographic longitude ~70° E, periodicity oscillations of low energy ion density and of its velocity in earthward and azimuth directions were revealed during this time. At the high-latitude Barentsburg observatory located in early afternoon sector (~1330 MLT) the magnetic impulse associated with TCV was accompanied with an auroral flash of about 1-2 min duration. This auroral luminosity can not be identified with oval aurora or substorm activity.

The StellaCam II as an allsky imager during the SCIFER 2 rocket campaign

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Due to the rise of the moon and sun during the SCIFER 2 (Sounding of the Cusp Ion Fountain Energization Region) rocket campaign over Svalbard in mid January 2008, it was necessary to come up with a solution to monitor the sky and aurora without using intensified camera systems. The reason is that intensifiers become damaged if they are illuminated directly by the moon or from scattered light from the sun. It was decided to test a simple and commercial available solution based on fisheye lens and a video camera used by the astronomical community. The camera successfully detected satellites, stars and weak dayside aurora. Stars were used to find the camera orientation and to evaluate the lens performance. Finally, an animation is compiled to identify the target aurora and locate the source area of ion outflow sampled by the rocket.

The influence of the solar wind dynamic pressure on the midday auroral precipitation under northward IMF

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Optical observations from high-latitude Heiss Island and Barentsburg observatories were used to examine the influence of the solar wind dynamic pressure (Psw) on midday aurora characteristics during periods of the positive interplanetary magnetic field Bz component. It was shown that the enhancement of Psw was accompanied with the increase in the dayside red auroral band intensity and with the shift of their equatorward boundary to lower latitude. However, a direct proportional dependence between changes of auroral features and Psw variations was not revealed. It is necessary to note that Psw variations with the duration of about 20 min and relative amplitude of ~20 % can influence effectively on soft (E<1 keV) dayside precipitation. The significant enhancement of auroral intensity ratio I₅₅₇₇/I₆₃₀₀ was observed in the equatorward part of red auroral band just after SC. It testifies that fluxes of harder (E>1 keV) precipitating electrons of the magnetospheric origin were superimposed on the soft precipitation spectrum. Using the latitudinal width of this part of red auroral band and the time of 630.0 nm luminosity increase, the thickness of the layer of solar wind plasma penetration on magnetospheric closed field lines and effective time of penetration were estimated in 2.5-3 Re and ~16-18 minutes correspondingly. The analysis of midday precipitating boundary displacement under smooth and sharp changes of the solar wind dynamic pressure testifies to that the simple equation of pressure balance in the vicinity of magnetopause was not carried out.

This study is supported by the RFBR grant 09-05-00818 and Program 16 of the RAS Presidium.

The change of magnetic configuration due to increase of plasma pressure in the inner magnetospheric regions: Results of modeling

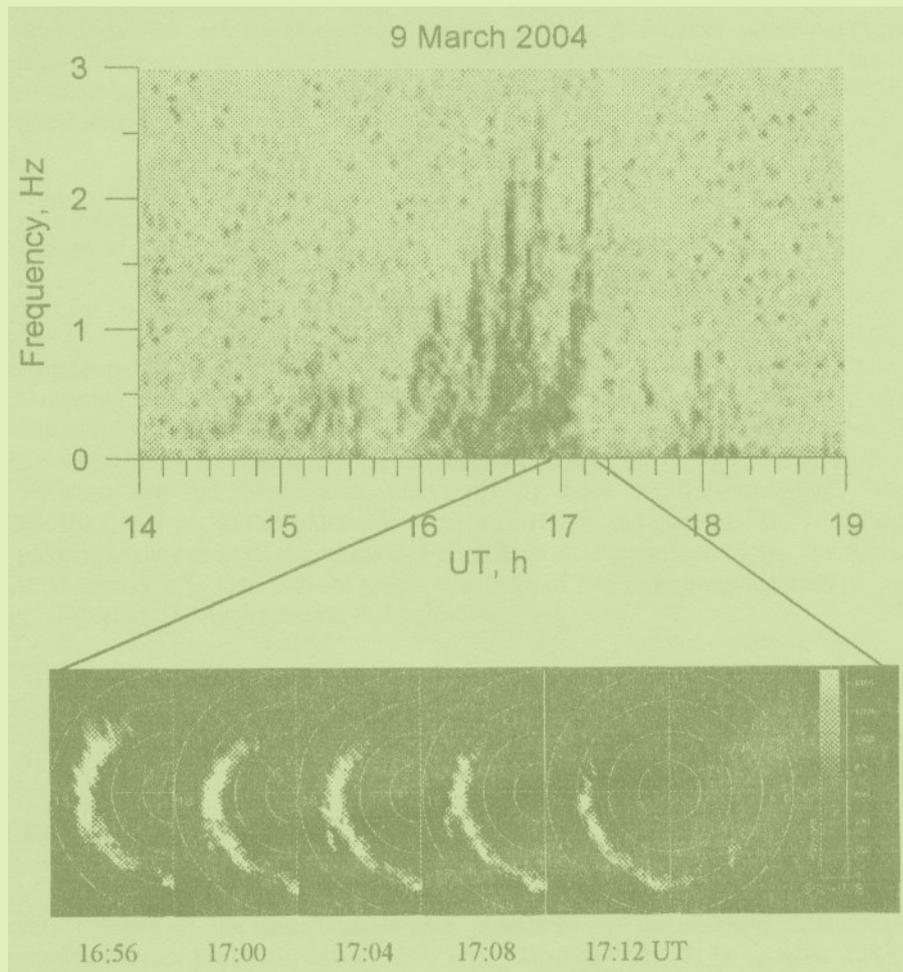
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The distortion of the magnetospheric magnetic field is developed due to the increases of plasma pressure inside the magnetospheric trap. Such distortion is especially pronounced during magnetic storms. The azimuthally symmetric part of this distortion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

Waves, Wave-Particle Interaction



Peculiarities of fractal characteristics of the ULF emissions in auroral zone based on the data of 210 MM stations

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Here we consider coordinated magnetic records (1Hz sampling rate) of the 5 stations located approximately at the same magnetic meridian (210 MM). The profile is tasted from the low latitude to the auroral zone. This chain of stations includes 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). One year period (1993) that embodies the date of the strong Guam earthquake of 8 August 1993 is analyzed. Fractal analysis of the ULF emissions (variations of the components H, D, Z in the ultra-low-frequency range of 0.002 – 0.5 Hz) has been applied. We have used the Higuchi method to get the stable values of fractal characteristics - spectral indexes β and fractal dimensions D . Comparison of the ULF emission scaling parameters obtained at different latitudes has been fulfilled with main attention to the auroral zone station Chokurdakh. Dependence of β and D versus Kp index of geomagnetic activity has been separately analyzed for all 24 local time intervals. Seasonal variation of the correlation between ULF emission scaling characteristics and Kp index is examined. It is revealed that the dynamics of the ULF emission fractal dimensions in the auroral zone (Chokurdakh) is more correlated with corresponding dynamics obtained in the near-equatorial region (Guam) rather than with the dynamics obtained for middle latitudes and subauroral region. We have compared the main fractal characteristics derived from the 210 MM stations (Guam, Chokurdakh) with the corresponding ones derived from the Barentsburg and Lovozero data. The results obtained are considered on the basis of the SOC (Self-organized criticality) concept.

Influence of impulses of solar wind dynamic pressure on Pc5 pulsations

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

In this work the influence of the negative and positive impulses of SI on Pc5 geomagnetic pulsations were examined. At 28 November 2000 the pair of negative and positive impulses of SI was observed in solar wind by the WIND and ACE spacecrafts with interval of few hours. At the same time Pc5 pulsations were observed on some stations of IMAGE profile during the four time intervals: before SI-, after SI-, before SI+, after SI+. For SOD station FFT spectrum were computed for 30-min time interval during these four time intervals. From the computed spectrum is seen that the frequency of Pc5 pulsations decrease after SI- and increase after SI+. Such behavior of the frequency of Pc5 pulsations may indicate that these Pc5 pulsations were generated by the cavity/waveguide mode in the magnetosphere. Moreover it is seen that the power spectrum of Pc5 pulsations increase not only after SI+ but after SI-. Therefore SI- just as SI+ may generate Pc5 pulsations.

Simultaneous Pc5 pulsations on the morning and evening sides of the magnetosphere

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The azimuthal characteristics of the simultaneous Pc5 pulsations on the morning and evening sides of the magnetosphere were considered. We select some events on 28 December 2002, 31 October 2003, 19 August 2001 when Pc5 pulsations were observed at ABK-IVA (morning sector) and TIX-CHD (evening sector) stations which correspond to the IMAGE and 210-M profiles. Azimuthal wave numbers (m) were computed by the cross-correlation method then the phase velocity (V_{ph}) was also computed. From the calculations we see that m and V_{ph} are directly differing for both flanges of the magnetosphere. So we conclude that the azimuthal characteristics of Pc5 pulsations were determined by the internal properties of the magnetosphere.

Storm-time Pc5 pulsations and CNA

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We examine CNA (cosmic noise absorption) in the conjugate station when storm-time Pc5 pulsations were observed in the magnetosphere. For this purpose we choose geostationary GOES-10 spacecraft and its conjugate station MCM (McMurray). For the interval 2000-2010 years which corresponds to the years of maximum solar activity we consider more than 20 events when storm-time Pc5 pulsations were observed at GOES-10. Storm-time Pc5 pulsations have a strong compression hp-component, it not seen at the MCM magnetic station due to shielding of the ionosphere, it have maximum of the occurrence at the afternoon hours. In all considered events we not observed Pc5 pulsations in CNA at MCM station. We suppose that this fact occur due to low level of the CNA in the afternoon hours when storm-time Pc5 pulsations were observed.

Some features of controlled generation of artificial ELF emissions during modification of the Earth's ionosphere by high-power HF radio waves

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We present the results of measuring the characteristics of electromagnetic disturbances at the altitude $h \approx 660$ km, which were obtained by the onboard equipment of the French microsatellite DEMETER when it passed through the magnetic force tube based on a region modified by high-power HF radio emission of the EISCAT heating facility. The experiments were performed in the autumn heating sessions of 2006–2008. The ionospheric E region was modified in the evening time by a high-power amplitude-modulated (AM) X-mode radio wave.

It is shown that the effective ELF wave generation due to the effect of demodulation of the AM radio wave at the auroral latitudes could even occur under quiet geomagnetic conditions ($K_p \approx 1$). In the performed experiments, generation of the second, third, and fourth harmonics of the ELF-emission fundamental frequency was recorded. This fact is related to the nonlinear character of the generation mechanism of ELF emissions since the spectrum of a rectangular-shaped envelope which was used for the amplitude modulation of the X-mode pump wave contained only odd harmonics. At the altitudes of the Earth's outer ionosphere, the artificially generated ELF emissions were recorded in a sufficiently narrow region of about 100 – 150 km along the satellite trajectory. This is indicative of the high directivity of the upgoing ELF emissions.

Efficiency of electron cyclotron acceleration by whistler-mode wave packets with varying frequency and amplitude

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We present some results of numerical modeling of the gyroresonant acceleration of radiation-belt electrons by quasimonochromatic whistler-mode waves with varying frequency, such as chorus wave packets. In particular, we study the influence of amplitude modulation typical for chorus elements on the efficiency of wave-particle energy exchange. The time scale of such a modulation is of the order of the period of nonlinear oscillations of trapped particles in the wave field. If the modulation depth is 50%, then the maximum energy gain of a single particle as well as the number of particles accelerated in the regime of trapping by the wave field decrease by about a factor of two. As the modulation depth is increased further, the maximum energy gain remains roughly the same and can reach several tens of keV for typical outer radiation belt conditions and for a wave frequency increase by 15%. However, the number of trapped and accelerated particles decreases quickly, i.e., by almost two orders of magnitude for the modulation depth of 100%. Thus, the role of particles trapped by a wave in the total energy balance of wave-particle interaction can become comparable to or less than the contribution of the particles accelerated in the stochastic regime.

The ionospheric response on SSC as measured by Doppler sounding

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The Doppler response is composed from long-period deviation with time scale about 10 minutes and short-lived, about one minute, positive spike. For the interpretation of this spike the variations of Doppler velocity induced by compressional and Alfvén waves are theoretically estimated on the basis of the thin ionosphere approximation. The plasma compression under influence of ULF wave is shown to be the dominating effect. Theoretical estimate indicates that for the same amplitude of the ground magnetic disturbances, a large-scale compressional mode produces a larger ionospheric response than an Alfvén mode. The magnitudes and waveforms of the simultaneously detected ionospheric and magnetic responses on SSC at low-latitude site in Japan fit the considered model.

Spatial-temporal dynamics of scaling characteristics of the ULF (0.002-2 Hz) fluctuations of the Earth's magnetic fields at high latitudes

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Mono- and multi-fractal analysis of the Earth's magnetic field variations in the ULF range ($f = 0.002 - 2$ Hz) has been fulfilled on the basis of data obtained at the high-latitude stations Barentsburg ($\Phi_m = 76^\circ\text{N}$) and Lovozero ($\Phi_m = 64^\circ\text{N}$) for one year period of 2008 with 10 Hz resolution (materials of Polar Geophysical Institute). Such a high resolution allows us to investigate appropriately the fractal properties of ULF emissions in the frequency range from $f=0.001$ Hz up to $f=3$ Hz. The Higuchi method has been used for monofractal analysis and WTMM and MF-DFA methods have been applied for calculation of the multifractal spectrum. Two intervals of scaling (high frequency and low frequency) have been revealed with crossover frequency being in the range of 0.01-1 Hz. The pronounced daily variations of the crossover frequency have been obtained for the Barentsburg data, which coincide with daily variations of the Barentsburg position regarding closed and opened field lines. It is shown that the high frequency branch of fractal scaling at the cusp latitude (Barentsburg) exhibits the antipersistent behavior at all local times, whereas in the auroral zone (Lovozero) there exists transitions between persistent and antipersistent behavior. Correlation relationships between fractal dimension (for both scaling branches) and geomagnetic indices (Kp and AE) have been investigated. It is shown that the high frequency branch is more variable and informative. The obtained fractal characteristics are compared with corresponding characteristics reported for the 210 MM stations. Multifractal spectrum appears to be wider during geomagnetic disturbances in comparison with quite periods. An example of influence of the solar wind dynamic pressure on the ULF emission fractal characteristics is demonstrated. The results obtained show that fractal properties of the ground-observed ULF emissions allow insight into the global and small-scale dynamics of the solar wind magnetosphere – ionosphere system.

Dayside storm-time ULF pulsation in the solar activity minimum

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The dayside ULF-pulsation activity has been analyzed during the selected succession of 10 recurrent magnetic storms (CIR-driven storms), repeated with the periodicity of about 27 days in 2006. This time corresponds to the solar activity minimum. The ULF-index, measured the wave activity in the frequency range 2-7 mHz, was calculated according to the ground-based 1-min observations at the morning (03-12 MLT) and afternoon (12-18 MLT) sectors for auroral (60-70°) and polar (70-90°) latitudes. It was found that in all phases of the magnetic storms under consideration, the enhanced ULF-activity was observed at the auroral as well as at the polar latitudes. In the studied CIR-driven storms, the value of the solar wind velocity was very large (more 600 km/c) provided the Kelvin-Helmholtz instability enhancement and correspondingly the ULF wave generation. The daytime polar zone ULF intensity was of the same order or even higher than the auroral zone one. The ULF-index, calculated for the Interplanetary Magnetic Field (IMF) fluctuations, indicated the enhancement of the strong ULF waves, mainly in the

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initial and main phases of the analyzed magnetic storms. We assume that some of these fluctuations could penetrate into the open polar cap and provide an enhancement of the dayside ULF geomagnetic pulsations at the high latitudes. The ULF-index, based on the geostationary GOES data, demonstrated increasing of the intense ULF pulsations in the magnetosphere in the storm main and recovery phases, but not in the storm initial phase. The comparison of the ULF-activity during the CIR-driven storms (typical for the solar activity minimum) and CME-driven storms (typical for the solar activity maximum) showed that the ULF-activity associated with the CIR-driven storms was observed at the higher latitudes then in the CME-driven storm.

Modeling of the IPDP generation

A.A. Lubchich (*Polar Geophysical Institute, Apatity, Russia*)

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

Long-Period ULF Wave Activity in the Cusp Region

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

The nature of the global Pc5 pulsations

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

We also used the EISCAT radar data from the tri-static Tromsø-Kiruna-Sodankyla system allowing for calculating vectors of the F-region ionospheric plasma flow and electric field. The Pc5 frequency band pulsations were clearly seen in the Hall and Pedersen ionosphere conductivity, ionosphere plasma density, electron and ion temperatures,

and the ionospheric electric field. For the both intervals when the Pc5 pulsations were observed in the magnetic field on ground, hodographs of the electric and magnetic fields were made. The angle between polarization axis of the electric and magnetic fields may show whether the pulsations relate to the Alfvén mode (indicated by a zero angle), or the magnetosonic wave. From these considerations we conclude that the morning Pc5 pulsations were predominantly Alfvén waves. For the afternoon Pc5 pulsations the picture is more complicated indicating a mixture of Alfvén and magnetosonic waves. The present result agrees with the statistical studies by Rostoker and Sullivan, [1987] and Liu et al., [2009] who have shown that the morning Pc5 pulsations are mainly the Alfvén waves generated by the K-H instability at the magnetopause, whereas the afternoon Pc5 pulsations are mainly magnetosonic waves generated by the impulses of the solar wind dynamic pressure.

Response of the geomagnetic pulsations in the Pc1 range to the sharp increase of the solar wind dynamic pressure

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We investigated responses of geomagnetic pulsations of the Pc1 range to sharp increases of the solar wind pressure. The pulsations were observed with the induction coil magnetometer at observatory Lovozero (). In addition, observations of proton aurora from the IMAGE spacecraft were considered. For years 2001-2005, those pressure increase events were selected when observations of proton aurora onboard the IMAGE spacecraft were available. Several types of the Pc1 pulsation responses to the pressure increase were observed: 1) Bursts of hydromagnetic emissions (Pc1 bursts); 2) Sharp increase of the intensity and/or sharp change of the mean frequency of the preceding Pc1; 3) Onset of Pc1 or IPDP-like pulsations; 4) No change in the Pc1 emission regime (including the lack of the Pc1 activity). First three kinds of the Pc1 activity were found to be correlated with the sub-oval proton aurora flashes on the dayside, which, in turn, occurred in 2/3 of the solar wind pressure jump events. The Pc1 bursts were typically observed when the proton flashes was short, had a large latitudinal extension, and occupied the region conjugated with the location of the ground station. The response of types 2 and 3 were mainly observed when the ground station was at the periphery or close to the flash region. In such cases, the proton flashes had rather small latitudinal dimension in comparison with that during Pc1 bursts. The cases of type 4 were found when no proton flashes were observed during the pressure increases, or when the ground station was far from the proton flash region. The correlation of the proton aurora flashes with the Pc1 (EMIC wave) activity at conjugated locations means that the flash-related proton precipitation is the result of ion-cyclotron (IC) interaction in the equatorial magnetosphere. In the case of the solar wind pressure pulse the IC instability develops due to the increase of the temperature anisotropy of the ring current protons. The ionospheric projection of the region of the strongest anisotropy is manifested by the proton aurora flash. The variety of the flash configurations, intensities, and dynamics, together with the position of the ground station relative to the proton flash region explains differences in the Pc1 pulsation response to the sharp solar wind pressure increase.

Dependence of Pc5 ground-based intensity on the oscillation mode in the magnetosphere, poloidal or toroidal

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

The Pc5 events are picked out from GOES-8 data, and they compared with simultaneous pulsations on the earth in PBQ observatory near the footprint of field lines passing through the geostationary satellite. Magnetospheric pulsation mode is taken into consideration, and it is found that intensive pulsations on the ground are connected with strong pulsating hn component in the satellite, i.e. with toroidal mode of oscillation, not poloidal.

ULF magnetic response to lightning and sprites

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High-sensitive induction magnetometer data from the station Moshiri has been examined in search of a transient response to the regional lightning activity. The information from the lightning detection system was provided by the Franklin Power Company. The lightning events have been selected within the 100 km circle from a point located 300 km southward of the station. For many events the impulse produced by the lightning discharge can be seen. Moreover, for some events, besides the main impulse, a secondary impulse delayed about 2-3 s was observed. These echo-impulses are probably caused by the reflection of a part of wave energy from the upper boundary of the ionospheric Alfvén resonator. This sequence of lightning-produced impulses is responsible, at least partly, for the IAR features in dynamic sonograms. However, there are many puzzling events, when no magnetic response at all was detected, even for a rather intense stroke current. We made a similar comparison of induction magnetometer observations in Finland with the sprite occurrence over southern France. We found that the magnetic ULF impulses generated by sprites could be seen detected at distances about 2000 km.

Dynamics of energetic electrons in the magnetosphere caused by resonant wave-particle interactions

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Charged particles of magnetized plasma and self-consistent electromagnetic fields are the main objects in the magnetosphere, while plasma processes that include wave generation, propagation, and interaction with charged particles are among the most significant factors which determine the dynamics of the magnetospheric plasma. Of many wave modes, which propagate in the plasmaspheric region of the magnetosphere, whistler waves play the most important role in the dynamics of energetic electrons, as their resonant interactions are very efficient. There are three main sources of whistler mode waves in the magnetosphere, namely, lightning strokes, VLF transmitter signals, and various kinds of kinetic instabilities leading to generation of whistler mode waves. Resonant interactions of energetic electrons with whistlers may lead to electron acceleration, scattering into loss-cone, and consequent precipitation into the ionosphere and atmosphere. While electron resonant interaction with lightning-induced whistlers and VLF transmitter signals may, to a certain approximation, be considered as particle dynamics in given electromagnetic fields, resonant wave-particle interaction in the case of plasma instability is intrinsically a self-consistent process. An important aspect of the last case process is the possibility of energy exchange between different energetic electron populations. Thus, in many cases, whistler wave growth rate is determined by "competition" between the first cyclotron and Cerenkov resonances, one leading to wave and the other one to wave damping. Since particles which give rise to wave growth lose their energy, while particles which lead to wave damping gain energy at the expense of the wave, and since the first cyclotron and Cerenkov resonances correspond to different particle energies, wave generation as the result of plasma instability may lead, at the same time, to energy exchange between two populations of energetic particles.

Another plasma mode, whose role in resonant interaction with energetic electrons seems to be underestimated, is upper hybrid resonance (UHR) mode. Since the distance (in velocity space) between cyclotron resonances in the case of UHR waves is much smaller than in the case of whistler mode waves, a particle may cross many cyclotron resonances while moving along the geomagnetic field line in the field of UHR wave, which makes resonant interactions quite efficient.

Theoretical discussion of various aspects of resonant wave-particle interactions in the magnetosphere, those mentioned above and others, will be the subject of the report.

Calculations of wave disturbances in Pc1 frequency range

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Full-wave algorithm was used for calculations of reflection coefficients of plane Alfvén wave from ionosphere under various geophysical conditions. This first order of approximation study has given general peculiarities of Ionospheric Alfvén Resonator (IAR) such as its eigenfrequencies. However attempts to compare modeling parameters and observed ones of magnetic variations requires more accurate scheme of calculations. Spatial spectrum of the disturbances depending on a wave vector set is calculated and solution for spatially localized wave is synthesized. Calculations are available for the wave of arbitrary polarization measured in the ionosphere and magnetic pulsations recorded on the ground.

Fractal dynamics of the ground-observed ULF emissions as manifestation of the magnetosphere nonlinear dynamics

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In recent years a novel approach to study magnetosphere dynamics has been developing on the basis of the SOC (self-organized criticality) concept. The SOC approach is generic to slowly-driven, interaction-dominated, threshold systems, which exhibit emergent avalanching behavior similar to magnetic storms and substorms in the magnetosphere. The principal “fingerprint” of the SOC state is fractal organization in space (self-similar structures) and in time (“1/f” noise). So fractal analysis of the noise and fluctuations generated in the magnetosphere system could be of special interest to analyze the dynamic state of the magnetosphere (the rate of its criticality). In this aspect the ULF range (0.002 – 2 Hz) is the most promising one since ULF waves provide interactions and interconnections in the magnetosphere-ionosphere system. Here we summarize our results of fractal analysis of the ground-observed ULF emissions in a wide range of latitudes from the near-equatorial regions to the cusp area. We demonstrate fractal dynamics of ULF emissions during quiet and disturbed periods and show how geomagnetic disturbance is manifested in fractal characteristics of ULF emissions. We attribute the revealed peculiarities such as “kink” frequencies in scaling curves at high latitudes to the corresponding “kinks” in power-law spectra of magnetic fluctuations obtained with the Geotail spacecraft in the distant magnetotail (see reference). We argue that fractal properties of the ground-observed ULF emissions allow insight into the global and small-scale dynamics of the magnetosphere.

Reference

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Variations in the spectra of VLF chorus emissions measured by Cluster spacecraft and the backward wave oscillator model

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A mechanism of chorus generation was suggested by V. Yu. Trakhtengerts (1999) on the basis of the backward wave oscillator (BWO) regime of magnetospheric cyclotron maser. According to this mechanism, a succession of whistler wave packets is generated in a small near equatorial region owing to the absolute instability of whistler-mode waves in the presence of a step-like distribution function of energetic electrons in parallel velocities with respect to the geomagnetic field. In this report we compare the spectral characteristics of VLF chorus detected by

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the Cluster spacecraft near the geomagnetic equator, i.e., in the source region of these emissions, with the magnetospheric BWO model.

In the previous study (Macusova et al., 2009), we showed that the mean frequency sweep rate of chorus elements for different orbits of Cluster spacecraft increases with a decrease in the mean value of the cold plasma density along the orbit, in accord with the BWO theory. Here, we focus on significant variations of the frequency sweep rates which are observed during each Cluster flyby in the generation region. We analyze the possible relationship of such variations with the measured plasma density for several Cluster orbits using the chorus wave packets detected by the Wideband Data instrument onboard the Cluster spacecraft and the electron density obtained from the WHISPER active sounder data.

We compare results of this analysis with the BWO model. In particular, by using the measured frequency sweep rate and the cold-plasma density in the generation region we estimate a dimensionless parameter Q quantifying the excess of the energetic-electron flux over the absolute-instability threshold. We also compare the results with numerical simulations based on the BWO model.

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STARE-EISCAT observations of the afternoon pulsations Pc5

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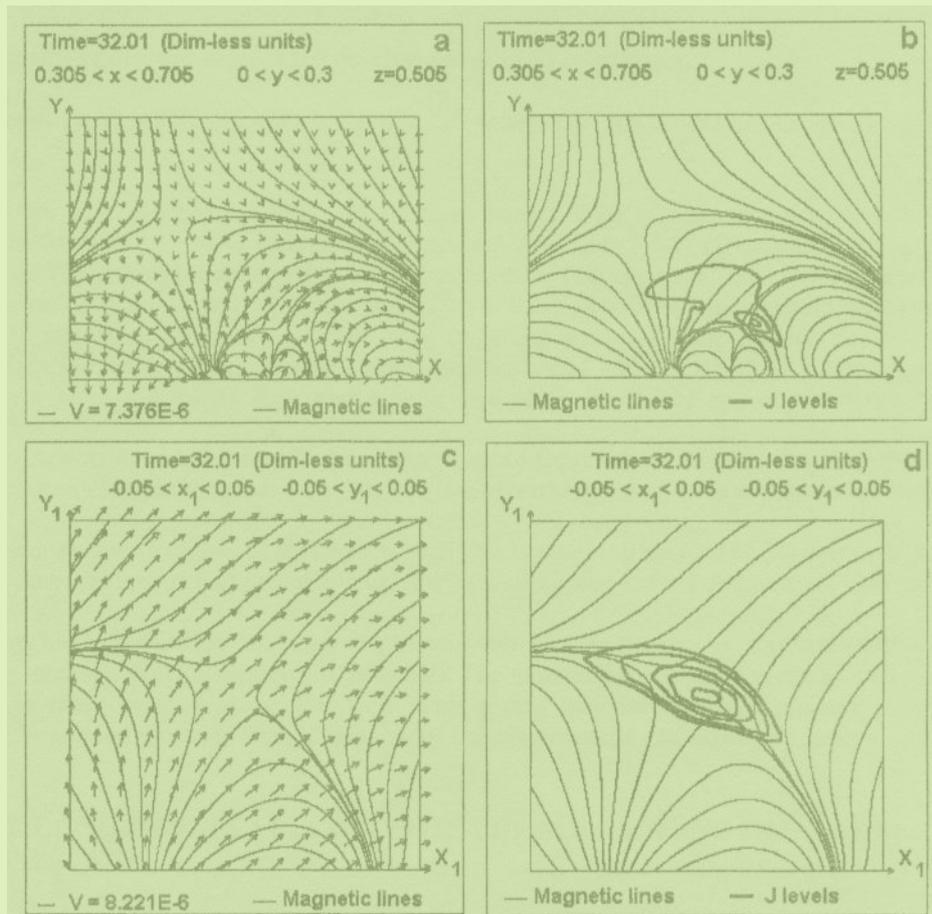
Ionospheric signatures of geomagnetic pulsations Pc5, e.g. pulsations of the ionosphere E-field and conductivity, can be well seen by the coherent and incoherent radars. The STARE and EISCAT collected area covers latitudes where the magnetosphere field lines can resonate in the toroidal Alfvén mode and the N-S electric field pulsations are enough large to excite ionosphere irregularities. Two cases (October 13 and 12, 1999) with a smaller and larger background electric field and conductivity show a clear common picture of in-phase pulsations in geomagnetic field, radar backscatter power and Doppler velocity seen by the STARE radars, in the ExB, Cs pulsations and moderate anti-phase pulsations in a precipitation and conductivity seen by the EISCAT radar. In both the cases E-field pulsations, $E_{rms} \sim 20$ mV/m, together with the background E-field, dominate in the backscatter power magnitude. For larger (smaller) mean conductivity and background E-field, there are larger (smaller) magnetic pulsations and smaller (larger) pulsation magnitudes in the backscatter power. We explain it as a case when for smaller background E-field the irregularities are nearly switched on and off, or for case with larger E-field the irregularity turbulence magnitude and the backscatter power are saturated due to increased wave losses.

Spectral parameters of ULF disturbances at high geomagnetic latitudes. Interplanetary and intra-magnetospheric control

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Spatial and temporal variations of several first moments of spectral distribution of long-period high latitude geomagnetic pulsations (Pc5/Pi3) and their dependence on field, plasma and particle parameters in the interplanetary space and in the magnetosphere are analyzed. Global and regional correlations exist on timescales about several days both for spectral power and for higher spectral moments. Coordinated variations of ULF spectral power is the result extra-magnetospheric control, while spectral slope and higher spectral moments are mostly controlled by the parameters inside the magnetosphere. A systematical behavior of ULF spectral parameters, almost independent on current extra-magnetospheric conditions, indicates the active response of the magnetosphere to the external forcing.

The Sun, Solar Wind, Cosmic Rays



Shower cosmic ray events detected by neutron monitors

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Three neutron monitors (NMs) in Barentsburg (Spitzbergen), Apatity and Baksan (Northern Caucasus) were equipped with new data acquisition system that records not only impulses, but time intervals between them with high precision. It allows studying such fast and fine phenomenon as a multiplicity. A multiplicity event is an isolated sequence of pulses with short time intervals between them. The isolated sequence of M pulses is multiplicity of number M. Multiplicity events can be generated by two ways: 1) by a local particle shower into the NM lead shell, or 2) by a shower generated by a nucleon into atmosphere above the NM.

On significant data array (250 days) the search of multiplicity events with M in limits 5-30 was performed. The multiplicity spectrum (dependence of events number on multiplicity M) was obtained. Some features of multiplicity events were studied: distribution of time intervals between pulses in dependence on M, occurrence rate of pulses forming a multiplicity in different channels, and so on.

Study of gamma - radiation connected to atmospheric precipitation

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Since 2008 we are monitoring the gamma - radiation in surface layer of atmosphere with scintillation gamma - spectrometers. Instruments consist of a crystal NaI, activated by thallium (NaI (Tl)), a photoelectronic multiplier and a pulse amplifier. The data are transmitted to the computer through a special block of electronics. The gamma-ray monitoring is presently made by three spectrometers. Two of them were installed at cosmic ray station in Apatity on June, 2009, and one more is included in the data collecting system of the neutron monitor in Barentsburg (Spitsbergen) since November, 2009. The spectrometers were tested with the help of a reference gamma source of Am241, having a weak line of 27 KeV and a basic one of 60 KeV. The measured energy resolution of the instruments makes ~ 20 %.

The detectors in Apatity are imposed by lead on each side and from below, for shielding them from environmental radiations from a building and ground. The detector in Barentsburg for the same purpose is established inside a metal tube.

Together with gamma-spectrometers in Apatity a precipitation measuring device (PMD) was installed, which allows to estimate presence and intensity of precipitations. PMD was designed in the Laboratory of atmosphere of Arctic of PGI).

The observations have shown that increases of gamma - radiation registered by spectrometers is almost always accompanied by intensive precipitations (rain, snowfall). The measured spectrum of gamma - radiation is continuous and smooth in a range from 1 up to 200 KeV. This means that the source of gamma - radiations are not radionuclides. The gamma spectrum from radionuclides has characteristic and expressed spectral lines.

EFFECTS OF LONG-TERM VARIATIONS OF THE SOLAR WIND PARAMETERS IN THE NEAR-EARTH SPACE

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There are a lot of the data of the solar wind parameters accumulated during epoch of the satellite exploration of the Space. It is possible to study interconnection between the long - term variations of the parameters of the solar wind and of the near - Earth Space during the last 4 cycles of the solar activity. We analyze quasi - stationary variations of the solar wind parameters during the solar cycle 23 in comparison with the correspondent changes in the cycles 20, 21 and 22. It was found that the main peculiarities of the cycle 23 are unusually low values of the solar wind magnetic field. We suggest that such long - term variations of the solar activity could change geoefficiency of the solar wind parameters which is expressed as diminishing of the electromagnetic energy transferred into the near - Earth Space. Therefore the global electric circuit parameters are changing correspondingly producing significant variations in the Earth ionosphere and atmosphere and indirectly in the planet climate. The last experimentally observed low values of the ground surface electric field, low concentration of the charged particles in the

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ionosphere, increasing area of the ice cover in the Arctic could be attributed to these changes in the solar wind parameters.

Modeling study of the hadron interactions in the neutron monitor

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With the purpose of specification of response function of a neutron monitor the modeling with a software package GEANT4 of hadrons (nucleons, π^\pm mesons) passage through a system lead - polyethylene simulating design of the neutron monitor is carried out.

The interactions of monoenergetic particle beams with energies 100, 300, 1000, 3000, 104 MeV with random angular distribution in an interval of incidence angles from 0 up to 30 degrees were considered. As a result of work the distributions of secondary neutrons on multiplicities were obtained. The dependence of multiplicity number on energy of incident neutrons was obtained as well.

Measurements of secondary cosmic ray neutrons at Spitsbergen with a Bonner sphere spectrometer and a neutron monitor

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The results of combined measurements of cosmic ray atmosphere neutrons by the Bonner sphere spectrometer (BSS), installed in Ny Alesund and neutron monitor (NM) in Barentsburg on Spitsbergen are considered. BSS is designed for measurements of a spectrum of neutrons in a range from 1E-09 up to 1E03 MeV at a surface of the Earth and its changes in time. The neutron monitor has the lower energy threshold of neutrons ~ 50 MeV and registers high-energy part of a neutron background. These instruments successfully supplement each other, when the detailed measurements of a radiating background of neutrons in a wide range of energy are required. For example, for tasks connected with aircrew dosimetry. For comparison of the data of both instruments it was required to carry out detailed and bulky accounts of the response BSS and neutron monitor, which were executed by the German group from GmbH with the help of a software package GEANT4. With use of these accounts a reduction to one scale of the BSS data in Ny Alesund with the NM data in Barentsburg became possible. In the long term we are going to perform combined measurements of a spectrum of neutrons by both BSS and NM instruments during GLE events, connected with relativistic solar cosmic rays.

ABOUT POSSIBILITY OF REAL-TIME MHD SIMULATION OF PREFLARE SITUATION IN CORONA ABOVE THE ACTIVE REGION

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The solar flare is explained by fast release of the current sheet magnetic energy in the solar corona above an active region. Current sheets appear in the vicinities of X-type singular lines by focusing of disturbances propagated from the photosphere. For simulation of the preflare situation in the solar corona above a real active region it is necessary to set all initial-boundary conditions for MHD equations from observations. The calculations are initiated several days before the flare when the strong disturbances are absent in the corona. So the potential magnetic field calculated from observed field distribution on the photosphere is used for setting of initial conditions. The boundary conditions are set from the observed magnetic field on the photosphere. Other values are set on the boundary by approximations of free-exit conditions. In previous MHD simulations the magnetic field on the photosphere has been changed in 104 – 105 times faster than in the reality. This causes strong disturbances with large currents, which can mask current sheets. Also the appeared unrealistically large velocities can displace current sheets positions comparing with real ones. To perform MHD simulation of active region evolution in the real time it is necessary to accelerate calculations strongly. It can be reached by improving of mathematical methods, so that the finite-

difference scheme is remained to be stable for sufficient large time steps. For this purpose the diffusion term approximation that earlier used in the absolutely finite-difference scheme is modernized. The scheme is conservative relative to magnetic flux. The finite-difference scheme becomes more stable, if the error of divergence of the initial magnetic field is sufficient small. To decrease this error the method of Laplace equation solving for initial potential field definition is improved. Then two corrections of potential field are performed to minimize the B divergence. First of them is realized by solving of the diffusion equation for B, the second one consists in adding the field of charges inserted in the centers of cells of the difference scheme grid. In spite of application of modernized methods the calculations are performed rather slowly so that one day of active region evolution is calculated on usual personal computer during ~ 1 year. The estimations of calculations acceleration using supercomputers, which is necessary to apply the MHD simulation for improving the solar flare prognosis, are done. Real time simulation of active region evolution during the time period significantly less then one day is performed. The beginning of current sheet creation by focusing of disturbances in the vicinity of X-type singular line is demonstrated. For convenient definition of the flare emission sources positions and representation of the magnetic field and plasma flow configurations near them the graphic visualization method with simultaneously calculations is partially modernized. The results are presented in the 2D and 3D space in the appropriate coordinate system. The magnetic field and plasma behavior near places, where current sheet creation should occur, are shown.

THE MAGNETIC FIELD OF AN ACTIVE REGION DURING A FLARE

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A solar flare appears as a result of energy release in the corona above an active region where energy accumulation can occur only in the magnetic field. Magnetic flux in the active region increases before the flare during 2 – 3 days up to 1021 Maxwell. But as for the time of flare development there is no considerable magnetic field change. It means that energy for a flare is accumulated in the magnetic field of currents in the corona, but magnetic energy of photospheric sources (solar spots) during a flare is conserved. Solar flares appear very seldom in the time of a solar activity minimum, because active regions are almost absent in that time. The typical interval between solar minimums is about 11 years. According to such a rule the minimum of the 23-th cycle should appear in 2007 year. However, now in spite of change direction of the solar magnetic dipole that always occurs in a solar activity minimum, the beginning of the new 24-th cycle still does not reveal itself. All predictions based on attempts to find any regularity in cycle periodic are failed. Another unusual solar behavior consists in solar spot magnetic field decreasing. The spot magnetic field during the 23-th cycle is decreased in ~ 1.5 times. If such tendency lasts, solar flares, coronal mass ejections, and magnetospheric storms will not arise. The similar situation has taken place in the XVI century during the famous Maunder minimum – so-called the little boulder-period. But in the last month active region have appeared again. It seems that 24-th cycle will not bring strong problems connected with solar activity.

The forecast of geomagnetic activity under the established characteristics of Solar wind magnetic cloud

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The task of the short-term forecast of geomagnetic storms intensity expected at interaction of magnetic clouds with Earth's magnetosphere is considered. The forecast is basis on technique of cloud parameters definition on few initial spacecraft measurements of magnetic field components and well known connection of geoeffective interplanetary magnetic field Bz component with Dst-index of geomagnetic activity.

Distribution of Bz magnetic field component in cloud is determined by its parameters: orientation in interplanetary space, value of magnetic field on an cloud axis and passage trajectory through the Earth. The behaviour of magnetic field vector Bz component of in cloud for almost 2 000 000 modelling magnetic clouds at various values of the specified characteristics has been analyzed. In result sets of magnetic cloud parameters at which occurrence of geomagnetic storms for various intensity is the most probable have been established. Conformity of these sets to the certain geomagnetic storm classes is tabulated. This table represents a basis for performance of the short-term forecast of geomagnetic storms intensity.

The sun, solar wind, cosmic rays

The suggested forecast method on real events has been checked. Comparison of magnetic storm intensity caused by real events, referenced in the literature as magnetic clouds, and storm intensity caused by modelling clouds, constructed on initial measurements on spacecraft is carried out. Conformity of geomagnetic storm classes for 80% of magnetic clouds is marked. Thus, the suggested method for performance of the short-term forecast of geomagnetic storm intensity caused by magnetic clouds can be used.

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Solar wind recurrent phenomena in 23-th minimum

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The prolonged minimum of solar activity (SA) in the end of 23-th solar cycle is continuing now, very low level of SA and geomagnetic disturbance is observed in the beginning of 2010. The phase of sunspot minimum is suitable for investigation of long-lived phenomena of SA, especially heliosphere plasma layer (HPL) and connected with him sector structure of interplanetary magnetic field (IMF) on the Earth's orbit. Recurrence of fast solar wind (SW) flows is the feature of regular phenomena, connected with equatorial and near-equatorial coronal holes (CHs) in minimal phase of SA. Namely these CHs are producing high-speed SW in immediate proximity to HPL. Absence of sporadic phenomena of SA (such as flares, coronal mass ejections and filaments) allows us to study SW and plasma parameters (data Wind) in the near-Earth cosmic space in quiet condition on the Sun. For these purposes the interval of Carrington rotations №2052-2091 (from January, 2007 till January, 2010) is defined. Fractal dimension calculations help us to estimate structural variations on intervals, which are lasting about a week or more. Such intervals have been named "activity impulses" in classical works of M.N. Gnevyshev and A.I. O'l. In an initial phase of a minimum these activity impulses have concrete manifestations: the high-speed recurrent streams of SW from equatorial and near- equatorial CHs. Impulses are separated by the regions of sector structure transition boundaries in according with heliosphere plasma layer intersection. It allows us to investigate longlived phenomena of SA and to explain changes by means of transformations of general solar magnetic field, large-scale magnetic fields and local photospheric magnetic fields in minimum, Comparison with solar maps, such as WSO source surface field, WSO photospheric magnetic field and coronal holes, helps us in SW flows – to recognize reliable source on the solar disk. A brief summary includes:

1. Fast solar wind streams from local equatorial coronal holes of minimum generate activity impulses.
2. Recurrence and variability of activity impulses are caused by heliophysical reasons, such as large-scale magnetic field transformations and reorganization of CHs in near-equatorial belt of the Sun..
3. Effect of the helio-projection of the Earth on the solar disk in yearly motion is seen in the preferred polarity of sector structure.
4. Fractal dimension calculations confirm the plasma layer transitions on the Earth's orbit.
5. Low geomagnetic activity exists in minimum. It is produced by activity impulses.
6. The duration of 23-th minimum is connected with the reaching of SA secular minimum, such as in the beginning of the twentieth century.

Butterfly asymmetry

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According to the classical α/Ω -type dynamo asymmetry between sunspot activity in the northern and southern hemispheres can be explained by interference between the dominant dipolar and quadrupolar modes of the solar dynamo. The last one can also be excited through nonlinear or stochastic effects. But if the north-south asymmetry exhibits long-term persistence, it should not be regarded as a stochastic phenomenon. We use dataset of historical sunspot records and drawings made by Staudacher, Hamilton, Gimmingham, Carrington, Sporer, and Greenwich observers, as well as sunspot activity during the Maunder minimum reconstructed

by Ribes and Nesme-Ribes. We compare hemispheric phase and latitudinal difference in the distribution of sunspots. We show that the phase hemispheric asymmetry exhibit secular variation. Periods of hemispheric leading varies from 35 to 55 \pm 1.5 years. Long-term antiphase relation between phase-leading and the latitudinal distribution of the sunspots, which is traced since 1750, is broken during the Maunder minimum.

О данных по интенсивности космических лучей в атмосфере над Апатитами и Долгопрудным в 2005-2010 гг.

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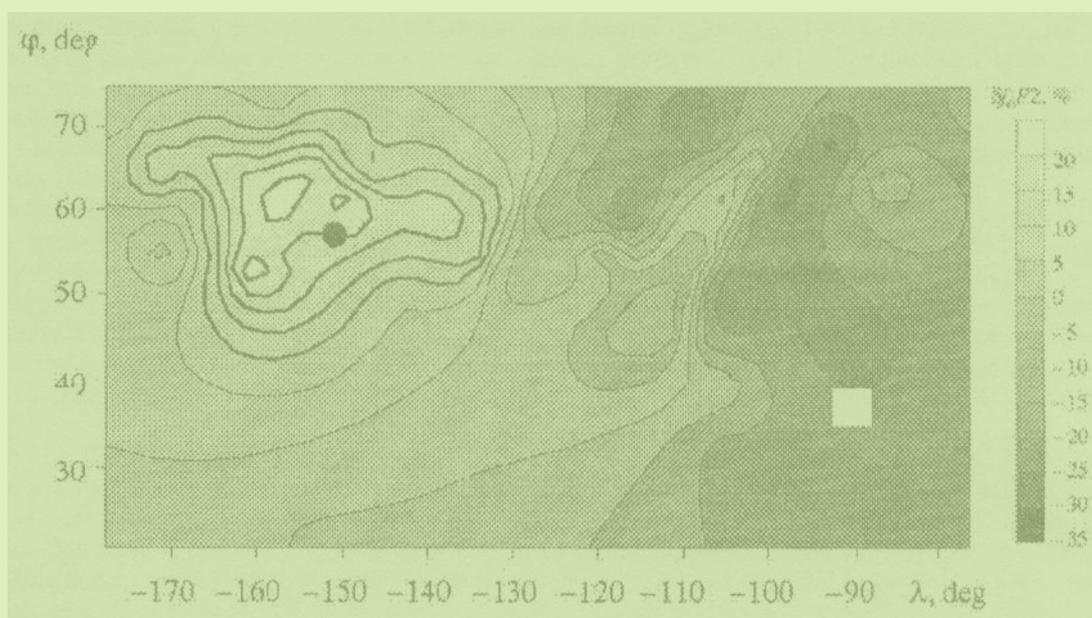
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Измерение интенсивности космических лучей в атмосфере над Кольским полуостровом и в Московской области проводится Физическим институтом им. П.Н. Лебедева с 1957 г. как часть регулярного баллонного мониторинга (РБМ) космических лучей в земной атмосфере. С октября 2005 г. параллельно с регистрацией стандартной информации (СИ, число зарегистрированных детекторами импульсов за каждую минуту) ведётся регистрация т. н. детальной информации (ДИ, форма каждого зарегистрированного импульса). Разработан программно-аппаратный комплекс РБМ-ДИ для регистрации ДИ, а также для визуализации процедуры приёма, привязки к мировому времени и фиксации важных событий (например, моментов контактов бародатчика). По результатам измерений создана база данных РБМ за 10.2005 – начало 2010, включающая как ДИ, так и исходную СИ и результаты ее обработки.

В докладе кратко описаны комплекс РБМ-ДИ и база данных РБМ и приводятся некоторые результаты обработки последней, иллюстрирующие преимущества использования детальной информации.

Ionosphere and Upper Atmosphere



Display of helio-geophysical parameters disturbances in the maximum observed frequencies on ionosphere oblique sounding traces

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Research of solar-geophysical parameters influence on maximum observed frequencies (MOF) variations for short-wave ionosphere oblique sounding traces Inskip – Rostov-on-Don and Cyprus – Rostov-on-Don in 2006, December and for traces Inskip – Rostov-on-Don, Noril'sk – Rostov-on-Don, Irkutsk – Rostov-on-Don in 2007, March is executed. MOF variation received by subtraction of a daily course from original MOF data. Velocity and concentration of Solar wind, module B and components B_x, B_y, B_z of interplanetary magnetic field and also intensity of X-ray radiation in wave-length range 1-8 Ang (XL) and in a range 0.5-3 Ang (XS) as a key parameters of interplanetary space were considered. The influence degree of each parameter on MOF variation has been established by search of its linear and nonlinear correlations with MOF on each trace. The time delay of MOF variations in relation to solar-geophysical parameters changes is analyzed.

Linear correlations results show more evident influence of B_y and B_z IMF components on MOF variation for subauroral trace Noril'sk – Rostov-on-Don in comparison with mid-latitude and low-latitude traces. In fact, the presence of B_y component becomes apparent in charged particles precipitation displacement effect closer to North Pole in the evening for B_y > 0 and to the same displacement in the morning for B_y < 0. Geoeffective component B_z < 0 occurrence conducts to increasing of layer F₂ electronic concentration maximum at latitudes about 65-67°. It is caused by day time cusp displacement to low latitudes near midday. Influence of B_x and B_z components for lower latitudes traces Inskip – Rostov-on-Don and Irkutsk – Rostov-on-Don is evident. For low-latitude trace Cyprus – Rostov-on-Don influence of IMF module on MOF variations is marked. Solar wind concentration and velocity influence on MOF variations for all traces is shown. For subauroral trace Noril'sk – Rostov-on-Don however these influence is less essential in comparison with other traces. For low-latitude trace Cyprus – Rostov-on-Don long-wave X-ray radiation in MOF variations is most evident.

Search of nonlinear connection between interplanetary space parameters and MOF variations by neural network recovery method is carried out. Variations on traces Cyprus – Rostov-on-Don, Noril'sk – Rostov-on-Don and Irkutsk – Rostov-on-Don has been recovered by data of Inskip – Rostov-on-Don trace. The degree of concrete parameter influence at its addition has been determined according to recovery efficiency increase. It is established, that account of the IMF module and components B_x, B_y in comparison with Solar wind parameters for trace Cyprus – Rostov-on-Don is the most evident. It is connected probably to location of reflection points at middle and low latitudes for examined traces, so changes in Solar wind concentration and velocity in their MOF variations is not shown.

Addition of IMF components B_x and B_y values allows to increase recovery efficiency of 7-8 %. Trace Noril'sk – Rostov-on-Don data recovery appeared impossible because of long night intervals. In addition MOF variations in subauroral zone are principle different from variations at middle and low latitudes. MOF recovery for Irkutsk – Rostov-on-Don trace is possible only with involvement of additional parameters. Recovery effectiveness at use of IMF module B increases by 40 %, at use B_y and B_z components by 30 and 40% and at use Solar wind concentration by 40%.

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Towards some peculiarities of gradient-drift instability in the E-layer of the ionosphere at low and high latitudes

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In the paper it is shown that the dispersion relation for gradient-drift and Farley-Buneman instabilities within the approximation of the two-fluid MHD should contain the terms, caused by the presence of gradients of the average particles velocity (velocity shear effect), that are neglected in the traditional theory. A general form of the dispersion relation was obtained for the case of slightly magnetized ions and with taking into account the gradients of the average velocities. It was suggested a solving technique for this equation, based on using the first approximation of Newton's method near the solution of the dispersion relation for gradient-free ionospheric plasma.

It was shown that after taking into account of slight magnetizing of the ions and gradients of average velocities the solution of the dispersion relation differs from solution used traditionally. The most significant difference should be

Ionosphere and upper atmosphere

observed at heights above 110-115 km, where ions becomes slightly magnetized.

At heights below 115km the solution transforms into standard one, except the situations, when the electron density gradient is parallel to magnetic field or wave-vector. In these cases the new summands to the growth rate obtained by us becomes significant and predicts the presence of gradient-drift instabilities even in these very cases in opposite to traditional theory.

The one of these terms becomes important at magnetic equator, when sounding is made almost vertically and sounding wavevector is almost parallel to the gradient of background electron density. The another term becomes important at high latitudes, where background electron density gradient is almost parallel to the Earth magnetic field.

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GPS deviatons at Kola Peninsula and Spitsbergen during auroral disturbances

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The study devotes the dependence of the GPS positioning temporal deviations on the aurora position and auroral disturbances throughout the polar region. The GPS measurements data include the Arctic GPS receivers data at Kola Peninsula and Spitsbergen. The auroral activity data include the low light level ground-based cameras and magnetometers network data from the Barents region stations. The auroral ionosphere disturbances are supposed to be one of the main sources of the GPS deviations in the polar region. A new method to reveal auroral disturbances impact on GPS positioning is under discussion. The main idea of the method is to block the GPS receiver field of view in order to model the situation, when the GPS receiver is inside the auroral oval. The comparison of the GPS temporal deviations and the aurora intensity spatial and temporal variations show a good correlation in case studies. The authors thanks to the Research Council of Norway through the project named: Norwegian and Russian Upper Atmosphere Co-operation on Svalbard part 2 #196173/S30 (NORUSCA2), the Nordic Council of Ministers grant number i A09161 and the Russian Fund of Basic Research grant 10-05-98800-r-sever_a for the support of this study.

Investigation of the UAM results sensitivity to the numerical integration parameters

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The numerical experiments have been made using the theoretical global Upper Atmosphere Model (UAM). We have investigated the influence of the numerical integration parameters such as the initial and lower boundary conditions, time and spatial steps of integration on the UAM calculated distributions of the neutral temperature and total mass density at the heights of upper thermosphere. The initial and lower boundary conditions were set according to the MSIS averaged by different means. It has been shown that the model results depend on the choice of the lower boundary conditions more strongly than on initial conditions. Variations of the integration spatial and time steps influence more on the absolute values of the model calculated thermospheric parameters than on their spatial structure.

Investigations of the diagnostic method possibilities of the ionospheric parameters basing on measurements and modeling of the background ULF magnetic noise spectral structures

E.N. Ermakova, S.V. Polyakov, D.S. Kotik (*Radiophysical Research Institute, N.Novgorod, Russia*)

The analysis of possible influence of the horizontal inhomogeneity of the ionosphere on spectra of ULF noise is made basing on the calculations of the tangential magnetic fields propagating in a spherical horizontally non-uniform Earth - ionosphere wave guide.

It is shown that this influence, as a rule, does not change essentially the character of spectra of background noise which is defined by properties of a local ionosphere. It confirms the possibility of development the diagnostic

methods of the ionosphere basing on measurements of natural ULF magnetic fields.

Numerical calculations of the magnetic components of background noise in frequency range of 0.1-15 Hz for homogeneous wave guide for the receiving points located at various geographical latitudes are executed. It was used for calculations the solution of a problem on excitation of the Earth – vertically non-uniform anisotropic ionosphere waveguide by a source like vertical electric dipole. Calculations were carried out for various numerical and analytical models of ionospheric parameter profiles.

Comparison of results of modeling and experimental researches of spectrum resonant structure at stations: Crete (35.15N, 25.20E), New Life (the Nizhniy Novgorod region, 55.97N, 45.74 E), Lovozero (68N, 35E) and Barentsburg (78.09N, 14.12E) was made. The degree of conformity of the various modeling profiles to the really existing was displayed due comparison of theoretical and experimental spectra.

The investigations are also complemented by the analysis of calculated and experimental spectra of the polarization parameter of magnetic noise. It is shown that the analysis of spectra of polarization parameters is most convenient for ionosphere diagnostics at heights of 80-300 km.

Work is executed under financial support of the RFBR, the grant № 09-02-97035.

Studies of the fine structure in the background magnetic ULF noise spectrum at the mid latitudes

E.N. Ermakova, S.V. Polyakov, D.S. Kotik (Radiophysical Research institute, N.Novgorod, Russi)

A new spectrum structure of the low- frequency noise was revealed from a monitoring at the ground station «New Life» (Nizhniy Novgorod region, Russia) in the period of 2007-2009.

The structure appeared as quasi harmonic oscillations of the magnetic component amplitude with frequency scales of 3-4 times smaller than those for conventional spectral resonance structure SRS.

The fine structure is observed simultaneously with traditional SRS and presumably is not connected with influence of the local ionospheric alfvén resonator. The occurrence of the fine structure during different seasons; its daily dynamics, width of the frequency range in which this phenomenon was observed have been investigated. «New life» characterconventional SRS (additional maxima, non equidistant resonant lines). The frequency range, in which the fine structure is observed, depends essentially on the season with maximum in autumn and spring time.

The analysis of possible mechanisms of formation such a spectral structure related to horizontal of the ionosphere and additional non homogeneity of the alfvén waves refraction index at the heights larger that 2000 km was performed.

Work is performed under financial support of the RFBR, the grant № 07-02-01189.

Reconstruction of stable diffuse arc intensity using two scanning photometer data

Yu. Fedorenko and Zh. Dashkevich (*Polar Geophysical Institute , Apatity, Russia*).

The experiment held in February 1999 on the Kola Peninsula yields data obtained by scanning multi-channel photometer at three sites aligned along magnetic meridian (Apatity, Verkhnetulomsky and Nikel). Three sites were equipped by optical receivers for 630.0, 557.7 and 427.8 nm emissions but only two of them were able to record 320.0 nm emission. The reconstruction of meridional intensity distribution and altitude intensity profile using three photometers data has already been made but the reconstruction using two sites only is a challenging task because in this case the inverse problem is heavily underdetermined and solution becomes unstable. We attempt to reconstruct spatial 2d intensity implementing obvious inequality constraint that intensity is always positive and also requiring minimum curvature and minimum length solution. The results demonstrate that our approach yields a solution without use of specific a-priory information such as probable or predicted by auroral model height intensity profile.

Global features of aurorae. Results of IGY

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For the first time almost all territory of the Earth was included in ground geophysical observations during International Geophysical Year (IGY, 1957-1958). Analysis of huge observational data led to establishment of two fundamental phenomena in the auroral physics: the auroral oval and the auroral (magnetospheric) substorm. This review describes origin of these new notions and their application to interpret various global polar aurorae distribution peculiarities. The satellite studies of near Earth's space began at a final stage of the IGY. It became obviously that the auroral luminosity is closely connected with the magnetospheric plasma structure, which opened new possibilities for monitoring of magnetospheric conditions based on ground observations of polar aurorae. The auroral oval and the magnetospheric substorm concepts became the paradigms of a new science – the Solar-Terrestrial Physics.

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

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

Results of the analysis of satellite (Cluster) and ground observation (Image Network) data of the experiment on artificial stimulation of the ionosphere and their mutual correlation

A.V. Gavrasov, A.L. Kotikov, A.L. Maulini (*Institute of Physics, St.-Petersburg State University, St.-Petersburg, Russia*)

The work is dedicated to one of actively developing lines of investigation in physics of ionospheric-magnetospheric interactions – experiments of artificial stimulation of the ionosphere. The experiment carried out in Feb. 16, 2003 on EISCAT (European Incoherent Scatter Scientific Association) heating facility (Tromsø) is considered. The transmitter operated on frequency of 4.04 MHz with a period of modulation 10 minutes (on / off). The heating was timed to Cluster satellites crossing the disturbed region, which is confirmed by projecting their orbits along geomagnetic field lines to the height of 100 km using Tsyganenko model (T96). Variations of electron density obtained from PEACE instrument were analyzed using Fourier and EMD (empirical mode decomposition) analysis. In order to observe heating effects from the ground level aurora all-sky camera recordings located in Kilpisjärvi and IRIS data were used. For aurora image processing a software package written Shibkov S.A. at the Department of Physics of the Earth SPSU has been used. The analysis shows that there is a visible effect at the frequency of modulation of transmitter 0.0017 Hz in different types of experimental data as in electron density at height of satellites orbit data as in ground based observation such as riometer data and variations of brightness of aurora .

Behaviour of the 5577Å and 6300Å emissions during substorms connected with recurrent solar wind streams

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

Additional data concerning the solar wind parameters, IMF, the precipitating particles and the magnetic field are used from the WIND and DMSP satellites and the IMAGE magnetometer network to determine the recurrent streams, the substorms during RS and the boundaries of the precipitating electrons.

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

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It is well known that in maximum of solar activity cycles the 630.0 nm emission intensity of a nightglow is increased up to twice. It was supposed that this phenomenon was caused by the solar ultraviolet variations in solar activity cycles (Fishkova, 1981).

In this report the results of photometric measurements of the nightglow emission intensity at the Yakutsk station (geogr. latitude 63° N) are presented. The presence of close relationship of the 630.0 nm emission intensity to the solar extreme ultraviolet intensity (EUV by SEM data) with a correlation coefficient ~0.8 during magnetic-quiet days of 1996-2007 has been established. Thus, the experimental confirmation of dominant role of the solar EUV in the 630.0 nm emission excitation of a nightglow has been obtained.

FEATURES OF THE RESONANT STRUCTURE OF IONOSPHERIC REFLECTION COEFFICIENT FORMING FOR THE NORMAL FALLING PLANE ELF VAWE

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Resonant structure of spectrum (RSS) for waves in the frequency range 0-10 Hz forms due to presence of two areas of reflection in the ionosphere. The first one forms by growth of electron density with the height and lies below the maximum of F-layer. The second one forms by specific decreasing of electron density above the maximum of F-layer. Interference of waves from these two areas forms nonmonotonic amplitude dependence of frequency, That's why for tasks of ELF waves in the Earth-ionosphere waveguide propagation, it is necessary to determine the ionospheric reflection coefficient or impedance exactly. In the number of works the ionospheric reflection coefficient was determined for the middle latitude ionosphere. Besides ionosphere was considered as a stratified medium. In the other works, method of bivector was used, in this method ionosphere is considered as continuous inhomogeneous with height, but this method leads to loss of information about the influence of ionosphere on the different polarization.

In this work for calculation of reflection coefficient Riccati equation solution for each polarization was used, and it made it possible to consider the ionosphere as the continuous inhomogeneous with height medium.

Necessary profiles of ionospheric parameters were chosen on the base of UAM (Upper Atmosphere Model) and IR12007 models, and the atmospheric parameters were chosen on the base of MSIS-E-90 model. Comparison of the results given by UAM versus IRI was carried out. It was shown that altitude and latitude behavior of some ionospheric parameters by IRI (particularly profile of mean ion mass and electron density above F-layer) doesn't shows specific RSS features. Calculations carried out on the base of UAM model give better coincidence with experimental results, but at the same time they need the correction according to current local state of ionosphere,

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which can be determined by other methods, for example by electron density tomographic reconstruction. The connection of some features of RSS with basic ionospheric parameters for different geomagnetic and heliophysical conditions was determined.

Irregular diurnal variations in foF2 in the summer ionosphere of the both hemispheres from the Intercosmos-19 data

A.T. Karpachev, N.A. Gasilov and O.A. Karpachev (*IZMIRAN, Troitsk, Moscow region, Russia*)

Zone of the irregular variations of foF2 in the Northern and Southern hemispheres is evolved from the Intercosmos-19 topside sounding data. In this zone the night-time foF2 values exceed the day-time ones. Such behavior is known as Yakutsk anomaly in the Northern hemisphere and Weddell sea anomaly (WSA) in the Southern hemisphere. In the Southern hemisphere WSA covers all the longitudes of the western hemisphere 180-360° and latitudes of 40-80°S, the maximum effect (up to 5 MHz) is observed at the longitudes of 255-315° and latitudes of 60-70°S (50-55° ILAT). In the northern hemisphere the anomaly is not so strong pronounced and occupies smaller area (at the latitudes of 55-65°N and the longitudes of 120-210°). The main characteristics of the anomaly do not practically depend on the solar activity. The reasons of the anomaly formation are examined on the basis of the quality and quantity analysis. To accomplish this the longitudinal variations in the ionospheric and thermospheric parameters for the midday and midnight conditions are in detail considered. They are mainly determined by the vertical drift effect induced by the neutral wind. The longitudinal variations in foF2 are strongly in the geomagnetic coordinates as a result of additional action of the solar radiation. Main ionospheric trough is the poleward border of the anomaly.

Detection of the large-scale inhomogeneities in the main ionospheric trough from the Intercosmos-19 topside sounding

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The complex ionograms of the topside sounding onboard the Intercosmos-19 satellite were observed on November 26, 1980 in the evening sector (18 LT) at the latitudes of the equatorial wall (55-65°N) of the main ionospheric trough, MIT. The two additional traces more distant than the main traces were recorded on these ionograms. All the traces become more diffuse, close in and finally merge into one, strongly diffused trace when the satellite approaches to the MIT minimum. The interpretation of the complex ionograms by means of the ray tracing was carried out. The 2D version of the ray tracing on the base of the method of the characteristics was used. The calculations show that the additional traces are related with the large-scale inhomogeneity which stretches along the magnetic meridian in the horizontal plane above the F2-layer maximum. The calculations allow to estimate the inhomogeneity parameters; $\delta N_e \sim 20-25\%$, the length, width and height are about 1000 km, 100 km and 300 km correspondingly. The increase of the spread F on all the traces is related with the growth of the small-scale inhomogeneities as the MIT minimum is approached.

Effects of magnetospheric substorms in the atmospheric electric field variations at polar latitudes (obs. Hornsund, Spitsbergen)

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The variations in the atmospheric electric field (vertical component, E_z) measured at the Polish station Hornsund (Spitsbergen) in 2004-2007 have been studied in the relationship with substorms development. In different local time and level of geomagnetic activity this station location can map into the polar cap, auroral oval or at the border between these structures. Only days, satisfied the "fair weather" conditions, have been used in our analysis. The average diurnal E_z variations under quiet geomagnetic state ($K_p \leq 2$) have been established. These variations are caused by many factors, such as an influence of high-latitude ionosphere plasma convection, local air conductivity,

the state of global electric circuit, i.e. the Carnegie curve, and etc. An interplanetary electric field enhancement (southward Bz IMF turning) and solar wind pressure increasing lead to a magnetosphere substorm development, the polar cap ionosphere convection enhancement and high-latitude magnetosphere structure change. We found the polar Ez variations related to substorms, observed at the auroral as well as at the polar latitudes. It has been established that such Ez disturbances are depend on the local time. The Ez deviations were positive in the local morning and negative in the local evening. We speculated that the sign of Ez excursion, probably, depends on the station location relative to the position of the positive or negative centre of the polar ionosphere plasma convection. This study was performed in frame of Russian-Polish scientific cooperation and was partly supported by the RAS Program № 16.

Numerical modeling of the Alaska 1964 earthquake ionospheric precursors

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The earthquake on Alaska in 1964 became the first one on which the researchers of the ionosphere have turned a fixed attention. The intensive searches of the earthquake ionospheric precursors have been carried out in many countries by numerous groups of researchers. The assumption that observable ionospheric effects some days prior to Alaska earthquake are caused by the disturbances of the zonal electric field in the near-epicentral area, stated by A.A.Namgaladze, was checked up in numerical calculations with use of the model GSM TIP and has found the confirmation. There is a question how such zonal electric fields can arise in the ionosphere prior to earthquakes? Now it is no answer to this question. Therefore for understanding of formation mechanism of ionospheric earthquake precursor it is necessary to understand the physics of lithosphere-atmosphere-ionosphere coupling before earthquake. Two hypotheses are in existence: the penetration of the vertical seismogenic electric field from lithosphere into the ionosphere; the propagation and dissipation in the upper atmosphere of the small-scale internal gravity waves (IGW) generated in the epicenter of the future earthquake. We have simulated with use of the model GSM TIP the effects of small-scale IGW and penetrated vertical electric field with different potential difference between Earth and ionosphere for the Alaska earthquake. The numerical experiments have shown, that the local perturbations of vertical electric fields and the small-scale internal gravity waves generated in the near-epicentral area allow reproducing of ionospheric disturbances observed in the periods of seismic activity.

Magnetospheric and thermospheric origin electric fields influence on the enhanced electron density regions in the night-time ionospheric F2-layer

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Earlier, we showed that the main cause of the occurrence of the night-time middle-latitude enhanced electron density regions (EEDR's) is the equatorward thermospheric wind driving the F2-layer plasma to the higher altitudes thus decreasing the ion loss rate. The electromagnetic drift influences on the latitudinal location of the high-latitude sides of the EEDR's, moving them to the lower latitudes due to the equatorward displacement of the main ionospheric trough under the action of the magnetospheric electric fields.

In this work we have presented the results of the investigation of the electric fields influence on the equatorial sides of the EEDR's for different helio-geomagnetic conditions including quite conditions, equinox and solstice under the low and high solar activity. The global numerical model of the Upper Atmosphere of the Earth Model (UAM) has been used in this investigation. The model calculations of the global electron density distributions have been carried in different combinations of the UAM with the empirical model of the thermosphere (NRLMSISE-00) and the empirical model of the horizontal thermospheric wind velocities (HWM-93). The results of the electron density calculations were compared with the empirical model IRI-2001 predictions.

The model results show that the equatorial sides of the EEDR's depend on the magnitude of the magnetospheric electric fields: the higher of magnitude, the smaller of the steepness of these sides.

The latitudinal location of the equatorial sides of the EEDR's depends on the seasonal and solar activity variations of the thermospheric (dymano) origin electric fields. These sides can lie on the equatorial anomaly remains at the night-time. As result the EEDR's and equatorial anomaly are not separated. This effect takes place at summer

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solstice conditions under the low and high solar activity.

Testing of the Upper Atmosphere Model using the empirical ionospheric models

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The seasonal variations of the quiet ionospheric F2-layer have been modeled by using the different versions of the numerical global Upper Atmosphere of the Earth Model (UAM). The model calculations have been carried out in two versions: 1) by using the empirical thermospheric NRLMSISE-00 model for neutral components and 2) by using the theoretically calculated thermosphere parameters. The both versions of the model calculations were carried in the following ways: 1) the 3D thermospheric circulation was calculated from the solution of the momentum and continuity equations; 2) the horizontal velocities of the thermospheric wind were calculated by using the empirical HWM-93 model. The results of f0F2 and hmF2 calculations were compared with data of two empirical models: 1) IRI-2001 and 2) Q-F2, which was developed by M.G. Deminov.

The all versions of the model calculations show a better agreement for winter solstice and spring equinox at the northern hemisphere. There are the maximal differences between all model results and experimental data in the night-time sector. It has been shown that these differences are related with variations of the thermospheric circulation and neutral gas composition.

Anisotropy of auroral scaling: application to ground-based observations

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By now, different types of scale-free behavior exhibited by auroral variations have been presented from analyzing ground-based imaging observations. Here we extend the wavelet-based method of Log-scale Diagrams (LD) to case of images with scaling anisotropy. To describe the anisotropy we characterize an image by the scaling index as a function of image rotation angle. The suggested method is applied to data of ground-based observations of different auroral structures by low-cost cameras AVT GUPPY F-044B NIR with $\sim 60^\circ$ lens. The data used were observed in Gillam (Canada) and Apatity (Kola Peninsula, Russia) during 2008-2009. The corrections of perspective distortions proceeding from altitude extension of auroral structures as well as some other corrections needed to obtain scaling characteristics of auroral particles precipitation are discussed.

New equipments for multi-scale auroral observations in Apatity

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New equipments contained of 5 cameras were developed for observations of auroral structures at different scales: (i) all-sky TV camera LCL-811K (1/3" CCD) with Fujinon lens YV2.2 \times 1.4A-SA2; (ii) two monochromatic cameras Guppy F-044B NIR (1/2" CCD) with lens for 15° field of view and glass filter ~ 558 nm; (iii) two color cameras Guppy F-044C NIR (1/2" CCD) with lens for 60° field of view. The cameras installed at the main building of Apatity division of PGI and at Apatity range. The distance between these points is 3850 m, so the identical cameras may be used as a stereoscopic system. All cameras may be accessed and operated remotely via Internet. The observational complex is aimed to following scientific problems: (i) Scaling in small-scale structures of aurora; (ii) Spatial structure of pulsating aurora; (iii) Vertical distribution in rayed structures; (iv) Relations between proton and electron precipitations (as a support of spectral observations at Apatity range). Some examples of observations are presented.

Full wave solution for a monochromatic VLF wave propagating through the ionosphereI.V. Kuzichev and D.R. Shklyar (*Space Research Institute of RAS, Moscow, Russia*)

Among many problems in whistler study, wave propagation through the ionosphere is one of the most arduous, and the most important at the same time. Both satellite and ground-based investigations of VLF waves include considerations of this problem, and it has been in the focus of research since the beginning of whistler study (Budden [1985]; Helliwell [1965]). The main difficulty in description of the problem arises from the fast variation of the lower ionosphere parameters as compared to typical VLF wave number. This makes irrelevant the consideration in the framework of geometrical optics, which, along with a smooth variation of parameters, is always based on a particular dispersion relation. Although the full wave analysis in the framework of cold plasma approximation does not require slow variations of plasma parameters, and does not assume any particular wave mode, the fact that the wave of a given frequency belongs to different modes in various regions makes numerical solution of the field equations not simple. More specifically, as is well known (e.g. Ginzburg and Rukhadze [1972]), in a cold magnetized plasma, there are, in general, two wave modes related to a given frequency. Both modes, however, do not necessarily correspond to propagating waves. In particular, in the frequency range related to whistler waves, the other mode is evanescent, i.e. it has a negative value of N^2 (the refractive index squared). It means that one of solutions of the relevant differential equations is exponentially growing, which makes a straightforward numerical approach to these equations despairing. This well known difficulty in the problem under discussion is usually identified as numerical swamping (Budden [1985]). Resolving the problem of numerical swamping becomes, in fact, a key point in numerical study of wave passage through the ionosphere. As it is typical for work based on numerical simulations, its essential part remains virtually hidden. Then, every researcher, in order to get quantitative characteristics of the process, such as transmission and reflection coefficients, needs to go through the whole problem. That is why the number of publications dealing with VLF wave transmission through the ionosphere does not run short. The purpose of this work is to give a new approach to the problem, such that its basic equations are regularized analytically before numerical calculations, while the latter become accomplishable with the help of a routine program. Such formulation of the task allows presenting all equations and related formulae in an undisguised form, so that the problem may be solved in a straightforward way, once the ionospheric plasma parameters are given. In the framework of the developed method, full wave solution for the electromagnetic field was obtained, and the reflection coefficient was calculated as a function of frequency for various angles of incidence.

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Hot oxygen corona simulations for VenusH.I.M. Lichtenegger¹, H. Groeller¹, H. Lammer¹, Yu.N. Kulikov², and V.I. Shematovich³¹*Space Research Institute, Austrian Academy of Sciences, Graz, Austria.*²*Polar Geophysical Institute, Russian Academy of Sciences, Murmansk, Russia.*³*Institute of Astronomy, Russian Academy of Sciences, Moscow, Russia.*

The existence of a hot oxygen corona was first suggested by the 130,4 nm observations of the UV spectrometer aboard the Pioneer Venus Orbiter and Venera 11 spacecraft about 30 years ago. However, these early hot oxygen detections from the UV spectrometer data have never been updated or confirmed by later measurements. In search for a solution to this riddle we have developed a 3D Monte Carlo model for the simulation of production and transport of hot atomic oxygen in the daytime ionosphere of the planet. With this model by using recent energy and mass dependent collision cross sections we calculated the energy distributions of hot O atoms produced in dissociative recombination of O_2^+ ions at different altitudes in the thermosphere. Then applying a test particle model which traces the ballistic trajectories of hot O atoms in the exosphere we calculated the exospheric density of the hot oxygen corona from the derived energy density and angular distributions at 240 km altitude. Our study indicates that if proper input parameters are taken into account, the hot oxygen corona at Venus appears to be about one order of magnitude less dense than suggested by the controversial PVO and Venera 11 observations.

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A study of some solar wind effects on the O⁺ ion escape from Venus

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The effects of the solar wind density and the interplanetary magnetic field (IMF) x component (the x-axis points from Venus towards the Sun) on the O⁺ ion loss rate from Venus have been investigated using a 3D quasi-neutral hybrid (HYB-Venus) model. The HYB-Venus model was first applied to a high-density (100 cm³) solar wind case selected from the Pioneer Venus Orbiter observations to demonstrate its potential for the study. Two sets of simulations with a wide range of solar wind densities and different IMF x components were then performed. It has been found that the O⁺ ion loss rate grows with increasing solar wind density nearly linearly at relatively small densities, but then saturates when the solar wind density becomes high (above 100 cm³). The results also indicate that the IMF x component enhances the O⁺ ion loss rate, provided the IMF component perpendicular to the x-axis is kept constant. Finally, the results imply a higher ion loss rate from early Venus, when solar conditions are expected to be substantially different from the present time.

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Validation of the model IRI - 2007 by the latest experimental data in auroral ionosphere

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Numerical calculations of ionospheric parameters by means of the model IRI-2007 were compared with the corresponding experimental data of vertical ionospheric sounding made at the auroral station Tromse ($\varphi = 69^{\circ}40' N$; $\lambda = 18^{\circ}56' E$) during September of 2009.

Experimental and calculated parameters of the ionograms as well as of vertical profiles of electron density were compared for the same periods of time.

It was found that the model values of the heights of electron density maximum during noontime exceed the corresponding experimental values in several times.

The same effect was obtained in comparison of the model and experimental foF2 values.

This difference could be explained by the fact that empirical model IRI-2007 is compiled by the data of the epoch before 2008 and could not contain the data of the year 2009. However epoch of 2009 is characterized by extremely low level of the solar activity which was expressed in complete absence of the sunspots as well as by very low values of parameters of the solar wind (its magnetic field, density and velocity). Such very low level of the solar activity was responsible for comparatively low intensity of the ionospheric electric fields which in its turn resulted in the low values of $h_{\max} F2$ and foF2.

Our conclusion is that the model IRI-2007 could not adequately describe a real situation in the auroral ionosphere in the periods of very low solar activity.

The role of ion diffusion in formation of 3-dimensional spatial structure of the plasmasphere

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The influence of various factors on formation of 3D spatial structure of the Earth's ionosphere and plasmasphere has been studying. In this work the role of ambipolar field-aligned diffusion in the process has been examined.

The study was conducted by a computer simulation method using the global numerical model of the Earth's upper atmosphere UAM. In order to select exclusively the role of the diffusion all other factors were eliminated in this calculation. Convection drift and neutral wind were set completely absent. In addition, the geographic and magnetic axes were superposed; the Sun was located exactly above the equator. The neutral temperature and composition distributions were "frozen" in Solar-magnetic frame, and ionospheric and plasmaspheric plasma rotated with the Earth, passing from day to night and back.

In the initial state the ionosphere and plasmasphere were uniformly filled with plasma of very low density. Then the ionization started and the plasma began field-aligned motion into upper parts of the field tubes. In order to smooth the sharp changes the calculation started in pre-midnight hours for each longitude (night-ionization of scattered radiation), and to the sunrise time the ion distribution became more natural.

The overall picture after 5 days of simulation time is fairly realistic: the repetitive diurnal variation in the ionosphere (the main ion is O^+) and the plasmasphere which is virtually uniform in the longitudinal direction (altitudes 1500 km and over – the main ion is H^+). Thus, we can assume that the model with all above listed simplifications is still physically appropriate, and smaller structural features of the "ionosphere-plasmasphere" system can also be considered as physically meaningful.

The main features of plasmasphere diffusion filling process obtained by the model calculations are:

1. During the 1st day the O^+ concentration maximum has been formed in the near-equatorial region (at the short tubes, $L \sim 0.1-0.15$). Its shape doesn't change later.
2. There are strong movements of O^+ ions above the daytime ionosphere on the first day. These fluxes are alternating in time and space. Later, as the "constant reserve" of H^+ ions is accumulating in the upper part of tubes, the O^+ fluxes are ceasing, sooner at the shortest tubes.
3. In the night sub-auroral ionosphere (latitudes $\sim 60^\circ-70^\circ$, $L > 4$) in the first day the maximum of O^+ ions appears. It extends into the plasmasphere up to 5000-10000 km. During the next days of calculation the latitudinal extent of this maximum decreases due to "melting" of its low-latitude margin. The ion concentration also decreases.
4. This maximum is clearly correlated with the descending sub-auroral night fluxes of O^+ ions. They also are maximum in the first day and are getting weak in the next ones.
5. In the first day there is a substantial concentration of O^+ in the upper part of mid-latitudinal tubes. In the following days the H^+ ions are accumulating there, O^+ concentration falls (H^+ pushes out O^+), and the characteristic shape of the meridional cross-section of the plasmaspheric O^+ concentration is being formed with a "hole" in the center and "horns" on the edges.
6. In the mid-latitudinal plasmasphere gradually (3-5 day of calculation) the maximum of H^+ ions is being formed, and corresponding maximum of O^+ ions appears at ionosphere heights. This feature correlates with the sharp lateral gradient of T_i (if T_i was assumed constant in the calculation, these maxima are not formed).

Physical mechanisms which are responding in the formation of these features have been discussed in the work.

Numerical simulation of the dynamics of fine-scale irregularities in the near-earth rarefied plasma

O. V. Mingalev, G. I. Mingaleva, M. N. Melnik, V.S. Mingalev (*Polar Geophysical Institute, Apatity, Russia*)

Electron density irregularities are regularly observed in the near-earth plasma. It is known that not large-scale irregularities are predominately magnetic field aligned. Therefore, plasma parameters inside and beyond the irregularity may be considered as independent on the longitudinal coordinate. Hence, it is sufficient to consider a two dimensional flow of plasma in a plane perpendicular to a magnetic field line. It is known that perpendicular to a magnetic field cross-sections of irregularities may have different forms. In particular, the perpendicular cross-section may be like a strait strip, so the irregularity structure is like a sheet. It is known that the electron density depletions and increases inside irregularities can lie in the range from a few portions to some tens of percents. The mechanisms responsible for the formation of small-scale irregularities may be not only natural but also artificial, for example, 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 irregularity is like a sheet, with its thickness being much less than the mean free path of particles between successive collisions

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and commensurable with a Debye length. The mathematical model is based on numerical solution of the Vlasov-Poisson system of equations, with the Vlasov equations describing the distribution functions of charged particles and the Poisson equation governing the self-consistent electric field. The system of equations is numerically solved applying a macroparticle method. The results of simulation indicate that the considered irregularity decays accomplishing periodic damped vibrations, with the process being collisionless.

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Study of generation of artificial magnetic pulsations in Pc1 range at Spitsbergen

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Excitation of artificial magnetic pulsations in Pc1 frequency range occurs rather rare. Moreover observation of the ionosphere response to ionosphere heating is not clear in the frame of a conventional model of their generation. Frequently for two events with very similar ionospheric condition artificial emissions may to be observed or not observed. This peculiarity was named as a sporadic nature of the artificial pulsations. Possible explanation of the sporadic nature is disturbances of neutral particle densities in the ionosphere. This parameter included in the numerical model is not controlled during experiments on ionosphere heating. Series of the heating experiments on the pulsation excitation at Spitsbergen give more features to the sporadic nature. Probability of their excitation is independent from local magnetic activity, although the artificial pulsation amplitude depends strictly on ionospheric magnetic field magnitude. The event study of the convection velocity also shows its insignificant correlation with the emission intensity. New ideas are needed to fit the experimental findings with the numerical model.

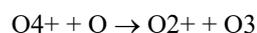
The influence of atomic oxygen concentration in the polar summer mesosphere on the parameters of ionospheric plasma in the presence of PMSE phenomenon

A. Osepian¹, S. Kirkwood², V. Терещенко¹

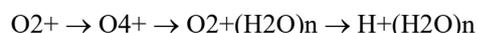
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It is known that the existence Polar Mesosphere Summer Echoes (PMSE) is accompanied by the fate of atomic oxygen in the mesosphere.. In the region of the mesopause concentration O decreases down to values 109 cm⁻³ (by factor 100 at the altitude 85 km compared to normal conditions in the absence of PMSE). A theoretical model of ionization-recombination cycle of the D-region is used to study the influence of atomic oxygen concentration on the height distribution of the main positive and negative ions, electron density and other parameters describing structure of the polar summer ionosphere in the presence of PMSE phenomenon against a background of both quiet (16.07.2004) and disturbed (Solar Proton event on 15.07.2000). ionosphere. The model is tested on the basis of experimental data. The rocket measurements allow to test results of numerical modelling of electron density for quiet conditions at the altitudes h>60 km; measurements with EISCAT 224 MHz radar in Tromso by incoherent scatter of radio waves method – at h>70-75 km. It is shown that decrease of atomic oxygen concentration in the region of mesopause observed at the time PMSE phenomenon influences significantly on ion chemistry in the mesosphere. Concentration both Cluster 1+ family (hydrated clusters O₂⁺ + (H₂O)_n, and NO⁺ (H₂O)_n) and Cluster2+ family (proton hydrated clusters (H⁺ (H₂O)_n)) increases. The height interval where positive cluster ions dominate over simple molecular ions NO⁺ and O₂⁺ expands up, electron density in the region of the mesopause decreases. These effects are more significant in a case when PMSE phenomenon is observed against a background of the SP-event. In quiet ionosphere numerical densities of the Cluster1+ and Cluster 2+ families increase by factors 3 and 6.5, electron density decreases in 1.3-1.5 times, During SP-event clusters increase in 5 and 10 times correspondingly, electron density decreases in 1.7-2.1 times . This is connected to the fate of atomic oxygen via the reaction:

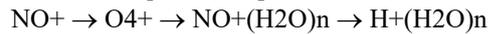


This reaction disrupts the initiating steps of the clustering chain that is a main path forming cluster ions during disturbances:



In the presence of PMSE phenomenon efficiency of this channel increases more rapidly compared to clustering

chain that is a main path forming cluster ions in quiet ionosphere:



University satellites development program

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Moscow State University has experience in developing and constructing small scientific and educational satellites. Young scientists, doctoral, and graduate students are participating in the development of the satellites and processing scientific data from the experiments. Not so far ago the program for satellites development was started in the MSU.

The “Universitetsky-Tatiana-2” satellite operates from September, 2009 till now and provides new scientific data. Its main scientific goal was raised after the “Universitetsky-Tatiana” experiment with UV detector – the detection of transient light effects in the atmosphere and the ionosphere. Now two more university satellites are being preparing – “Michailo Lomonosov” (“MVL-300”) and “YouthSat” satellites. The “Michailo Lomonosov” is planned to be launched in 2011, its main scientific goals are:

- The study of the high-energy CR and their sources;
- The on-line monitoring of the gamma-ray bursts with simultaneous study of their effects in ionosphere and atmosphere;
- And the investigation of the radiation environment of high-inclination orbits and Radiation Belts study.

The project of the Russian-Indian scientific-educational satellite “YouthSat” is developed in cooperation with the Indian Organization of Space Research. The Russian party - M.V. Lomonosov Moscow State University - provides the development of the scientific equipment SolRad for the studies of the solar activity.

More information about these experiments will be presented in the report.

Long-term variations of the energetic electrons at the low altitudes

V.L. Petrov, M.I. Panasyuk (*Skobeltsyn Institute of Nuclear Physics of Moscow State University, Moscow, Russia*)

The charged particles under the Radiation belts at the small altitudes are few studied till now. The wide-used radiation models do not take into account such fluxes. The long-term variations of the electrons with energies of hundreds keV at $L < 2$ are discussed. The variations were studied using the NOAA POES series satellites data. These satellites are operating at ~ 800-km circle polar orbits. The variations of the average electron flux for more than 10 years (1998-2009) are presented.

The new effects were revealed at near-equatorial and middle-latitudinal regions:

- Seasonal half-year variation of the quasi-trapped electrons flux;
- The average flux of the quasi-trapped electrons considerably increased in the previous solar cycle.

The electron flux variations were compared to different magnetospheric parameters. The results of the comparison are discussed in the report.

Precise time synchronization in ground observations: instrumentation and preliminary results

S. V. Pilgaev, O. M. Lebed and Yu.V. Fedorenko (*Polar Geophysical Institute, Apatity, Murmansk region, 124209, Russia*)

Ground observations of natural signals like atmospheric and natural ELF emissions and electromagnetic signals from transmitters operated in ELF – VLF frequency range become more informative if remote stations are synchronized to UTC with a maximum timing offset about several microseconds. The conventional approach is to synchronize ADC clock by GPS receiver that obviously must be placed close to ADC. Latter is sometimes unacceptable, especially if experiment required to run stations in autonomous mode and batteries can not be

Ionosphere and upper atmosphere

replaced often. We propose to synchronize not an ADC clock but datastream which let us to shift GPS from ADC placed remotely outdoor to main site. Such equipment has been successfully exploited during more than 3 years. It is installed in Apatity (vertical electric field and current measurements), Lovozero (3 magnetic and 3 electric components) and Barentsburg (3 magnetic components). The atmospheric electric field variations at Apatity and Lovozero were jointly analyzed in different frequency ranges, the preliminary results are presented and discussed.

The Novel PGI All-Sky CCD camera

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We represent new All-Sky CCD camera designed and developed in PGI in 2009 for observations of aurora, nightglow, twilight phenomena etc. It integrates outstanding Fish-Eye lens MAO-08 designed in the Main Astronomical Observatory (MAO) of National Academy of Science of Ukraine, monochromatic Stingray F-146B camera based on SONY CCD matrix ICX285 and advanced operational software produced in PGI. The MAO-08 is a large aperture lens of F/value=0.8, field of view 180 degrees, spectral range 430...750 nm, high resolution ca 70-100 1/mm and the possibility to use an interference filter. The Sony ICX285 offers good performance both in terms of sensitivity and extremely low dark noise. It has quantum efficiency up to 0.67 at 600 nm and more than 0.35 in 400-760 nm range. The 16 – bits ADC ensures a wide dynamic range while matrix size of 1388x1038 pixels allows pixel summation to improve sensitivity. The advanced software allows to make measurements and create a quick-look plots with and without operator intervention. In normal operational mode it is able to read measurement schedule from file and set exposition, gain and frame rate according to this schedule. The convenient feature is that camera may be accessed and operated remotely via Internet. The software required Open Source Linux distribution such as SuSE and Ubuntu so it is free of charge. The software tested under different Linux operation system including SuSE and Ubuntu.

Our novel All-Sky CCD camera was extensively tested and exploited under real operational conditions in Barentsburg and Lovozero observatories (PGI). The observations are presented and discussed. The suite of Barentsburg images is also shown at the site pgi.webhop.net.

Optical effects connected with the launch of ballistic rocket "Bulava" 9 december 2009

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Анализируются данные фото- и видео наблюдений "аномальных" оптических эффектов, сопровождавших запуск баллистической ракеты "Булава", проведенных в Норвегии.

Обработка полученных данных позволила установить связь различных характерных эффектов с определенными режимами работы двигателей ракеты.

The data of photo- and video of observations of the "abnormal" optical effects accompanying the launch of a ballistic missile "Bulava", recording in Norway are analyzed. Processing of the received data has allowed to establish direct connection of various characteristic effects with certain operating modes of engines of a rocket.

Mathematical modeling of the TEC variations prior to the New Zealand earthquake, Nov. 22, 2004

B.E. Prokhorov, A.A. Namgaladze, O.V. Zolotov, O.V. Martynenko (*Murmansk State Technical University, Murmansk, Russia; BorisProkhorov@yandex.ru*)

This paper is a further development of our previous work and presents the results of the investigation of the anomalous ionospheric TEC (total electron content) variations as pre-earthquake signatures for the strong seismic event of Nov. 22, 2004, 20.26UT (07.26LT), New Zealand (46.69 S; 164.78 E), M 7.1.

Maps of the TEC deviations have been obtained using NASA IONEX products (<ftp://cddisa.gsfc.nasa.gov/pub/gps/products/ionex/>). We analyzed differential TEC maps for a few days before and

after the seismic event. The observed anomaly defined as the local TEC deviation from the non-disturbed level at the near-epicenter area looks like the TEC reduction about ~40 degrees in longitude and ~25 degrees in latitude reaching values up to -43% during a day before the earthquake.

In this paper we check the previously set hypothesis of the vertical drift of the F2-layer ionospheric plasma under influence of the zonal electric field of presumably seismic origin as the main reason for the observed TEC disturbances. We test this hypothesis in case of the New Zealand earthquake by carrying out numerical calculations by means of the global time-dependent 3D self-consistent Upper Atmosphere Model (UAM).

We try to reproduce the TEC disturbances using additional electric sources. We modified the modeling scheme in comparison with previous calculations: 1) we saved the electric potential during first "non-disturbed" run; 2) then we loaded the electric potential during "disturbed" run and performed numerical calculations with gradually increasing modification of electric field over expected seismic event area, solving all the equations together with this new potential. In our previous work we just fixed the electric potential value at the given points during whole model run. Such "trick" allow us to reduce numerical instability at the modified electric potential nodes and flexibly set the additional electric potential's distribution.

Model results reveal better agreement with observations than in previous case and reproduce well the observed TEC behaviour in the southern hemisphere.

The work was partially supported by the Russian Foundation for Basic Research, grant No. 08-05-98830.

On TEC variations prior to the Haiti earthquake, Jan. 12, 2010

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This paper presents basic features of the TEC (total electron content) variations prior to the Haiti earthquake (Jan. 12, 2010, 21:53UT; 18.46°N, 72.5°W; M 7.0) possibly related to the seismo-ionosphere coupling that could be treated as forthcoming earthquake's precursors. We define seismo-ionosphere shock event precursors as anomalous local long-living TEC deviations from the non-disturbed level linked to some geoposition at the near-epicenter area. We have calculated and analyzed differential TEC maps for a few days before and after the seismic event using the NASA IONEX products (<ftp://cddisa.gsfc.nasa.gov/pub/gps/products/ionex/>). We have used running median for a few days before or centered to the current calculation moment as quiet background conditions (non-disturbed level). TEC deviations maps show long-living positive structures on Jan. 10 22UT till Jan. 12 08UT reaching values up to ~40% at the near-epicenter area and more than 50% at the magnetically conjugated region.

The work was partially supported by the Russian Foundation for Basic Research, grant No. 08-05-98830.

The infrared spectrometer IR180: design, and preliminary results

A. Roldugin, S. Pilgaev, Yu. Fedorenko and Zh. Dashkevich (*Polar Geophysical Institute KSC RAS, Apatity, Russia*)

We present infrared spectrometer IR180 constructed for studying the spectral composition and spatial distribution of the nightglow and aurora at near infrared region. The spectrometer is able to obtain spectral image along the main arc of sky hemisphere. It has the spectral range 732÷892 nm. The spectral response is about 0,7 nm. It operates at the rate 4 frame/min. Optical scheme has classical composition with transmission grating. IR180 was engineered and maked in 2008 year. The device can work both offline and being a part of a computer network. The preliminary results obtained at Barentsburg (Spitsbergen archipelago) in winter season 2009-10 years are presented. These results demonstrate that the spectrometer is an informative tool for studying processes in the upper atmosphere. When combined with an all-sky camera the device provides the broad view of the general auroral situation necessary for interpretation. The software used in data acquisition system offers flexibility which allows to realize an extensive range of operation modes. The device is operable under the most heavy field conditions.

Wave disturbances in the lower ionosphere during the earthquakes on August 2006

N.G. Sergeeva, O.F. Ogloblina, B.E. Vasiljev (*Polar Geophysical Institute, Murmansk, Russia, Sergnell@mail.ru*)

Abstract. The experimental data obtained by a partial reflections radar and a vertical ionosphere sounder located at the Kola Peninsula (Tumann, Russia) and the Northern Scandinavia (Sodankyla, Finland) are analyzed with the aim to detect the ionosphere response to earthquakes on 7 August and 11 August 2006. These earthquakes with magnitude of 6.2 and 6.7 on the Richter scale were fixed by seismic stations, located on Kola Peninsula and in Scandinavia. Earlier, for the analysis we have chosen earthquakes which took place under the quiet geomagnetic field and at small (background) solar flares. In this work we have considered changes of the ionosphere parameters during strong earthquakes which have occurred in the Pacific Ocean and Indian Ocean under different geophysical conditions.

The strong earthquakes with the magnitude of 6.7 took place on 7 August at 22:18:55UT in the Pacific Ocean (-15.80° S, 167.79° E) on the depth of 150 km under disturbed geomagnetic field ($\Sigma Kp=32.3$) and at small solar flares of the class A. Another earthquake with the magnitude of 6.2 has occurred on 11 August at 20:54:14 UT near Sumatra (2.40°N, 96.35 °E) on the depth of 22 km under quiet geomagnetic field ($\Sigma Kp=10.3$) and solar flares of the class B, C.

On day of earthquakes on 7 August and 11 August, the internal gravity waves with the periods of 2-6 hours were observed in the daily spectra of the ordinary component of a partly- reflected signal, of minimal frequency of reflection (f_{min}) and critical frequency of sporadic layer (f_oE_s) along with the tidal atmospheric waves with the various periods (18,10,8 hours). Spectra of the amplitudes of the ordinary components on 11 August under the big solar activity were broader, than spectra of the amplitudes on 7 August. On day of earthquake on 7 August the auroral absorption increased under very disturbed geomagnetic field ($\Sigma Kp=32.3$).

We may conclude that the amplitude fluctuations of the ordinary component of the partially reflected signal and of the other parameters of the lower ionosphere having periods of several hours are produced by the internal gravity waves which are related to the earthquakes.

Conjugate and inter-hemispheric occurrence of GPS TEC fluctuations in high latitude ionosphere

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In these report analyses of similarities and differences of TEC fluctuations occurrence at north and south polar ionosphere a during July 2004 geomagnetic storm are presented.

The permanent GPS measurements of IGS network were used to study occurrence of TEC fluctuations at north and south high latitude ionosphere. For the northern hemisphere we selected GPS stations located higher than 55N Corrected Geomagnetic Latitude (CGL) at different longitudes. For the southern hemisphere, Antarctic permanent GPS stations were used. Dual-frequency GPS measurements along individual satellite passes served as raw data. As measure a fluctuation activity the rate of TEC (ROT) was used and fluctuation intensity was evaluated using ROTI index.

Using daily GPS measurements from all selected stations, the images of spatial and temporal behavior of TEC fluctuations (in Corrected Geomagnetic Coordinate and local geomagnetic time) we formed. Similarly to auroral oval the images demonstrate an irregularity oval. The occurrence of irregularity oval relates with auroral oval, cusp and polar cap. During storm TEC fluctuation activity and intensity essentially increase. The irregularity oval expands equatorward with increase magnetic activity. As a whole the dynamics irregularity oval in both hemispheres is similarly in storm time, however we found some difference in development of TEC fluctuations between northern and southern ionosphere. They may be caused by seasonal features of excitation of irregularities in high latitude ionosphere. Daily pattern of the irregularities oval was controlled by the motion of the station location into auroral oval. Maximal intensity of TEC fluctuations took place over polar stations. The strong TEC fluctuations were associated with polar patches. The study was showed that the existing high- latitudes GPS stations can provide a permanent monitoring of the irregularity oval near real time. In report are discussed features of TEC fluctuation development at geomagnetic conjugated GPS stations.

FEATURES OF ARTIFICIAL ELF ELECTROMAGNETIC WAVES PROPAGATION IN HIGH LATITUDE AREAS

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In September of 2007 and in August of 2009 complex experiments on generation and receiving of electromagnetic waves in the extremely low frequency range, 0, 1-10 Hz. At the distance of 1200 km in the high latitude area where contribution in total field spreading in the upper ionospheric waveguide (above F-layer) becomes more significant to the wave spreading in the Earth-low ionosphere waveguide. In this report the experimental results are given and comparison of this data versus theoretical evaluation made with the use of method of two-dimensional telegraph equation for anisotropic inhomogeneous ionosphere model is examined.

As the emitter in described experiments the horizontal grounded power line with the length about 107 km located in the north part of the Kola Peninsula practically along geographical latitude was used. Measurements of the magnetic field strength were carried out in observatory of Barentsburg, Spitsbergen with the use of 3-component induction magnetometer.

Maximum field strength in the experiment occurred for horizontal component HW-E (west-east). Resonant structure of magnetic field amplitude as the function of frequency was detected. The results were compared with theoretical evaluation carried out with the use of ionospheric characteristics by the IRI and UAM models. It was shown that calculations carried out with the use of IRI model harmonize with the experiment badly. Evaluation with the use of UAM model gives better coincidence with the experimental data, but it is not free from defects too, so it is rational to use the results of experimental researches of ionosphere to determine ionospheric parameters more precisely.

Analysis of experimental results and theoretical ideas shows essential influence of lower as well as upper ionosphere on of artificial ELF waves propagation, and it shows practical opportunity of development of new methods of diagnosis of ionosphere by artificial generated ELF waves.

Study of high-latitude D-region ionosphere characteristics during periods of polar mesospheric echo appearances

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On the basis of partial reflections data and calculations on theoretical model of the lower ionosphere the D-region composition and structure were determined during occurrence the Polar Mesospheric Echo (PME) average radiowaves (2.6 MHz).

Satisfactory conformity between spatial-temporary characteristics of intensive reflections of medium radio waves and the Polar Mesospheric Summer and Winter Echoes (PMSE and PMWE), which were observed in the VHF and UHF ranges, was established. It was shown, that PMSE of the medium waves are formed at the heights near to the cold summer mesopause (84-87 km) in conditions of strong reduction of the electron concentration, and PMWE – at the heights below 80 km in conditions of sharp increase of the electron concentration.

On basis of comparison of experimental and theoretical profiles of the electron density and the analysis of geophysical conditions necessary conditions for occurrence of intensive mesospheric reflections are determined. It was shown, that for formation of PMSE at the heights near to the summer mesopause presence of negative charged aerosols or dust, and for occurrence PMWE presence in average D-region of the polar ionosphere of layers of meteoric ions is necessary. However, these conclusions demand the further experimental studying.

Research D and E regions of the polar ionosphere using the amplitude and phase measurements of partial reflections of ordinary and extraordinary radio waves

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Results of measuring the amplitudes and phases difference between magneto-ionic components of pulse radio signals on frequency of 2.6 MHz reflected from the lower ionosphere are presented. Measurements were spent on the modernized installation of partial reflections PGI in a vicinity of settlement Tumanny Murmansk region (69.0° N, 37.5° E).

Ionosphere and upper atmosphere

The description of a receiving equipment and technique for carrying out of the amplitude and phase measurements of pulse signals is given. The new way of operative determination of the electron collision frequency on measurements of the differential phase in the lower part of the ionospheric D-region is offered during strong disturbances.

Simultaneous measurements of amplitude and phase of partial reflections will allow to receive a trustworthy information about concentration and electron collision frequency and to understand the nature of the irregularities, causing reflections and scattering of radio waves at various heights in the lower ionosphere.

CORRELATION ANALYSIS OF ION AND ELECTRON TEMPERATURE VARIATIONS WITHIN THE AURORAL DYNAMO LAYER

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²*The Space Physics Department, University of Oulu, Finland*

Features of the linear correlation between temporal variations of the ion (dTi) and electron (dTe) temperatures measured by the EISCAT facility within the dynamo layer altitudes over Tromso during the ERRIS auroral campaign are studied as depending on the radar integration time and the strength of the ionospheric electric field. The data bank contains 19 events in 1988-89 spring seasons covering in total of about 60 hours of observations in near mid-night MLT sector. The results are the following: 1) Permanent anti-correlation of the ion and electron temperature variations is found for all of the events; 2) Values of the negative linear regression coefficient corresponding to different events cover range from about 1.5 up to 5.5, i.e. ion temperature variations are, on the average, a few times greater than that of the electrons; 3) Mean square root of the dTi decreases approximately three times when the EISCAT integration time was changed from 30 up to 90 seconds. Analogous parameter of the dTe became smaller merely by about 30%; 4) Correlation coefficient (CC) of the dTe and dTi increased from 0.2 up to 0.9 (within Mar.23, 1988 case study) during of about 40 minutes interval when electric field strength was smoothly varying from 10 to 18 mV/m. However, the CC coefficient has sharply decreased to zero during the next 10 minutes when E-field has exceeded the FB-instability threshold growing up to 30 mV/m.

Permanent presence of the negatively charged meteor dust in the auroral dynamo layer is proposed as an interpretation of the observed features. In particular, it is assumed that polarization electric fields of the charged dust are responsible for anti-phase temporal heating of the ions and simultaneous cooling of the electrons. Obviously, collisional energy exchange goes much more effectively between huge dust particles and massive ions than between the former and practically weightless electrons. That's why ions are capable to heat up and be cooled much more effectively and consequently faster than electrons in good agreement with the above results. The shown positive (negative) correlation between the ion-electron temperature variations coefficient and the ionospheric electric fields for under (above) of the conjectural level of FB-instability threshold E-field strength is interpreted in such a way. Electrostatic turbulent waves growing in course of the FB-instability destroy the ordered stable picture of the charged dust polarization E-fields induced by the ionospheric E-field within the laminar dynamo layer current.

The latitudinal profiles of O(1D) emission based on optical measurements and tomographic reconstruction of electron density in ionosphere

R.Yu. Yurik, B.Z. Khudukon, V.A. Turyansky (*Polar Geophysical Institute, Murmansk, Russia*)

In February and March 2009, coordinated ground-based optical and tomographic observations were carried out by the Polar Geophysical Institute (PGI). The aim of this campaigns were studying properties of the nightglow O 630-nm emission and electron density obtained by the satellite radio tomography. An optimized model of the volume emission rate for the atomic oxygen from the O(1D)-state is described and used in the data analysis. The optical equipment is based on a digital color camera centered at the 630-nm wavelength and it has been installed at a satellite receiver site near Murmansk. About 100-s integration time was applied during the optical observations. TEC measurements were performed at the same time by monitoring the coherent satellite transmissions ~150 and ~400 MHz of the Russian navigational satellites at a chain of nine radio receivers aligned essentially along the orbit projections of the satellites moving from North. A comparison has been made between the observed 630-nm line intensity, tomographic electron density data and model distributions of the appropriate parameters by applying the NRLMSISE-00 model during quiet and slightly disturbed helio-geophysical conditions which reveals the dominant role of the ionospheric electron density in formation of the red emission layer.

Utilization electron density distribution reconstructed from the radio tomography data in common with the

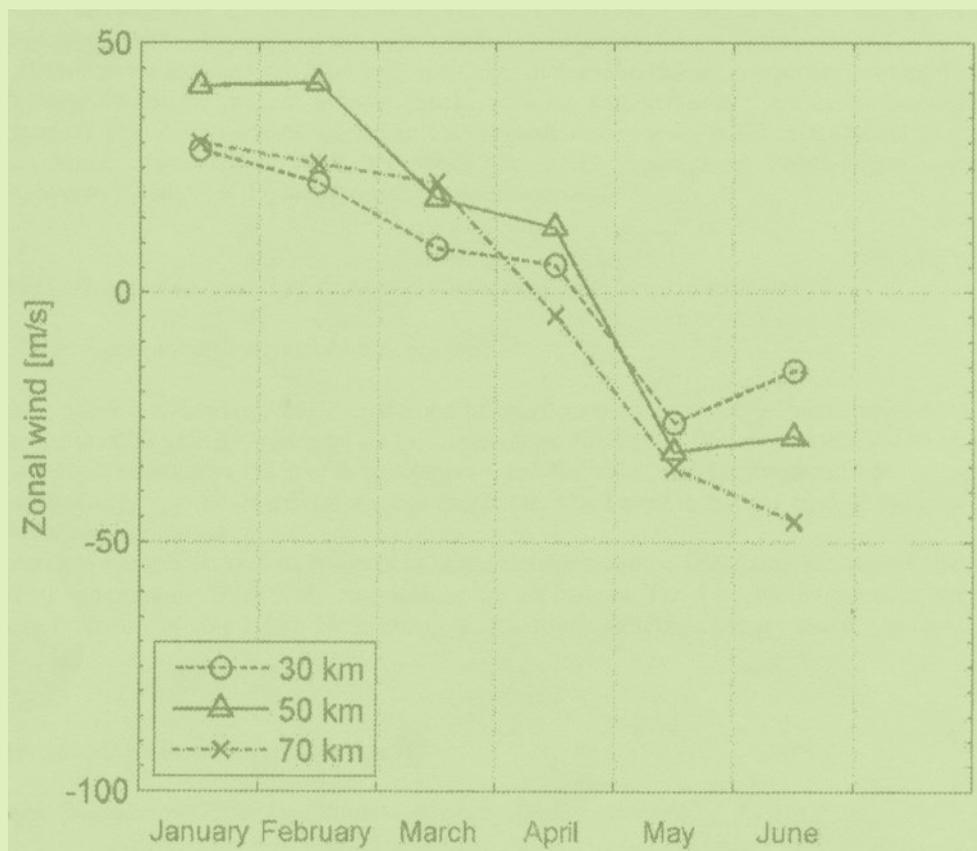
developed modeling of the volume emission rate demonstrates more realistic results than empirical model and allow us to predict the red emission occurrence in the wide area covered by the radio tomography chain.

Investigation of the ionospheric F-layer response to the FAC2 variations during April 16 and 17, 2002 using the magnetospheric block of the Upper Atmosphere Model

Yu.V. Zubova, A.A. Namgaladze (*Murmansk State Technical University, Murmansk, Russia*)

The F-layer behaviour during April 15-20, 2002 was investigated using the global numerical Upper Atmosphere Model and the incoherent scatter data. The worst agreement took place between the numerical results and the F-layer electron density measured over Millstone Hill during the night hours of April 16 and 17, 2002. The model simulations have showed that the observed electron density enhancement during the night hours of April 16 and 17, 2002 was caused by the “anomalous” convection pattern with the zonal plasma drift converging the ionospheric plasma to the midnight meridian. Such convection pattern occurs when the FAC2 intensifying and moving to higher latitudes. The standard UAM version with setting of the FAC2 location and intensity as input parameters produces the “classical” convection pattern with diverging plasma flow. The model simulations with the FAC2 distribution calculated by the UAM magnetospheric block have reproduced the “anomalous” convection pattern with converging plasma flow.

Low Atmosphere, Ozone



Ozone content and indoor air quality

V.I. Demin (*Polar Geophysical Institute, Apatity, Russia*)

Monitoring services inform us about air quality of the atmosphere. At the same time most townsmen spend indoors from 21 to 23 hours in day where air is more polluted than outdoor. However the use of air purifier does not ensure the air quality. When cleaning products and air fresheners are used indoors, occupants are exposed to airborne chemicals, potentially leading to health risks. Although not widely recognized, chemical transformations do occur in indoor air.

Research focused on three common classes of cleaning products and air fresheners: ionizers, electrostatic dust filters and ozonizers. The results of this study provide important information for understanding the inhalation exposures to certain air pollutants that can result from the use of common household products.

For example these electronic air cleaners emit ozone either purposely (ozone generators) or as a by-product of their particle removal process (ionizers and electrostatic dust filters). However despite the aggressive claims of manufacturers and distributors that the devices can remove many types of indoor air pollutants, ozone is ineffective at cleaning indoor air. Ozone cannot eliminate airborne bacteria, mold, or viruses in occupied spaces because very high levels of ozone – 5,000 ppb or more are needed to kill them. Note the 1-hour Russia ambient air quality standard is 50 ppb in air of work area and 80 ppb in atmosphere air of populated area. The test results of four models ozone generators showed that all of the models produce room ozone concentrations that exceed health-based standards (often several times higher) and can pose a serious health risk.

What's more electronic air cleaners can lead to a significant increase in indoor levels other pollutants through ozone reaction with other chemicals present indoors. Such reactions can generate toxic air contaminants (secondary pollutant formation). For example terpenes are volatile organic compound (VOC) constituents of products that are used indoors. Ozone reacts rapidly with terpenes. The direct products of ozone-terpene reactions include formaldehyde, hydroxyl radical (OH) and secondary organic aerosol.

Solar activity influence on starting date and durations of synoptic seasons

V.I. Demin (*Polar Geophysical Institute, Apatity, Russia*)

Cool December, 2009 and January, 2010 in Europe in conditions of continuing deep solar minimum quicken a discussion about the solar activity influence on the atmosphere circulation. Relations between the starting date and durations of synoptic seasons in the North Hemisphere and the solar and geomagnetic activity parameters were studied. The statistically significant effects are not found out. For example similar cool winters are possible in all levels of the solar activity.

SC. Starting dates of synoptic season do not concur with calendar seasons. The synoptic season is the year part when the main thermal and pressure fields in the troposphere are unchanged. The 6 circulation patterns and corresponding seasons are determinate over the North Hemisphere. Circulations patterns changes sharply going from seasons to season.

Surface ozone content in different air mass

V.I. Demin, M.I. Beloglazov (*Polar Geophysical Institute, Apatity, Russia*)

Assumption has arisen that meteorological demarcation line between air masses become apparent in boundaries in the surface ozone field. Slight ozone variability in the homogeneous air masses and rapid changes of ozone concentration under atmosphere front passing were reason for this assumption.

The ozone contents and ozone variations in the different air masses in the surface layer at the Kola Peninsula were studied. Air-mass analysis are based on meteorological data from located at the Kola Peninsula meteorological stations, surface and constant-level meteorological charts and calculation of 24, 36 and 96h backwards trajectories. The cases of advection of the arctic air, maritime polar air masses and continental polar air masses were considered. The cases of moving polluted continental air at the Kola Peninsula from East and Middle Europe were studied separately.

Advective component into ozone variations was calculated on the basis of typical values of ozone in main air masses in different seasons.

It is shown that characters of large positive and negative ozone anomalies are different. The large positive anomalies are caused by advection while the light turbulence is cause of appearance of negative anomalies. Time features of these anomalies are different too.

Low atmosphere, ozone

The ascertained patterns give rise to estimation of the ozone content in the boundary atmosphere layer over the Barents and Kara seas. According to advective model ozone concentrations over the Barents are approximately 30 ppb in autumn and winter, 35-40 ppb in spring and 20-25 ppb in summer, In the mean ozone concentrations over east part of the Barents Sea and over the Kara Sea are 5 ppb less.

Trace surface ozone measurements at the Kola Peninsula

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in 2009 the trace ozone measurements at the Kola Peninsula are started for study of spatial distribution of the surface ozone field in different meteorological conditions and under the influence of various types of the underlying surface. The first results show the slight ozone variability in the homogeneous air masses. The ozone concentrations at the seashores are close to one's at the central part of the Peninsula.

Influence of HF powerful waves on the ozone content in the Earth's atmosphere

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We consider in the report some results of microwave measurements of ozone content variations in the mesosphere (in the ionospheric D-region at heights of 50 – 60 km). These experiments were carried out on March 12 – 19, 2009 at the SURA heating facility located near Nizhny Novgorod, Russia (56°N, 46°E). Determination of the ozone content in the upper atmosphere were made using the method of the ground-based microwave radiometry, which is based on spectral measurements of thermal atmospheric emissions detected in the frequency range of ozone radiation and on analysis of data obtained.

The experiments were arranged in the following manner. The SURA facility radiated X-mode powerful radio waves at pump wave frequency of 4300 kHz with the effective radiated power $P_{eff} = 80$ MW. The pump beam was tilted 12° to the south from the zenith. In this direction it was directed the beam of a mobile microwave ozonometer used for measurements of thermal atmospheric emissions in a frequency range relative to 110.836 GHz. This frequency corresponds to the emission frequency of ozone rotational transition 60.6 – 61.5 when ozone molecules are in the main oscillatory state. The instrument for emission intensity measurements is comprised of a microwave heterodyne receiver and a multichannel spectrometer. A calibration system at the input of the receiver was used to calibrate registered emissions at frequency of 110.8 GHz. To receive the emissions it was used a horn antenna, with half-power beam width of 5.4°. This width is a few times smaller than the Sura antenna beam width of about of 15°. Characteristics of the microwave instrument are the following: the noise temperature is of 2500 K; the bandwidth of analysis is of 240 MHz; the spectral resolution is from 1 to 10 MHz; the number of channels is of 32. The ozonometer allows measuring ozone line spectral characteristics for a few minutes. Basing on these data a vertical distribution of the ozone content in a height region from 20 to 60 km can be determined with an accuracy of 20%.

During the experiments the ozonometer operated continuously from 14 March to 19 March. Ozone line spectra were measured with the time resolution of 15 min by the use of the method of absolute calibration of registered emission intensity by means of two radiation standards, one of which was at the temperature of background air and the second was at the temperature of the liquid nitrogen boiling-point. Twenty-four-hour observations allowed finding also diurnal variations of the ozone emission content in the mesosphere at a height of about of 60 km, which are connected with sunrise and sunset phenomena.

Heating of the ionospheric D-region was conducted on March 14 from 11:30 till 15:00 LT, on March 15 from 12:11 till 14:41 LT, on March 16 from 12:01 till 14:31 LT, and on March 17 from 11:40 till 13:10 LT; during these séances the facility was operated on 30 min – on, 30 min – off scheme. It allowed to obtain in twos ozone line spectra during both heater –on and –off periods.

The following results were obtained during these experiments:

1. D-region HF pumping causes to the decrease of the content of the neutral ozone in 17% at a height of about of 60 km. After pump wave switches-off the ozone content is restored.
2. Averaged diurnal variations of the mesosphere ozone content at a height of about of 60 km, which are connected with sunrise and sunset phenomena, has the magnitude of about of 40%.

Acknowledgments. This work was supported by RFBR grants 08-05-99047, 08-02-00171, 09-05-01041, 09-05-10033, and 09-05-97014.

10 years investigations of the solar UV radiation and total ozone in Stara Zagora, Bulgaria

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Some major results from the ground-based measurements of the ultraviolet solar radiation and total ozone content (TOC), performed in Stara Zagora (42° 25'N, 25° 37'E), Bulgaria in the last decade, are presented. The UV radiation reaching the Earth's surface at different conditions is investigated. The ozone amount is determined using the scanning ultraviolet spectrophotometer Photon, which measures the direct solar UV radiation (300-360 nm). The TOC dynamics is analyzed using data from ground-based measurements made by Photon, as well as these by satellite instruments (GOME, TOMS-EP and SCIAMACHY). The seasonal TOC variations are clearly marked. Quasi-biennial periodicity in the amplitude of the ozone maximums can be seen. The experimental data show that there is no any trend in the ozone course during the period 1997-2008.

The solar eclipse is an event, which gives the opportunity to receive an important information about the sun itself as well as about the influence of the solar radiation on the processes, defining the atmospheric components dynamics. The results from the TOC and UV measurements during two solar eclipses: on 29 March 2006 and on 11 August 1999, carried out in Stara Zagora, are presented.

Time-dependent modeling of the initial stage of the formation of cyclones in the intratropical convergence zone of the northern hemisphere

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A regional mathematical model of the neutral wind system of the lower atmosphere, developed recently in the Polar Geophysical Institute, is utilized to investigate the initial stage of the formation of cyclones at tropical latitudes of the northern hemisphere. The utilized mathematical model is based on numerical solving of full gas dynamic equations and produces three-dimensional distributions of the wind components, temperature, air density, water vapor density, concentration of micro drops of water, and concentration of ice particles in the height range from 0 to 15 km over a limited region of the Earth's surface. The dimensions of this region in longitudinal and latitudinal directions are 32° and 25°, respectively. The south boundary of the simulation domain is situated in the vicinity of the equator. The model takes into account heating/cooling of the air due to absorption/emission of infrared radiation, as well as due to phase transitions of water vapor to micro drops of water and ice particles, which play an important role. The finite-difference method and explicit scheme are applied for solving the system of governing equations. The calculated parameters are determined on a uniform grid. The latitude step and longitude step are equal to 0.04° and height step is equal to 200 m. Time evolution of model parameters in the simulation domain was numerically simulated using the developed model under condition that, at the initial moment, distributions of zonal, meridional and vertical components of the wind were consistent with the situation when the intratropical convergence zone intersects the simulation domain in the west-east direction. Calculations were made for various cases in which the initial forms of the intratropical convergence zone were different and contained crooks with distinct shapes.

Simulation results indicated that the initial shape of the crook of the intratropical convergence zone influences considerably on the transformation of the wind system in the simulation domain during one day. It was found the specific initial shape of the intratropical convergence zone crook which, in course of time, brings forth a cyclonic vortex flow with the center close to the southern edge of the intratropical convergence zone. The horizontal wind velocity in this cyclone may achieve a value of 20 m/s during the period of twenty seven hours. The radius of this large-scale cyclonic vortex is about 600 km.

This work was partly supported by the Basic Research Program No. 16 of the Presidium of the Russian Academy of Sciences.

Peculiarities of connection between space-time variations of precipitation and geomagnetic activity

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Currently mechanisms of solar activity effects on weather and climate have been discussed. In [1,2], authors proposed a physical mechanism of solar activity effects on climatic characteristics and the atmospheric circulation through the atmospheric electricity. A model of the solar activity effect on climatic characteristics of the Earth's troposphere was elaborated on the basis of the mechanism under consideration. The model key concept is the heliogeophysical disturbance effect on the Earth climatic system's parameters, which influence energy flux going from the Earth to space in high-latitude areas. When the solar activity increases, radiation cooling of high-latitude regions decreases, thermobaric field restructures, average meridian gradient of temperature between polar and equatorial regions decreases, defining the atmospheric circulation. Precipitation is a quantitative and the most sensitive indicator of the atmospheric circulation change.

NCEP/NCAR Reanalysis and CMAP data were used to analyze particularities and regularities of long-term variations in amount of precipitation in 1950-2007. Global decrease in amount of precipitation was found to dominate till late 1990s. It started increasing only 10 years ago. Peculiarities of distribution and long-term variations in amount of precipitation in different latitudes and longitudes were also considered.

Correlation analysis of connection between the amount of precipitation and the geomagnetic activity and atmospheric circulation was carried out. Peculiarities of the space-time distribution of correlation coefficients were studied. The connection was found out to depend on a season. Cold periods in the northern hemisphere were characterized by a direct relationship between the geomagnetic activity and amount of precipitation in high latitudes, whereas a negative relationship was observed in subequatorial latitudes.

One of the main statements of our model is corroborated by the results obtained from the analysis of changes in the geomagnetic activity, troposphere's thermobaric characteristics and precipitation.

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Observation of polar stratospheric clouds above Murmansk on January, 11 and 19, 2010

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On January, 11 and 19, 2010 in Murmansk during the period from 10:00 till 13:30 LT polar stratospheric (nacreous) clouds were observed. Similar very beautiful and the unusual phenomenon have been fixed above Murmansk on January, 29, 2008.

Results of photographic observation of nacreous clouds in Murmansk are presented, their heights are determined and conditions of formation of such clouds and their influence on the total ozone content in the atmosphere are discussed. Observations over stratospheric clouds will allow to determine character and speed of movement of air at heights from 20 up to 30 km and to understand processes of condensation water pair and conditions of its existence in a stratosphere.

Long and short time variability of the global temperature anomalies – Application of the Cochrane-Orcutt method

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Climate change holds a key position in science and policy today. A central issue to discuss in the scientific publications is the question how much humans contribute to the climate warming. To get answers in the last decades a lot of efforts were made to model the processes determining the climate, to make forecasts under defined conditions for the development of the society (climate projections). Another scientific tendency to find a more probable right answer consists in the application and development of the statistics.

Here a classical statistical method - the linear regression – is applied to examine the parts of the global warming due to different radiation forcings, by the use of their long and short time variabilities. It is shown that the residuals of the regressions are significantly autocorrelated. Therefore the Cochrane-Orcutt method is applied to test the statistical significances.

Азимутально-временные закономерности естественных источников КНЧ-шумов по данным высокоширотных наблюдений

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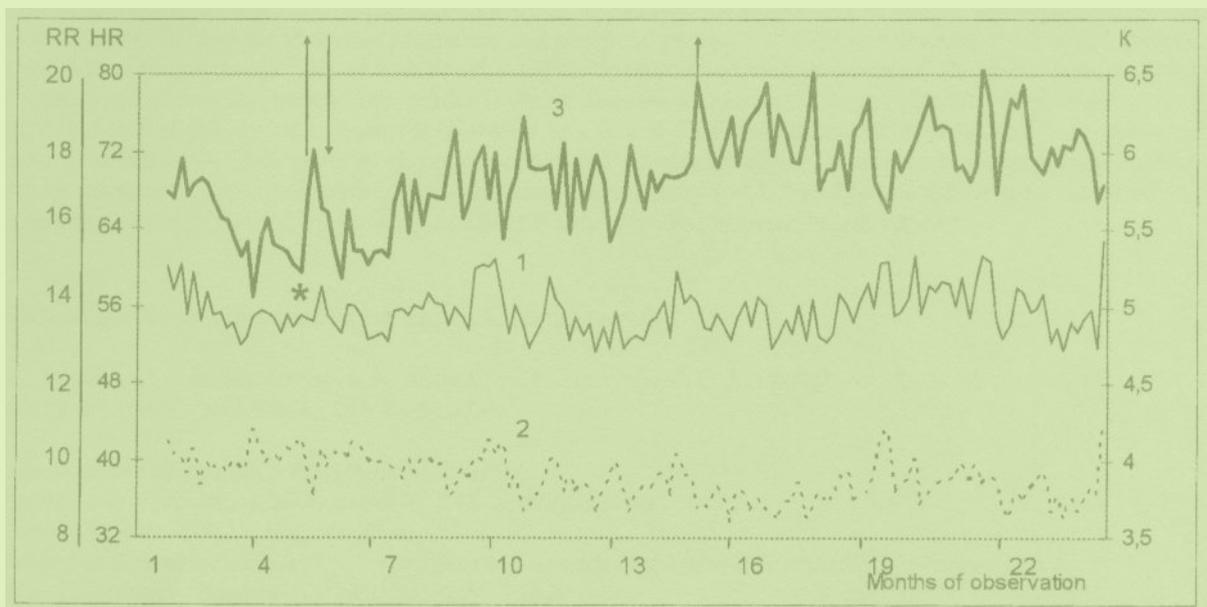
В работе изучаются направления прихода сигналов от естественных источников КНЧ-шумов – молний и магнитосферных возмущений. Экспериментальным материалом являются результаты измерений на магнитометрах высокоширотной обсерватории Ловозеро. Для спокойных и магнитовозмущенных дней построены азимутально – временные распределения регистрируемых сигналов – отдельно для общей совокупности данных, для выборок превышений над заданным порогом и для так называемых всплесков Q-типа. Распределения обнаруживают суточный ход азимута на максимально активные области источников и уверенно выявляют очаги грозовой активности. Одним из наиболее интересных результатов анализа являются доказательства в пользу того, что источники Q-всплесков лежат в грозовых очагах и связаны с грозовой активностью.

Амплитудные распределения шумов КНЧ диапазона

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В работе исследованы амплитудные распределения естественных шумовых колебаний диапазона частот первого шумановского резонанса. С этой целью по данным высокоширотной обсерватории Ловозеро построены суточные хода превышений над заданными порогами, также выполнены временные разрезы. Обсуждается возможность применения для аналитического описания амплитуд шумов данного диапазона известной из литературы формулы амплитудного распределения атмосфериков.

Heliobiosphere



Disease incidence at Spitsbergen as result of solar-terrestrial connections

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Shpitsbergen is position on the Arctic high latitude, where the Earth's magnetospheric magnetic field strength are depressed in the northern cusp. The polar cusp is narrow region of recently "opened" or merged magnetic field lines mapping to the high-latitude ionosphere just pole ward of the last closed field line on the Earth's day side. The open field lines of the cusps are connected with those of the interplanetary magnetic field, which allows the shocked solar wind plasma to enter the magnetosphere and to penetrate to the ionosphere. The injection of magnetospheric plasma into the cusp is associated with multiple geophysical phenomena near the Earth's surface, which could be affected on the human health and by which are manifested the solar-terrestrial connections. We have analyzed the statistical material disease incidences in the settlements of Barentsburg and Pyramid (1980-2008 years) on Shpitsbergen and found the correlations between certain disease incidences, Solar sunspots, Ground Level Enhancement (GLE) of secondary components of solar cosmic rays and Cosmic Rays. We have revealed correlations ($p < 0.05$) between increase of the Solar activity (SA), increment of kidney- urinary path diseases incidences ($r = 0,43$), abnormal pregnancy and puerperal period ($r = 0,60$), infections of the hypodermic and subcutaneous fat ($r = 0,51$), diseases of musculoskeletal system and connective tissue ($r = 0,39$), trauma from occupational poisoning ($r = 0,39$). The tendency to increase of mental disorder incidences ($r = 0,39$), the drastic increment of arterial-, arteriole-, vein-diseases incidences ($r = 0,70$) and the abnormal pregnancy and puerperal period ($r = 0,57$) were associated with GLE events. At the same time the increase of SA as well as GLE events were coupled with decrease of the exacerbation of chronic respiratory apparatus- and gastric and duodenal ulcers diseases incidences. The correlations of diseases incidences with CR manifest the opposite character relatively to CA and GLE. So, the number of arterial-, arteriole-, vein-, abnormal pregnancy-, infections of the hypodermic and subcutaneous fat-, trauma from occupational poisoning diseases incidences were decreased under increase of CR intensity ($p < 0.05$). The mechanisms of health effects by the geomagnetic activity and by variations of the CR intensity are discussed in the report.

Psycho-emotional effects of exposure to Cosmic rays

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The studies of the human psycho-emotional state were carried out on the similar groups of the examinees at the different latitudes (Apatity, 67.57°N, 33.4°E; Chupa, 66.3°N, 33°E; "Alexandrovka-Donskaya"- sanitation complex of the KSC RAS "Ekovit", 51.39° N, 39.10°E) and in the different spans of the Solar cyclic activity (SA) (1991, 2008, 2009 years). In the course of these studies, some psycho-emotional characteristics were assessed on daily basis through one month. The dynamics of the psycho-emotional state of the examinees were compared with variations of the global and regional geocosmical agents estimated by indices of SA, the state of the near the Earth's space, geomagnetic activity, regional characteristics of the neutron count rates (Neutron monitor stations at the Apatity, PGI KSC; Moscow, IZMIRAN). In the result of the multivariate analysis was shown, that human psycho-emotional states are modulated by "dose" ratio of the active agents, where basic role belongs to the geomagnetic field (GMF) variations and the intensity of the secondary component of cosmic rays (CR), irrespective of latitude and phase of the cyclic solar activity. The increment of the CR "dose" induces the unstable psycho-emotional state which are manifested by nervousness, anxiety, depressive states. The research are performed at the Apatity (2008 year) on the volunteers have demonstrated that psycho-emotional state of the 81% examinees are depend on intensity of CR, when nervousness, ill will, apathy, uncertainty, tiredness are manifested in accordance with the increment of CR intensity. The similar results were found under examination of the school-boys psycho-emotional state at the "Alexandrovka-Donskaya" (2009 year), where the 90% of examinees were appeared of the weariness, uncertainty, susceptible, whining and etc. negative psycho-emotional state under the increment of CR intensity. Our

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research has demonstrated that an increase of the neutron intensity near the Earth's surface is associated with anxiety, decrease of normal and increase of paradox reactions of examinees. By the analysis of the human brain functional state in dependent on the geomagnetic variation structure, "dose" under exposure to the variations of geomagnetic field in a certain amplitude-frequency range and also the intensity of the nucleon component of secondary CR has been shown that the stable and unstable states of the human brain are determined by geomagnetic field variations and the intensity of the nucleon component. The stable state of the brain manifested under the periodic oscillations of the geomagnetic field in the certain amplitude-frequency range. The low level of geomagnetic activity associated with an increase of the CR intensity and the mainly of the aperiodic disturbances, may lead to an unstable state of the brain. In the years with low geomagnetic activity associated with the minimum of the Solar cyclic activity the role of the CR in the modulation of psycho-emotional state drastic increases. The spans with the low Solar cyclic activity are the time, when the depressive psycho-emotional effects of exposure to CR are expressed by extreme manner.

On manifestation of periodical disturbances of interplanetary medium in fluctuations of unithiol oxidation half-time

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The unithiol test originally used to reflect changes in solar activity (SA) is now used as an indicator of cosmophysical influence on the biosphere.

We analyzed the sequence of daily data of unithiol oxidation half-time (UOHT) with sodium nitrite during the 21-year SA cycle (1974-1985). The main task of the study was to detect correlations between rhythmic fluctuations of UOHT at various phases of the SA cycle and cosmophysical factors of electromagnetic and gravitation origin. We broadened the range of influential cosmophysical factors by adding cyclic interactions between the planets of the Solar system (SS). In regard to this, we focused on revealing correlations between detectable UOHT fluctuations and the dynamics of intensity of planetary conjunctions. The solution was facilitated with the adaptive filtering method that we employed. The advantage of the method was the possibility to separate nonharmonic elements in UOHT fluctuations, which are determined by superposition of planetary effects (pulsation) at conjunctions.

If we take into consideration only the Sun-Earth-Moon pan of the SS, as it was considered previously, we can easily detect the following influences on UOHT in a long-term period (1975-1985): of yearly orbital movement of the Earth (equation of time), the nutation in the Earth's axis with respect to the celestial pole (equation of the equinoxes) and gravitational disturbances on the Earth and the Moon caused by the Sun. The correlations between UOHT fluctuation and each of the factors are affected by SA changes in the 21-year cycle.

Taking the whole SS into consideration allowed us to reveal a wide range of periodicities in the UOHT dynamics related to planetary conjunctions - 2.9-3.8, 7.4-7.8, 11, 19.2, 22.7-26.8, 52.6 and 57.1 months.

The detected correlations between characteristics of the biosphere and positions of the planets indicate the coherence in terrestrial biosphere development and evolution of the Solar system.

In our opinion, further studies in this direction will give the opportunity not only to explain but also to foresee consequences of cosmophysical factors of various origins affecting the biosphere.

Indices of human urinary excretion of thiol and urochrome in the Antarctic and their correlation to cosmogeophysical factors

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During the 46th Russian Antarctic Expedition (2001-2002), at the Antarctic station Vostok, an attempt was made to estimate the antioxidant status of humans by measuring the rate of thiol compound excretion. Thiol concentration in

urine was tested with Ellman's photometric method, which is based on thiol's reaction with DTNB/ 5,5'-dithiobis-(2-nitrobenzoic acid) and formation of the colored product (NTB/ nitrothiobenzoate) light absorption at 420 nm.

As pigments in urine are characterized with the same maximum absorption allows us to employ the standard curve, based on SH-glutathione and also used for estimating thiol concentration in the studied solution, for measuring the amount of pigments.

Since it is known that most urinary pigments (about 95%) are so-called urochromes, we measured their content in urine stated in conventional units, which are equal to number of SH-groups per micromole.

From the test results of each portion of urine during 24 hours (more than 2800 samples) and their volumes (ml), we calculated concentrations of thiols and urochrome in daily urine ($\mu\text{M/l}$).

Longitudinal analysis of thiol compounds and urochrome content in human urine during long-term stay and work in extreme conditions revealed that the rate of excretion of the substances varies with a certain rhythm and that the rhythm correlates with variation of some cosmogeophysical factors, such as solar activity, gravity disturbances caused by Sun and Moon and alternation of polar day and night.

Another important result of the study was the detection of the relationship between thiols and urochrome, which allows urochrome to be considered a chemical component of urine reflecting changes in antioxidant processes in vivo. The supposition that the compounds forming urochrome have antioxidant properties is supported with the well-known fact that colored urochrome is generated from colorless urochromogen by its oxidation. The modern concept of urochrome being formed from the iodole-containing amino acid tryptophan also witnesses in support of the supposition, as one of tryptophan's metabolites is the antioxidant melatonin.

We are inclined to consider the results of the study as a stimulus for a purposeful research of the role certain urochromes play in the mechanism of cosmobiological correlations.

Influence of changes of space weather parameters on a cardiovascular system of a human being

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To reveal the influence of heliogeophysical disturbances on a state of cardiovascular system of a human being the synchronous biophysical experiment "Geliomed" has been carried out. The experiment was carrying out simultaneously at 3 observation points: the Yakutsk (Russia), Kiev (Ukraine) and Simferopol (Ukraine) using the same facility (Fazagraf complex) by a common protocol of study examining a group of volunteers enrolled at each point of observation.

The analysis of experimental data obtained by the project "Geliomed" has allowed to find out experimentally for the first time a similarity between indications of an electrocardiogram of subjects and geomagnetic disturbance even at its very low values. The presence of simultaneous similar variations of an electrocardiogram at widely separated points (the Yakutsk, Kiev, Simferopol) coinciding with geomagnetic disturbance variations and solar wind parameters indicates to the influence of space weather to the functional state of cardiovascular system of a human being.

The work has been partly supported financially of the Russian Fund for Basic Research (grants 09-02-98505-r_vostok_a and 09-02-00284-â) and Program of basic researches of Presidium of the Russian Academy of Science №16. Part3.

The temporal variability of the water properties is a promoter of evolution

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We found, that water properties, which were estimated by temperature difference values (ΔT), manifest diurnal oscillations with maximum peak about 9-10 hours of local time. The values of ΔT variability were compared with variations of geomagnetic field, fluxes of nuclear-active particles in near Earth's space, which are able to reach the Earth's surface at certain sites, with neutron count rates at the different neutron monitor stations. The all data were correlated with using local time as the indicator of the arrival of the cosmic high energetic particle rays to certain latitude and longitude. We found that the values of ΔT correlate with magnitude of total magnetic field and fluxes of cosmic rays (CR) near the Earth's space. The significant ($p < 0,05$) correlations were found between nuclear-active α -particles with energy range 2560-3400 MeV (GOES-10), energy > 3400 MeV (GOES-8) and protons with energy > 700 MeV (GOES-8). Our results demonstrate that variations of CR intensity are associated and correlate with

temporal variability of the water properties. We assume that variability of ΔT could be result of the water heat capacity transformation induced by water structural reconstructions, which could be initiated by interactions of the neutron component of the CR and water molecules. The neutron interactions with water are determined by their energy spectrum: hydrogenous matter are exposed to fast neutrons are transformed to the fast protons. Thermal neutrons initiate the nuclear interactions, if they are captured by nucleus ($^{14}\text{N} (n, p) ^{14}\text{C}$, $^6\text{Li} (n, \alpha) ^3\text{H}$, $^{10}\text{B} (n, \alpha) ^7\text{Li}$ and etc.). Water, when exposed to radiation, undergoes a breakdown sequence into hydrogen peroxide, hydrogen radicals and assorted oxygen compounds such as ozone which when converted back into oxygen releases great amounts of energy. Reactive oxygen species are known to have a signaling role in many organisms. In bacteria and yeast various response systems have evolved to combat oxidative stress which are triggered by reactive oxygen species. Mammals and plants are known to actively generate reactive oxygen species such as super oxide during signaling responses to a variety of extra cellular factors. Super oxide as a signaling molecule induce aggregation of single cells of *Dictyostelium* to form a multicellular organism. Neutron interactions with water, accompanying by local pulse particle emission, one may be compare with pulse radiolysis. Pulse radiolysis is a recent method of initiating of the fast reactions by pulse ionizing agent for studying events occurring between 10-11 and 102 s after energy absorption. Such impact could accelerates the chemical reactions and modifies the properties of the biological molecules. Since modulation of water properties by CR is extend on planetary level, the cyclic temporal variability of the water properties in the planetary scale increase the chemical effectiveness of the water solutions. Temporal variability of the water properties could be promoter of evolution by means of the initiation of the plural novelties in molecule compositions and biochemical reactions.

Geomagnetic activity and frequency of delivery complications

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Several hundred deliveries in Karelia are analyzed statistically to answer the question about the association between frequency of delivery complications and geomagnetic activity, first of all long period ULF disturbances in Pc5 frequency range. Data for Medvezh'egorsk (Lat = 62°5'N, Lon=34°27' E, CGM Lat = 59.16, Lon= 111.83, L=3.83) show that the rate of complicated deliveries is higher for the days with high geomagnetic activity. It is speculated that high amplitude ULF pulsations in the frequency range of typical labor frequency (several mHz) can be an external interference, resulting in disordinated labor.

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