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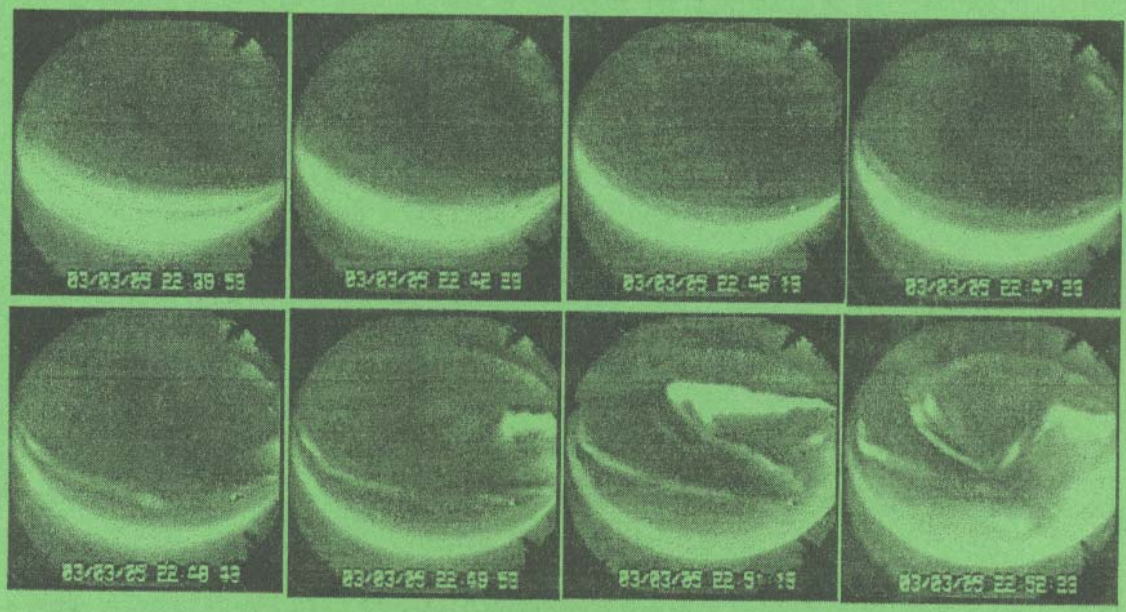
PHYSICS OF AURORAL PHENOMENA

31th Annual Seminar

26 – 29 February 2008

Abstracts



Apatity

2008

Russian Academy of Sciences
KOLA SCIENCE CENTER
Polar Geophysical Institute

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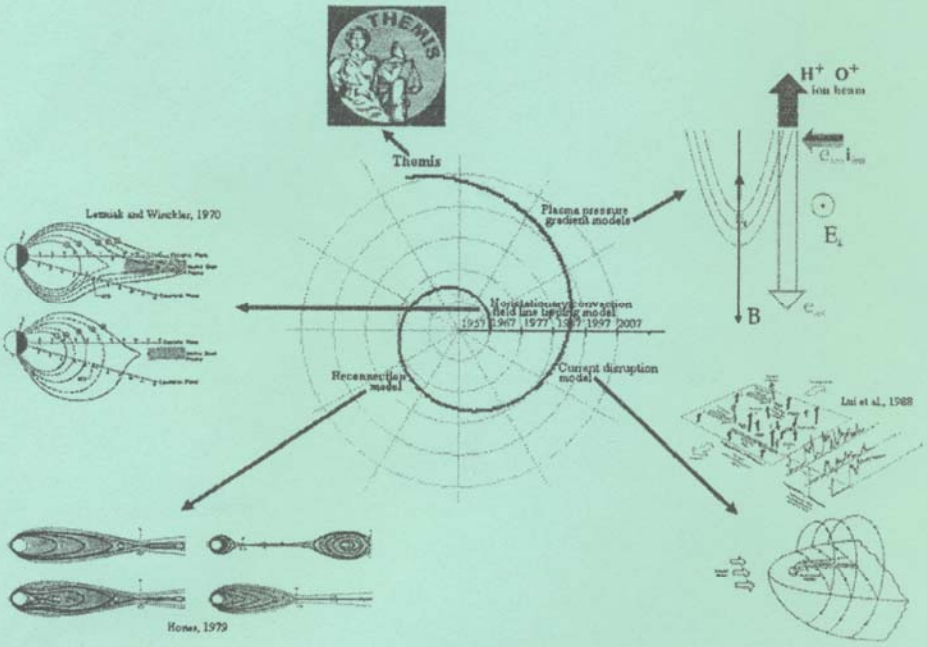
Geomagnetic Storms and Substorms



First auroral arc brightening and magnetospheric substorm

E.E. Antonova *(Skobeltsyn Institute of Nuclear Physics Moscow State University Moscow, Russia)*

Results of experimental observations of substorm expansion phase onset are analyzed. The main features of substorm expansion phase onset are the auroral brightening at the equatorial boundary of auroral oval and beginning of equatorial magnetic field depolarization and Pi2 onset ~1 min after the first auroral arc brightening. Results of observations are compared with the predictions of different theories. It is shown that observed substorm features create the real limitations on the possible scenario of substorm expansion phase onset. The development of quazielectrostatic instability can explain the time delay between first auroral arc brightening and magnetic disturbance leading to magnetic field line dipolarization and intensification of geomagnetic micropulsations. The process of auroral arc brightening is analyzed. The formation of powerful beam of electrons at the boundary of inverted V structure is selected as the most probable mechanism of bright aurora formation during substorm onset.

Nonlinear connection of global and polar current systems on the main phase of a geomagnetic storm

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The connection of magnetic disturbance on auroral area and disturbance on middle and low latitudes during magnetospheric storm still not found out completely [1]. Well-known ideas about SYM, ASY and AU, AL relationship is based on the connection of westward electrojet (AL) with asymmetric current (ASY) on the storm main phase, and eastward electrojet (AU) – with a symmetric current (SYM) on recovery phase [2]. In research [3] appreciable linear correlation between indices of a ring current and indices of auroral electrojets for couples SYM, AU and ASY, AL on different magnetospheric storm phases has been found.
In present work with the help of artificial neural networks (ANN) technology the degree of nonlinear connection between indices SYM, ASY and AU, AL on the main phase of a magnetic storm is established. For the analysis it has been selected 15 isolated magnetospheric storms of different intensity for the period 2000-2001. Necessary numerical experiments were carried out on specially created Elman ANN. The search of nonlinear correlations between indices SYM-AU, ASY-AL, SYM-AL and ASY-AU was carried out for each of couples of examined events. Detection of an opportunity of auroral indices restoration on middle-latitude indices shows a high level of connection of a symmetric part of a ring current with eastward electrojet and an asymmetric current with westward electrojet. A condition of high quality of such restoration is consideration of the "classical" storm excluding sharp changes of Solar wind parameters and interplanetary magnetic field component oscillations within the main phase.
The second stage of neural network researches was restoration of auroral electrojet indices on SYM- and ASY-groups of ring current indices independently of considered storm intensity. At execution of numerical experiments there was an opportunity to use time derivative from indices of a ring current as input parameters, and also to enter time shifts between input and output parameters. As a result the nonlinear connection between examined indices which received above is confirmed and delays in development of auroral current systems relatively middle-latitude found out. For couple SYM-AU they are 0.5 hours and for couple SYM-AL – 2 hours. The asymmetric current develops synchronously with both electrojets.
The applying of Solar wind and interplanetary magnetic field parameters in similar research will allow to increase a quality of restoration of global indices on auroral indices and to establish real cause-effect relation.
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Substorms associated with different structures in the solar wind

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On the basis of data from WIND spacecraft we investigated the difference in the behavior of substorm development during different types of solar wind streams: recurrent solar wind streams (RS), co-rotating interaction regions (CIR), magnetic clouds (MC), and the region of interaction of magnetic clouds with undisturbed solar wind (Sheath). The RC/CIR (MC/Sheath) structures were examined for the period December, 1996 – June, 1997 (January - December, 2000). All available auroral substorms observed by the Ultra Violet Imager onboard Polar during these periods were studied (72 events during RS, 26 during CIR, 20 during MC, and 10 during Sheath).
It is shown that substorm expansion behavior is different for these four types of the solar wind. The strongest auroral bulge expansions were found for CIR and Sheath situations. In contrast to substorms during RS, during MC the latitudinal expansion of the auroral bulge is less pronounced, but longitudinal expansion is stronger. We suggest that later feature is explained by different configuration of the near-Earth magnetotail during RS and MC.

Structure of the diffusion region in reconnection: Kinetic simulation

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Kinetic simulation of reconnection provides the most detailed view on the structure of diffusion region. Earlier works, which utilized fluid approach or lack size of the simulation box, presumed diffusion region to be as small as few electron inertial length (tens of kilometers in Earth`s magnetotail). Recent works clearly indicate that the internal structure of an X-point and neighbouring outflow region are different from those derived from scaling of the fluid Ohm`s law. In this work we report on the detailed structure of the diffusion region, using the particle code P3D [Zeiler, 2002] with open boundary conditions. Ion diffusion region (IDR), in which long electron diffusion region (EDR) is embedded, indeed stretches up to 10s of the ion inertial length holding the thickness of only about 1/2 inertial length. Chew-Goldberger-Low approximation breaks down for that region. The study of distribution functions shows their strongly non-Maxwellian behaviour in outflow region; electron distribution function deviates from Maxwellian in both IDR and EDR. Embedding of electron current within ion current, and intense in-plane electric field are observed.

Variations of the radiation belts energetic particles after the July 22-30, 2004 magnetic storms

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Temporal intensity variations of relativistic and subrelativistic electrons and solar protons injected into the radiation belts after the strong magnetic storms are analyzed using measurements on board of law-altitude satellites Servis-1 and CORONAS-F. Variations are consist on slow intensity decrease caused by the pitch-angle scattering into the loss cone and fast intensity increases and/or decreases during periods of enhanced magnetic activity. Life time of the energetic particles are estimated for different particle species and energies and radial drift shell position. The results are compared with pervious direct measurements and theoretical predictions.

Relation of the polar cap magnetic activity to the substorm development

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Relation of the polar cap magnetic activity (characterized by the PC index) to magnetic disturbances in the auroral zone (the AL index) was examined for the isolated, prolonged, periodic, sawtooth, and combined substorms. The

following results have been obtained basing on the case studies and statistical analyses. The growth phase is typical of substorms irrespective of their type. The growth phase beginning is seen first of all as the PC index persistent increase starting 15 minutes, on the average, ahead the appropriate growth phase in the auroral zone, which beginning statistically coincides with such spacecraft substorm identifiers as dipolarization of the nighttime magnetosphere and injection of energetic particle flux at geosynchronous orbit. Afterwards, with the additional delay time of ~ 15 min, the ground substorm sudden onset occurs. The growth rate and the substorms intensity are determined by the energy pumping into the magnetosphere (characterizing by the PC value) during the growth and expansion phases. For conditions when $2 \leq PC \leq 4$ mV/m the growth phase duration lies in the range from 60 to 15 minutes. For conditions of PC>6 mV/m the growth phase can shorten up to zero. The PC index reaches the maximum irrespective of the AL maximum, just as before so after, implying that the polar cap magnetic activity, being related to the solar wind energy input, does not practically respond to the substorm development. The inverse linkage between the substorm intensity in expansion phase and the magnetic activity decrease in the recovery phase is found.
Our results suggest that neither driven mode no loading-unloading mode of the magnetospheric substorm do work in pure form, but rather the threshold-dependent mode is realized. Indeed, the incoming energy is continuously removed while the field-aligned current closing in the polar ionosphere. Thus, the mode of the magnetosphere response to the external influence, being dependent on the varying ratio between the energy input and energy loss rates, changes on the define thresholds displayed by the PC value.

Dependence of substorm effects in the auroral electrojet and parameters of F-region on UT of the substorm onset

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In this report results of modeling four substorms beginning in 00 UT, 06 UT, 12 UT and 18 UT for spring equinox conditions in a minimum of solar activity (F10.7 = 76) are presented. Calculations were carried out using the Global Self-consistent Model of the Thermosphere, Ionosphere and Protonosphere (GSM TIP), developed in WD IZMIRAN, with use of the new calculation block of electric fields of a dynamo and magnetospheric origin. For all four substorms the time course of the intensity of westward and eastward auroral electrojet was obtained. Calculations have shown, that during substorms there is very strong growth of westward electrojet from - 20 A/km in quiet conditions up to - 400 A/km for the substorms beginning in 00 UT, 06 UT and 12 UT, and up to - 450 A/km for the substorms beginning in 18 UT. At the same time there is a strengthening of eastward auroral electrojet intensity from ~50 A/km in quiet conditions up to 120-150 A/km for the substorms beginning in 00 UT, 06 UT and 12 UT and up to ~230 A/km for the substorms beginning in 18 UT. The results qualitatively agree with experimental data from which it is followed that in quiet conditions the intensity of the eastward auroral electrojet is higher in comparison with westward one, and that during disturbances there is the strengthening of auroral electrojet as a whole, and the intensity of westward electrojet grows more strongly than eastward one.
Global distributions of foF2 perturbations calculated for the substorm which has begun at 18 UT are presented, and their behavior during and after the substorm is analyzed. Calculations have shown that at the substorm initial stage the positive (negative) disturbances arise in auroral zones and polar caps with maxima in post-midnight (post-sunset) hours. The absolute maximum of positive (negative) disturbances is formed in auroral zone of a southern hemisphere. Further there is a strengthening of disturbances, especial in auroral zones and in a southern polar cap which practically is completely occupied with positive disturbances. Gradually the maximum of positive disturbances drifts from southern auroral zone to a polar cap. Negative ionospheric disturbances are observed mainly at night from subauroral latitudes up to geomagnetic equator. After the substorm termination there are negative disturbances in auroral zones at pre-midnight hours with a maximum in northern hemisphere. The amplitude of these disturbances exceeds a disturbance range during a substorm. These disturbances are explained by action of the disturbance dynamo field.
Calculation results of the foF2 behavior during substorms are presented and analyzed for several high-latitude stations.

An analysis of the auroral input data of the Upper Atmosphere Model on the basis of the ionospheric radio tomography reconstructions

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The complex analysis of all input parameters used for setting auroral precipitation in the global numerical upper atmosphere model (UAM) has been done. Input model values of mean energy and energy flux of the precipitating auroral electrons have been compared with the data produced by Vorobjev, Roble, Spiro and Hardy. The radio tomography reconstructions of the high-latitude electron density observed during the geomagnetic storm on 26 October – 01 November 2003 have been divided into four groups (for daytime quite and disturbed conditions, and nighttime quite and disturbed conditions). They have been analyzed and new functional dependences of the polar and equatorial bounderies of the auroral electron precipitation zone have been obtained. Numerical model results with the new variant of the auroral input have been compared with the radio tomography reconstructions between them and a better agreement have been achieved.

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

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More than 100 breakups of different types and intensities were studied on the base of PGI Lovozero geophysical observatory data. We used digital magnetic pulsation recordings (H, D, Z components) in three frequency bands (periods 5– 150 seconds, 0.5–15 seconds, and inductive magnetometer data - about 0.05–20 Hz). Available information about VLF emissions was in the form of the average wave intensity (input signal from VLF antenna was filtered by analog pass band filters with a bandwidth about 20 % of the central frequency and digitized after integration with effective suppression of atmospherics and other impulse noises). Central frequencies of filters were 0.7, 1.3, 2.5, 4.0 and 6.0 kHz. The main data on aurora brightness and dynamic were collected by TV camera (videotape recordings with 25 frames per second frame rate), and supported by photometers (5577, 4278 and 6300 emissions). TV data were digitized and processed with the using of different methods of image filtering allowing revealing the weakest luminosity variations inside and around the prebreakup arc, and marking the moment of auroral breakup with a high accuracy. For all the breakups under consideration it was found that magnetic pulsations in all frequency bands definitely lag the moment of breakup for 1.5 – 3 minutes (and there is a tendency for the time delay of the higher frequency pulsations to be larger). It means that magnetic pulsations are the consequence of breakup, they are probably the result of strong horizontal ionospheric currents developing after the breakup activation. VLF data interpretation is more complicated (parasitic interference with the different industrial and local electronic equipment, and almost free VLF emissions propagation under ionosphere from auroral activity in the other regions of auroral oval). Nevertheless, for at least 15 breakups we detected that VLF emissions intensification undoubtedly leads the breakup moment for 3-5 minutes, and for another 30-40 breakups after special high frequency filtering for the better revealing weak VLF intensity pulsations, this fact was confirmed as well. So, some very active process, probably developing in the upper ionosphere, precedes the moment of auroral breakup. We can suppose that is ionospheric plasma instability caused by strong increasing of field-aligned currents.

Source of electron precipitation for breakup and pulsating aurora

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Previously developed procedure using TV camera data for the detecting of very weak wave of luminosity spreading upward along auroral arcs and beams was essentially modified and improved. This wave of luminosity produces by precipitating electrons velocity dispersion and differential atmospheric penetration of multi-energy electrons, and speed of wave gives direct information about the location of electron acceleration region in the magnetosphere. Procedure was tested with a lot of different model signals and applied for the study of pulsating aurora and auroral breakups. Applying this method for pulsating aurora (total about 30 events recorded in Lovozero, Barentsburg and Finland were processed) revealed definite velocity dispersion of precipitating electrons, and electrons source position were estimated to be at the distance about 5-6 Re in a complete agreement with a received opinion. Though electrons energy in pulsating patches is very high, and so the vertical extent of aurora is rather small, spreading

upward wave of luminosity is well visible in all the data. Results of breakup study are radically different. More than 100 breakups were digitized and processed, and with the exception of some short and seldom events (0.2-0.3 seconds duration), needed more detailed investigation, not a single case of well-pronounced vertical wave of luminosity was found. It should be inevitably concluded that all auroral breakup electrons are accelerated just above ionosphere, at the heights about 2000 – 4000 km. We can suppose that anomalous resistance generated in the upper ionosphere by strong field-aligned currents during the breakup phase produces very intensive parallel electric field accelerating ionospheric electrons and creating breakup aurora.

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

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On Dec.03.2005 strong substorm started at the southern horizon of Barentsburg TV camera field of view about 15.00 UT, and quickly extended far towards North. About 16.00 UT after strong spiral deformation (so intense field-aligned currents existed that time) of very bright and active auroral forms unusually fast auroral pulsations (frequency 5-10 Hz) were detected in the zenith of TV camera. In spite of camera SIT-vidicon tube target inertia (about 100-200 milliseconds) pulsations were well visible without any special processing, so the modulation of precipitating electrons was rather high (ON/OFF ratio at least about 10). Pulsations mostly concentrated along the arc, though much weaker fast pulsations inside the area bounded by spiral arc have been observed as well. The size of individual pulsating element was about 10*10 km. Pulsating elements had an obvious tendency to concentrate in clusters, and very strong temporal and spatial correlation between the neighbour pulsating fragments was found.
Earlier V.Safargaleev created the theory of high frequency pulsations of precipitating electrons basing on the fast variations of field-aligned currents and periodical fluctuations of anomalous resistance. Strong periodical variations of parallel electric field generated in this process accelerate electrons and produce pulsating aurora. Initially the theory was developed for explanation of the ordinary pulsating aurora, but with any reasonable parameters predicted frequency of pulsations was much less than 1 second (period of pulsating patches is about 10-20 seconds). It was found that this theory explains the physical properties of flickering aurora in all details. We can also suppose that anomalous resistance mechanism can play an important role in auroral breakup activation.

Spatio-temporal auroral dynamics during main and recovery phase of magnetic storms with different intensity

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We present a comparative study of aurora dynamics for the substorms observed during magnetic storms of different intensity (-50 >Dst> - 400 nT) in the dusk-midnight sector based on the TV data of high latitude observatory Barentsburg and of auroral zone observatories Lovozero and Loparskaya, using solar wind and IMF data. It is found that aurora dynamics of substorms related to different phases of magnetic storm, in many aspects differs from that exhibited during isolated substorms and depends on previous IMF and solar wind conditions. Before the beginning of storm main phase, high-latitude substorms occur. The main phase of a storm and the beginning of its recovery phase are mostly characterized by long-living rayed structures, by development of weak, pseudo-breakup type activations, or small substorms spreading equatorward in the auroral zone latitudes. The substorms initiated at the end of storm main phase do not develop according to the classical scenario, that is, as step-like leaps of auroral arcs to the pole. Instead, they manifest as fast unstructured aurora luminosity spreading over large areas. The substorms occurring at the main phase and at the beginning of storm recovery phase are rather intense, they develop in a large latitudinal range up to the polar cap latitudes. The double oval configuration, with its poleward boundary intensifying, and auroral streamers, separating from this boundary and drifting southward, are typical signatures of such events. At the end of storm recovery phase, in high latitudes weaker substorms emerge, which are characterized by polar arc development.
Features of auroral dynamics are rather associated with the SC phenomena than the phase and intensity of magnetic storms.

Relative order in the cellular automata model of the magnetospheric-ionospheric system

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The cellular automata model (CAM) was proposed in [Kozelov and Kozelova, Ann.Geophys., V.21, P.1931, 2003] to describe the substorm activity of the magnetospheric-ionospheric system. The state of each cell in the model is described by two numbers that correspond to the energy content in a region of the current sheet in the magnetospheric tail and to the conductivity of the ionospheric domain that is magnetically connected with this region. The driving force of the system is supposed to be provided by the solar wind that is convected along the two boundaries of the system. The energy flux inside is ensured by the penetration of the energy from the solar wind into the array of cells with a finite velocity. The third boundary is closed and the fourth boundary is open, thereby modeling the flux far away from the tail. The energy dissipation in the system is quite similar to other CAM models; however the second number attributed to each cell mimics the ionospheric conductivity that can allow for a part of the energy to be shed on field-aligned currents. The feedback between "ionosphere" and "magnetospheric tail" is provided by the change in a part of the energy, which is redistributed in the tail when the threshold is surpassed. The control parameter of the model is the south component of the interplanetary magnetic field (B_S IMF). It is known that the dynamics of the system undergoes several bifurcations, when the control parameter varies [Kozelov and Kozelova, 2003].
Here we analyze the relative order of the system states as a function of time and the control parameter. An approach based on the S-theorem by Yu.L. Klimontovich has been used. The considered characteristic is an analogy of entropy which has been extended to non- equilibrium states.
We conclude that 1) for fixed control parameter the order in the system increases as a new transient develops; 2) the strongly driven system is more ordered.
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Commonalities of self-organized criticality and fluid turbulence

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The most popular approaches to dynamical complexity in space plasma are based on turbulence or self-organized criticality (SOC) paradigms. The coexistence of signatures of SOC scaling and intermittent turbulence has been noticed for auroral structures and for solar flare activity. Power-law scaling are characteristic features which are common for the output from models of turbulence and models and of avalanching systems exhibiting SOC states. However the usual approaches to turbulence and SOC employ different methodological frameworks, therefore a direct link between the two paradigms is still missing.
Here we analyze the dynamics of two numerical models to demonstrate the link between avalanche-like and turbulence-like dynamics. One of them is the 2D Zhang model widely used to study SOC dynamics [Zhang Y.-C., Phys.Rev.Lett. V.63, #5, P.470-473, 1989]. In contrast to the usual SOC approach, we consider relatively strong driver conditions giving rise to continuous avalanching, and analyze the spatiotemporal toppling field by means of an adaptation of the method of generalized structure functions, which is commonly applied to turbulence. The second model is based on NVIDIA CUDA implementation of a simple fluid solver for the Navier-Stokes equations for incompressible flow [Goodnight N., CUDA/OpenGL Fluid Simulation, NVIDIA Corporation, 2007]. We drive the fluid model randomly in the central region of the simulation field. The resulting turbulent flow may also be subject by local avalanche analysis, which is well known from analysis of data from SOC models.
Another feature both systems may have in common is a universal non-gaussian probability distribution of the total kinetic energy (turbulence) or total toppling activity (Zhang model). The existence and limitations of this commonality is discussed.
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Substorm associated changes of the ion pressure in the magnetosphere

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The spatial and temporal variations of the plasma pressure and magnetic field in the inner magnetosphere are important for the understanding of the particle population formation, the magnetosphere-ionosphere coupling, and the destabilization of plasma distribution during the substorm expansion phase onset. In this paper the total ion pressure has been considered in the range of the parameter *L* from 2.3 to 6.7 in the nightside magnetosphere. The data of the LEPA and EPAS particle detectors on-board CRRES satellite have been used.
The nose structures were observed at *L*~3.1-3.7 about 3-5 hours after previous substorm activation with the maximum *AE* values ~ 450 -1000 nT. The additional total ion pressure maximum was found at *L*~4.6-4.9 about 20-30 min after the beginning of the small intensification of the magnetic activity (*AE*~200 nT). This pressure maximum is formed by the low-energy (<28 keV) ions. The increase of total ion pressure was found at *L*~5.4 associated with the pseudobreakup when the local peak of *AE* was about 450 nT. This ion pressure maximum was formed by the ions with the energies ~ 37- 69 keV. During the large substorm (*AE*~1100 nT) the enhancement of the high-energy (>70-100 keV) portion of the ion pressure was found at *L*~6.3 simultaneously with the sharp reduction of the low-energy portion. The results are discussed and compared with other observatioons.
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Average ULF-level during geomagnetic storms

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A new wave ULF-index has been used for analyzing wave activity in ultra low frequency (ULF, namely, 2-6 mHz) range during strong magnetic storm (-150 nT < Dst_{min} < -100 nT). It is found the most intensive geomagnetic pulsations were observed in the morning-noon sector of auroral latitudes in the main phase of the magnetic storms. It is shown the sudden commencement of the magnetic storm, which is characterized by the solar wind density and speed jump, is accompanied by the sharp increasing ULF- index. In the recovery phase of magnetic storm the ULF-index level increased, however, an appearance of separate time intervals with the negative values Bz- component of IMF during this phase leads to the short-time increasing ULF- index.

Comparative analysis of the energetic electron and solar proton dynamics during strong magnetic storms

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Transformation of the radial profiles of 0.3-3.0 MeV electrons during the main and recovery phases of the magnetic storms was investigated by the measurements on board of the low-altitude satellites CORONAS-F and Servis-1. As an indicator of the transformation of magnetosphere configuration solar proton penetration boundary dynamics was used. It is shown that during the main storm phase electron dynamics was governed by the concurrency of the radial shift of the drift orbits and losses at the flanks of the magnetosphere and into the loss cone caused by the divergence from the adiabacity. At the recovery phase of the magnetic storms similarity of the radial profile dynamics of the electrons and protons was observed indicating on the relation of the nature of both particle species acceleration.

Transformation of energy spectrum and pitch-angle distribution of high-energy electrons in Earth's the radiation belts after acceleration during magnetic storms

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Measurements of high-energy electrons onboard the CORONAS-F satellite are used to investigate the characteristics of the radiation belts particles during radiation belt relaxation after strong magnetic storms. Temporal variations of the particle detector field of view have been calculated. Particles pitch-angle distribution has been estimated. It has been shown that the change of the intensity and spectrum of electrons and protons is the nature of the slow variations in time, modulated by the fast changes associated with storm activity and moderate magnetic storms.

Magnetotail plasma sheet with anomaly large By magnetic field

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Recent Cluster observations during substorm growth phases revealed that almost 30% of events are characterized by the large (>5 nT) guide (By) field component. Such strongly sheared configuration has many consequences for local particle dynamics, precipitation patterns and stability conditions important for substorm investigations. Similar conditions were reported also episodically in some case studies. In this report we analyze the occurrence rate of the strongly sheared configuration in the plasma sheet with more confidence with the 11 years of Geotail data. We show that the large By conditions are more common for the inner pre-midnight plasma sheet (X>-20 Re, 0<Y<10 Re) and intervals with larger IMF By, which are more common during solar maximum. However while on average the penetration rate of IMF By in the plasma sheet is 0.3-0.6, during intervals with sheared configuration it is formally larger than unity. Therefore the mechanism of its formation is internal rather than external. We also list and discuss some consequences of strong shear in the plasma sheet.

Storm-time ionospheric dynamics revealed through GPS tomography

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The global pattern of the ionospheric plasma convection can be deduced from characteristics of microwave GPS signals acquired by ground-based network of GPS receivers. The tomographic inversion of these GPS data in a three-dimensional time-dependent inversion algorithm can reveal the spatial and temporal distribution of ionospheric plasma density. This algorithm has been applied to reconstruct the dynamics of ionospheric plasma content (TEC) and density during some major magnetic storms of the recent solar maximum. Comparison between the results of GPS tomography and in-situ measurements of thermal plasma motion by LEO satellites allow conclusions to be made about the degree to which the ionospheric convection flow expands during the major storms and the efficiency of electromagnetic magnetosphere-ionosphere coupling at sub-auroral latitudes.

Characteristic oscillations of the magnetotail during sawteeth events according to GOES satellite data

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The bias of the magnetic field lines, passing through GOES-8 and GOES-10 satellites, to the geographic equatorial plane is investigated for 2000 year. Sometimes the magnetic filed lines stretch to the tail. The ratio of the earthward ***he***-component to the parallel to Earth axis ***hp***-component, exceeding 1, is observed in this year during 10% time at GOES8 and during 4% at GOES10. This stretching occurs near geomagnetic midnight and mostly at summer time. The bias has oscillation mode with period about of 2-4 hours and geomagnetic activity at this time is known as "sawtooth event". The oscillations fall at planetary magnetic disturbances: *Kp*-index is between 4.0 and 5.1, but the stretching is not accompanied by substorm activity; a substorm appears in depolarization phase, or at reset of field line configuration. We suppose that these hour-long oscillations are due to the wave motions of the Earth magnetotail. For several "sawtooth events" the bias is estimated by Tsyganenko magnetosphere model and the

result is compared with experimental data. The discrepancy is enough considerable, and it confirms the idea about characteristic oscillation of the tail.

Observations of GPS TEC fluctuations in Antarctic and Arctic ionosphere during 28 October 2003 storm

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GPS observations of IGS network were used to study development of TEC fluctuations during 28 October 2003 storm. The fluctuations caused by the different scale ionospheric irregularities. High-latitudinal fluctuation occurrence relates with auroral oval, casp and polar cap. In the analysis we used more than 20 GPS stations at north hemisphere and 5 stations at south hemisphere. The highest-latitudinal stations were THU1 (84.6°N, CGL) at north and CAS1 (80.6°S, CGL) at south.. For analysis of the temporal variations of different carrier phases the GPS measurements along individual satellite passes were used. As the measure of phase fluctuation activity we used the rate of TEC on 1 min interval (ROT). To evaluate the intensity of TEC fluctuations was used the index ROT (ROTI).
Deep TEC fluctuations have been regularly detected in phase measurements along individual GPS satellite passes at polar ionosphere. During quiet conditions on auroral stations the maximum of phase fluctuations activity was observed near local magnetic midnight. During storm the strong fluctuations were observed even during daytime. At polar stations the weak fluctuations were registered all day even in quiet geomagnetic condition. The intensity of phase fluctuations essentially increases during storm. The strongest TEC fluctuations were detected in polar stations which were associated with polar patches. The enhancement of TEC in polar patches reached more than 2-5 times relative to background. The intensity of patches significantly increases during substorm activity. Storm-time occurrences of phase fluctuations were clearly controlled by UT.

Поток Пойнтинга в магнитосферу Земли в модели с двойным магнитным хвостом

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Описан начальный вариант нового метода расчёта потока электромагнитной энергии (потока Пойнтинга, ε*), поступающего в магнитосферу Земли из солнечного ветра. Входные данные – значения скорости солнечного ветра и значения переменной части магнитного потока через полярную шапку, Ψ_1, а также постоянной части, $\Psi_{2,0}$. Сумма Ψ_1 и Ψ_2, Ψ – составляет полный «открытый» магнитный поток хвоста. Используется модель магнитосферы с двойным хвостом, в которой поток Ψ определяется в ходе суббури известными методами – как поток через внешнюю часть площади п.ш., а поток $\Psi_{2,0}$ – теми же методами, но как внутренняя часть потока через п.ш., наблюдаемая перед суббурей. Отмечено, что поток через внутреннюю (околополюсную) часть п.ш. есть $\Psi_2=\beta\Psi_{2,0}$, где β - переменный коэффициент, изменяющийся в ходе суббури в широких пределах между 1 и 0. Рассмотрена модель магнитосферы с двойным хвостом, что соответствует сопоставимым значениям Ψ_1 и $\Psi_{2,0}$. Приведен первый вариант алгоритма и результаты вычислений ε* по данным наблюдений. Полученные предварительные результаты сопоставлены с данными ранних методов определения потока Пойнтинга по наблюдениям.

Суббуря 14.09.04: оценки параметров области разрыва токов поперёк и вдоль хвоста

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Известно, что пара ПТ (продольных токов) классического токового клина суббури (SCW) замыкается посредством тока поперёк хвоста в плазменном слое ближнего и среднего хвоста. Интенсивность этого тока J равна интенсивности ПТ, втекающего (вытекающего) в полярную ионосферу в утреннем (вечернем) секторе ионосферной проекции SCW. Эти значения обозначены J+ и J-, соответственно. Мы построили 2D карты распределения плотности ПТ в полярной ионосфере с шагом 1 – 5 минут по данным суббури 14.09.04, используя технику инверсии магнитограмм (ТИМ), и определили значения J+ и J-, а также положения центров D и U втекающего и вытекающего ПТ, соответственно. Как и ожидалось, оба центра располагаются в ночном секторе Зоны 1 Ииджимы и Потемры, центр U к западу от центра D. Однако было найдено также, что центр U вытекающего ПТ в ходе активной фазы суббури располагается систематически на несколько

градусов выше по широте, чем центр D, т.е. магнитосферный ток - источник пары ПТ SCW – имеет как известную компоненту J_y, так и компоненту J_x. Используя карты ПТ и модель Цыганенко Т-96, мы определили компоненты J_x и J_y разрушающего тока хвоста. Далее, задав размеры X и Y и положение области разрыва тока хвоста, на основе законов Ампера, Фарадея и Ома были вычислены средние на площади разрыва параметры разрушенного магнитного поля, разрушенного магнитного потока, соответствующей индукционной эдс, и мощности процесса разрушения. Отмечено также, что в обеих областях, где текут токи J_y и J_x, выполняется условие динамо-области, $\mathbf{j}\cdot\mathbf{E}<0$. Обсуждается природа токов в плазменном слое (J_x) и долях (J_x). Отмечено ясно выраженное распространение области пересоединения от Земли в хвост при переходе от PSR к PSR+TLR. Кратко обсуждается природа отмеченного выше скручивания по часовой стрелке пространственного образца ПТ.
Использовалась двумерная модель токового слоя хвоста, с $\partial/\partial z=0$. Расчёты выполнены по данным фазы псевдобрейкапов (PSR) и, отдельно, по данным следующей фазы - пересоединения в плазменном слое и долях хвоста (PSR +TLR).

Меридиональные системы токов в магнитосфере и их вклад в генерацию авроральных электроструй суббури

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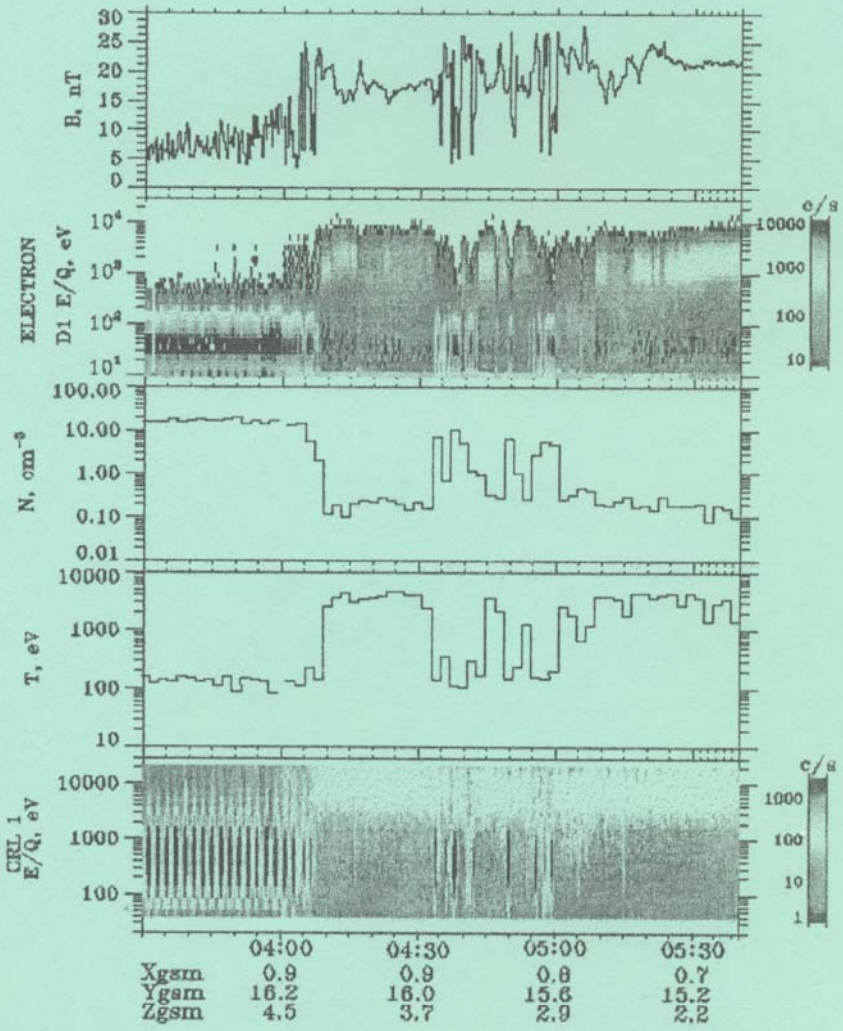
Назовём «зональной» систему токов типа SCW, токового клина суббури. Эта система ZCS состоит из тока вечер-утро в магнитосферной области разрыва тока хвоста, западного (зонального) ионосферного тока авроральной электроструи AEJ-W (это ток Педерсена и/или Каулинга), и пары продольных токов (ПТ), соединяющих два названных перпендикулярных тока в магнитосфере и ионосфере. Один ПТ системы ZCS/SCW втекает в ионосферу аврорального овала около полуночи в утреннем секторе, второй ПТ вытекает из ионосферы в вечернем секторе, т.е. два ПТ в ZCS разделены в зональном направлении. Вращение ZCS на 90^0 трансформирует эту систему в то, что называют «меридиональная система токов», MCS. В системе MCS для AEJ-W (мы её назвали MCS-1) ионосферный ток Педерсена течёт в меридиональном направлении, от втекающего ПТ к вытекающему ПТ. Два слоя ПТ в MCS-0 обрамляют AEJ-W с севера (втекающий ПТ) и юга (вытекающий ПТ). Между двух слоёв ПТ образуется ток Холла на запад, создающий вклад MCS-1 в AEJ-W.
Т.о., западная авроральная электроструя разгрузочной фазы суббури создаётся как сумма вкладов системы ZCS/SCW (токи Педерсена и/или Каулинга) и системы MCS-1 (ток Холла). В настоящей работе используются 2D карты распределения в полярной ионосфере плотности ПТ, полученные с помощью техники инверсии магнитограмм (ТИМ-2) для рассмотренных суббурь с шагом 1 – 5 минут. Выполнен расчёт интенсивности каждой из двух компонент AEJ-W, создаваемых в ходе избранных суббурь: одна компонента - системой ZCS/SCW, вторая компонента – системой MCS-1.
Описаны также системы MCS-0 и MCS-2. Первая создаёт расширение Холловского тока AEJ-W глубоко в вечерний сектор, вторая создаёт Холловскую восточную авроральную электроструую AEJ-E. Обсуждается физика замыкания ПТ в магнитосфере.


B, nT
ELECTRON
D1 E/Q, eV
c/s
N, cm⁻³
T, eV
CRL 1
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04:00
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Xgsm 0.9 0.9 0.8 0.7
Ygsm 16.2 16.0 15.6 15.2
Zgsm 4.5 3.7 2.9 2.2

Multi spacecraft observation of plasma dipolarization/injection in the inner magnetosphere

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Addressing the origin of the energetic particle injections into the inner magnetosphere, we investigate favorable constellations of Cluster, THEMIS and LANL spacecraft mapped to the equatorial plane within 6-12 Re. We discuss the relationship between the dispersionless energetic particle injections and local magnetic dipolarizations. Using two methods we evaluate the injection inward propagation velocities and show the deceleration of the injection front with appoaching to Earth (from hundreds km/s at ~10 Re to tens km/s near the geostationary orbit). Based on observed injection properties, we suggest that it is the underpopulated flux tubes (bubbles with enhanced magnetic field and sharp inner front propagating earthward) which transport particles into the strong-field dipolar region.

Intensity and duration of magnetic storms depending on passing Earth's trajectory through magnetic cloud

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The nature of geomagnetic disturbances caused by solar mass injection is stochastic and the same magnetic cloud can generate different magnetic storms of various intensity and duration that depends on the Earth's trajectory which passes across central or peripheral region of the cloud. We demonstrate model calculation of the interplanetary magnetic field parameters that should be measured by a satellite that moves through the magnetic cloud along different trajectories. Parameters of model magnetic cloud: radius R = 2500 Re; cloud velocity V = 400 км/с; module of the magnetic field on the cloud axis B_0 = 20 нТл; spirality H = 1Re. The cloud coordinate system (Xc, Yc, Zc) varies depending on angle ε, which makes an axis of a cloud with ecliptic plane, and azimuth angle β counted from axis X of solar-ecliptic system of coordinates in ecliptic plane. Basing on the model of magnetic field in a magnetic cloud it is to estimate possibility of a certain cloud to cause magnetic storms of different intensity that depends on the magnetic field of the cloud and trajectory along which the Earth is passing the cloud.
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Images of aurora obtained by ground-based device under twilight conditions

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The new CCD PhotonMAX camera was tested in PGI observatories at Apatity (Kola Peninsula) and Spitsbergen (Barentsburg) in 2007 in observations of aurora and nightglow under twilight conditions. The camera was used in coupling with ordinary lenses and Fabry-Perrot interferometer (FPI) used as narrow spectral band filter for 557.7 nm emission. Preliminary data show that sensitivity of this camera is higher by one order or even more of sensitivity of conventional Intensified CCD instruments. Another advantage of the camera is concerning to behavior of signal/noise ratio, which permits to accumulate useful signal for long time (up to several hours) almost without CCD saturation. Those features of the device permit to use this camera with different input optics to obtain rather high signal/noise values. The use of FPI in green line in front of CCD permits to dump scattered Sun radiation by several

orders and therefore allow to register relatively weak emissions of upper atmosphere including aurora and nightglow during twilight hours. PGI daylight auroral imager consists of front all-sky lens with working field of view about 140˚, band interference filter at 557.7 nm and FPI as extremely narrow band –passing filter. The special software was developed for processing and presentation of the data obtained. Authors will demonstrate some auroral images obtained in twilight. Possible physical tasks of the upper atmosphere optical investigations by described above equipment are under discussion. Especially this kind of measurements are valuable for artificial cloud release from a rocket and heating experiments because of possibility to observe images of artificial objects during twilights and daylights for a longer time.

Accounting for electric field variability in calculations of Joule heating in the high-latitude ionosphere

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For modeling global thermospheric circulation and other atmospheric processes, it is important to know reliably the amount Q of Joule heating, which is one of the major energy sources in the upper atmosphere. Systematic discrepancies between thermospheric modeling results and observations indicate that Joule heating at high latitudes, when calculated from average electric field patterns, i.e. proportionally to the square of the average E-field, is underestimated. This is most likely because of ignoring small-scale fluctuations in the electric field, which sometimes exceed the mean values by an order of magnitude. In the present study, Joule heating has been calculated as proportional to the average of the square of the E-field, observed in high-latitude passes of DE2 under different IMF conditions. It is shown that accounting for variable electric fields may significantly increase the assessment for high-latitude Joule heating, thus bringing into consistence the energy budget in the upper atmosphere.

Features of scaling behavior of auroral luminosity fluctuations observed by ALIS

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Several tens of auroral images obtained by the Auroral Large Imaging System (ALIS), an optical facility with extremely low noise level and large dynamical range, have been examined in order to investigate scaling properties of spatial variations in auroral luminosity. The images referred to substorm conditions and contained active auroral forms of different types. We analyzed logscale diagrams (LDs) constructed by discrete wavelet transform of the data as well as scaling features of probability density functions (PDFs) of the fluctuations. Closeness to mono scaling is shown in the case of auroral spots, the scaling index α varying around 2.6. Substorm auroral arcs reveal higher degree of intermittency, manifested in a deviation of LDs from linearity and a poor collapse of the PDFs re-scaled with a single scaling exponent. We demonstrate that optical fluctuations observed in different emissions (4278 Å and 5577 Å) at close observational times have nearly the same scaling characteristics. A comparison is performed with scaling properties of electric fields observed by the *Dynamics Explorer 2* satellite under substorm conditions. It is shown that when data series are nearly self-similar, the scaling parameters for substorm electric fields are in a reasonable agreement with those for auroral fluctuations. This suggests a relationship between high-latitude turbulence features manifested in electrodynamics and in optics.

Using models of magnetospheric magnetic field for real-time assessment of geomagnetic activity based on CHAMP magnetic measurements

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It is presented development of the method of real-time assessment of geomagnetic activity based on satellite magnetic measurements. Satellite data of the magnetic field module and/or its components measured along each orbit (or any of its segments) should be compared with a magnetic field model for some external conditions. External conditions are to be arranged into groups according to geomagnetic activity grades (quiet, weakly disturbed, disturbed, strongly disturbed conditions) which have been defined by different way. Model magnetic field

calculated for all points of the satellite pass for each geomagnetic activity grades is compared with real-time satellite measurements. We used the magnetic field measurements of CHAMP satellite and modern models of the magnetospheric magnetic field (Paraboloid model, T96, T01) for real-time monitoring of the geomagnetic activity level.
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The development of time-series data management system

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The Time-Series Data Management System (DMS) was developed to provide a common data handling tasks in scientific computing. The system is intended for processing a data with time-series structure.
We used advantage approaches based on specialized database management system and server-side computing to support a wide-range of data formats and the common data handling tasks. Our solution provides import/export for various data formats and performs the common data handling and analysis operations, such as decimation of data, smoothing, filtering, and data sampling by criteria.
We implemented application interfaces for MATLAB and IDL to provide an interaction between user's applications and DMS. Also we developed web-based interface for DMS that allows access to all stores of data, provides various data handling and data conversation operations.
At present, DMS has been installed at Polar Geophysical Institute, RAS and use to perform a common data handling operations as part of data acquisition system.

On the energy spectra of protons and electrons in the auroral magnetosphere

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Summary of the electron and proton spectral measurements are presented. Depending on the energy, several particle populations are described from cold plasma to Mev particles of the radiation belts. Presented results are based on the CRRES and CORONAS-F satellite measurements on different drift shells and pitch-angles during quiet and disturbed periods. Speculations on the nature of the spectral variations during substorms are presented.

Long-term variation in geomagnetic field measured by IZMIRAN observatory

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The long-term variation of the geomagnetic field on the Earth's surface are generated by internal and external sources and may be caused by changes inside of the Earth and in the near-Earth space. The problem of separation of the variation into selected sources is not well-posed, its solving depends on a method of used geomagnetic data examination. Usually it is assumed that changes of internal sources of the Earth's magnetic field is the main cause of long-term variation of the geomagnetic field. We examine the geomagnetic field measured by IZMIRAN observatory during late 60 years to estimate long-term variation of hourly averaged amplitudes of the geomagnetic field components caused by wave and corpuscular radiation of the Sun. It is shown that long-term variation of the geomagnetic field are due to variations in the Sun activity within the Sun activity cycle and from one cycle to another one.
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Asymmetrical 1D configurations of thin current sheet in the magnetotail with constant B_z and B_y

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

Photometric study of pulsating precipitations of the energetic particles at latitudes of diffuse aurora and SAR arc

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Ground-based observations of the diffuse aurora and mid-latitude red arcs (SAR arcs) are informative investigation method of the dynamic processes in the vicinity of plasmapause and inner boundary of the plasma sheet during magnetospheric disturbances. It has been known that SAR arcs are the consequence of interaction of the outer plasmasphere (plasmapause) with energetic ions of the ring current. The diffuse aurora is caused by low-energy electron precipitation from the plasma sheet. During substorms the intensity increase of diffuse aurora and its equatorward extension up to the plasmapause projection which is mapped by the SAR arc appearing at that time are observed. At the recovery phase period of intense substorms at latitudes of SAR arc, usually there are the luminosity pulsations in the 427,8 nm N_2^+ emission owing to the pulsating precipitations of the ring current energetic particles in the outer plasmasphere. (Ievenko, 1995, 1999; Parnikov and Ievenko, 2006).
In this work the simultaneous variations of the 427,8 nm N_2^+ emission intensity with periods of 10-20 s at latitudes of the diffuse aurora and SAR arc are studied. The detailed relation of the development of luminosity pulsations to the formation of SAR arc equatorward of the DA boundary in the 557,7 nm emission is found. The spectral and correlation analyses of luminosity variations have been carried out. The delay 0,3-0,5 s in pulsating precipitation development in the latitude interval ~4^o (ΔL=0,5-0,7 R_E) has been revealed. It is supposed that the appearance of pulsating precipitations of energetic particles at latitudes of the SAR arc (outer plasmasphere) in these cases can be caused by the propagation of magnetosonic waves from the region of source (pulsations in the diffuse aurora) inwards the magnetosphere.

Model study of transition from impulsive to steady-state reconnection

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Observations of magnetic reconnection in the Earth's magnetosphere show that reconnection is very seldom stationary or quasi stationary, more often it has impulsive character. The purpose of this paper is to study the transition from Petschek-like to quasi steady-state reconnection. For this purpose, we use the time-dependent reconnection model for a symmetric current layer. Reconnection is produced by a time-varying reconnection electric field along the x-axis. The temporal variations of the magnetic field and the plasma velocity are computed for a) a one pulse of electric field, b) a steady-state electric field and c) a series of electric field pulses. At small distances from the current layer we find for case c) all signatures of impulsive reconnection, for intermediate distances

signatures of steady-state reconnection, and, finally, for large distances it looks like the usual one pulse reconnection.

Partial least squares model for the prediction of magnetospheric relativistic electron dynamics

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The creation of relativistic electron flux prediction models is very important, because these particles pose the main hazard to the functioning of high-orbit spacecrafts. Commonly, relativistic electron enhancements in the outer radiation belt are associated with magnetic storms. However, the wide variability of the response and the puzzling time delay of two days between the storm main phase and the response of the radiation belt have frustrated the identification of responsible mechanisms. Moreover, some electron events may occur even without a magnetic storm or during very mild storms. The efficiency of these non-identified mechanisms of the energetic electron acceleration is strongly enhanced upon increase of solar wind speed. Because the solar wind does not interact directly with magnetospheric electrons, some intermediary phenomenon must more directly provide energy to the electrons. Rather surprisingly, ULF waves in the Pc5 band (few mHz) have emerged as a possible energy reservoir: the presence of Pc5 wave power after minimum Dst was found to be a good indicator of the relativistic electron response [Rostoker et al., 1998, Mann et al., 2004]. In the literature it has also been shown, that auroral activity is of great importance for the appearance of electron enhancements (presented, for example, as AE index).
Partial least-squares (PLS) regression is a method that can deal efficiently with data sets where there are very many variables that are highly correlated and is gaining importance in many fields of science. An empirical model for the relativistic electron dynamics, constructed by means of the PLS method, will be presented in this talk. The model uses as input parameters a set of heliogeophysical index values (Dst, AE, R, ULF, etc.) covering the previous three days of observation. It permits one to forecast the electron flux level and estimate the contribution of each input parameter to the result. The model has been applied to two years of data (1994-1995) and preliminary results indicate that ULF wave activity in the magnetosphere is found to play an important role in the relativistic electron flux increase. Furthermore this model is able to predict electron flux levels several hours in advance. The correlation coefficient of the predicted electron flux with the measured flux is 0.6 for one hour averaged values.

Structural features of auroral precipitations and topology of high latitude current systems

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Results of simultaneous Meteor-3M and auroral imager observations are used for investigation of different features of auroral precipitations. It is taken into account that the threshold of auroral imagers does not exceed the brightening, which can be connected with plasma sheet electron precipitation without field-aligned acceleration. Accelerated electron fluxes are the sources of upward field-aligned currents. Values of such currents are estimated using Meteor-3M electron flux observations. Obtained values give the possibility to estimate transverse magnetospheric current supported by observed field-aligned currents. Simple model of high latitude continuation of ordinary ring current – cut ring current system (CRC) is developed. Values of magnetic disturbances produced by such current system are obtained.

Stand-alone station for registration of GIC in power systems

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M.B. Barannik, V.V. Kolobov, V.N. Selivanov (*Centre of physical-technical problems of the energetic of the North)*

Queasy - stationery electric fields at the ground level in the auroral region are sequent of magnetospheric disturbances. They lead to geomagnetically induced currents (GIC) development. The registration of GIC in the high voltage power lines in Polar Regions requites the special equipments to operate for a long time without of the control or handling of operator. For this task stand-alone system for data acquisition and transmission was developed. Data are transmitted on time schedule. To provide the high level of reliability we use the special diagnostic tool to prevent of the system failures. System have been installed on the power substation in Revda.

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

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

Magnetic reconnection in nature is essentially 3D nonstationary process which needs adequate mathematical description. The 3D Green function is found for delta function-like time behaviour of electric field along the reconnection line of the finite size. The method developed allows to calculate disturbances of magnetic field and plasma velocity in the surrounding the accelerated plasma flows space as well as the surface waves on the current sheet produced by reconnection pulse. Different configurations for the initial conditions are considered. The temporal and spatial distributions of magnetic field and plasma velocity are presented.

Daytime auroral dynamic during unusually large northward interplanetary Bz

O.I. Yagodkina, V.G. Vorobjev *(Polar Geophysical institute, Apatity, Russia)*

The meridian scanning photometer and all-sky TV camera observations at Heiss Isl. (Φ'=75.0° N, MLT=UT+4.6) were used to examine the daytime auroral dynamic during unusually large northward interplanetary Bz (~20-25 nT) associated with the interplanetary magnetic cloud on January 13-14, 1988. Characteristics of dayside aurorae were analyzed in time period from 06 to12 UT on January 14, 1988 along with interplanetary magnetic field and solar wind plasma observations. Throughout all dayside sector from 10.5 to 16.5 MLT the wide stable red auroral band with about 1-2 kR intensity in the 630.0 nm emission was revealed at corrected geomagnetic latitudes (CGL) from ~74º-75º to ~80º-81º. Variations of the auroral intensity in this band as well as the dynamics of its boundaries were in a good agreement with the changes in the solar wind dynamic pressure. It was found two branches of discrete aurorae within the red auroral band: bright rayed auroral arcs at about 75º-77º CGL and faint rayed arcs at ~80º CGL. The appearance of bright rayed arcs (up to 6-7 kR in the 557.7 nm emission) was coincided with the turn of interplanetary By from positive to negative direction. The occurrence and intensification of bright rayed arcs in most cases followed increases in the solar wind dynamic pressure.
This study is supported by the RFBR grant 06-05-64374.

Temporal variations of the equatorial boundary of auroral proton precipitation during moderate geomagnetic disturbance

L.S. Yevlashin *(Polar Geophysical Institute, Apatity, Russia)*

There have been studied temporal variations of the (southern) equatorial boundary of hydrogen emission H_α with the intensity of over 200 Rayleighs within the latitude range (67^0 - $56^0\Phi$).
Data of observations during 2 nights (December 28-29 and 29-30, 1970) are the subject of consideration. Conditions for registering the spectra using C-180-S cameras were favourable concurrently for two stations (cloudless weather, good transparence of the atmosphere) under moderate geomagnetic disturbances. Observing stations Loparskaya ($\Phi = 64^0$) and Kem ($\Phi = 60^0$) are located at practically the same geomagnetic meridian; this allowed to exclude the longitudinal variations of emission H_α.
During one of the events (December 28-29, 1970 the mean hourly Dst value in the evening time 16-20^h UT made -26 nT) the equatorial boundary of hydrogen emission H_α underwent wavelike changes in time with the wave length

of ~ 800 km and the maximum amplitude of ~ 350 km. This phenomenon may testify of the presence in the Earth's ionosphere of giant undulations of the equatorial boundary of diffuse luminosity of the auroral oval. Similar phenomena have been found in the integral light by optical instruments installed on board DMSP satellite.
This study was partly supported by RFBR (grant 06-05-65044) and by the Program for Basic Research of the Presidium of RAS №16.

Universal scaling of the non-adiabatic acceleration of ions in current sheets

L.M. Zelenyi, M.S. Dolgonosov, E.E. Grigorenko *(Space Research Institute of RAS, Moscow)*

We have studied acceleration of ions in current sheets in a collisionless plasma. The analytical analysis of non-adiabatic ion dynamics provides a universal property of the ion acceleration mechanism, which is independent of the magnetic-field model and the initial particle distribution function. The width of the resonance region is estimated. The theoretical results are compared with the experimental and numerical simulation data.

Время распада кольцевого тока в модели с двойным магнитным хвостом

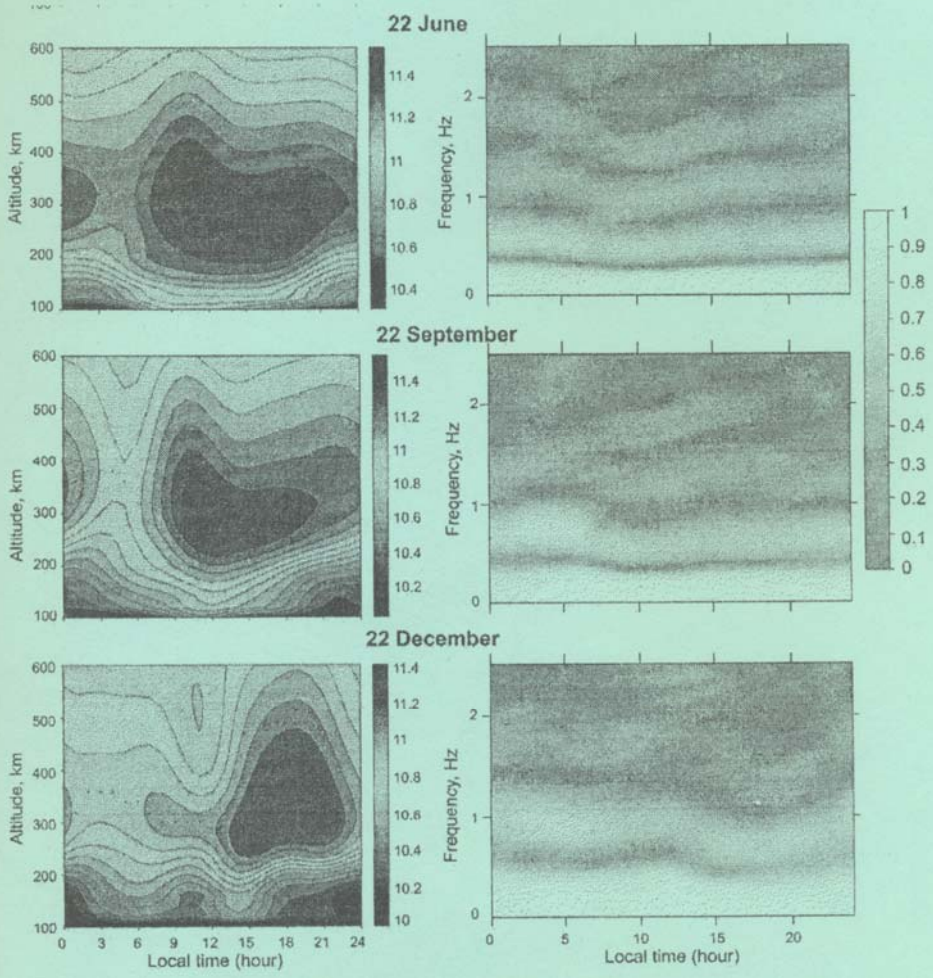
Ю.А. Караваев, Ю.В. Кузьминых, и В.М. Мишин *(Институт солнечно-земной физики СО РАН)*

Описан первый вариант нового метода расчёта времени τ распада кольцевого тока DR. Метод основан на известном уравнении Десслера-Паркера-Скопке, но включает в себя новые методы определения из наблюдений мощности DR тока, использующие заданный поток Пойнтинга в магнитосферу (ε*) и заданную мощность потерь поступающей энергии в ионосфере. Приведён график изменений τ в ходе супербури 20.11.03, полученный по новым данным ε*, вычисленным в рамках модели магнитосферы с двойным хвостом (см. абстракт доклада Кузьминых и др. на данном семинаре). Отмечены улучшения правдоподобия полученного графика τ по сравнению с известными литературными данными.

Магнитосферные генераторы токов поперёк и вдоль хвоста

В.М. Мишин, А.Д. Базаржапов, Ю.В. Кузьминых, Л.А. Сапронова, и М.В. Толочко *(Институт солнечно-земной физики СО РАН)*

Обсуждается концептуальная модель системы генераторов магнитосферных токов, а также продольных и ионосферных токов, возникающих при южном ММП. Описаны механизмы, ответственные за ряд наблюдаемых явлений, включая изменения в ходе фазы роста суббури разности потенциалов на границе полярной шапки, образование недавно обнаруженных меридиональных систем токов, скручивание по часовой стрелке пространственного распределения продольных токов трёх Зон Ииджимы и Потемры, и др.


22 June
22 September
22 December
Altitude, km
Frequency, Hz
Local time (hour)
Local time (hour)

Project "Development of the methodology of experiment and technical support for studies of the flow cyclotron maser in the Earth's magnetosphere by creating an artificial ionization cloud from a geophysical rocket"

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Main goals Investigation of the wave particle interaction in the magnetosphere and ionosphere by governed experiment in near Earth space is in focus of modern space geophysics now. We propose to stimulate auroral precipitation by changing of parameters of the Flowing Cyclotrone Maser (FCM) and test the FCM model itself.
Existing scientific basis The theory of FCM is base on a magnetic force tube containing a filament of enhanced plasma concentration and energetic electrons with anisotropic velocity distribution. These particles enter the FCM in the course of magnetic drift. They then switch on to cyclotron instability and emerge from the filament with isotropic velocity distribution. The model was constructed on the basis of simultaneous observations of aurora and natural VLF emissions and quantitatively explains pulsating energetic particle precipitation and auroral pulsations, which are correlated with pulsating VLF emissions. The essential feature of FCM is a strong dependence of the reflection coefficient of the whistler mode on the ionization at the foot point of the filament in the ionosphere. This dependence gives us the possibility to generate the auroral pulsations by creating ion clouds mirror in the ionosphere. Indirect evidences of the FCM model is possible to see in the rocket experiments, which carried out by Americans in Alaska and Russians in the Atlantic Ocean, when auroral pulsations were apparently triggered during the artificial release of Ba clouds in the ionosphere.
Scheme of the experiment and equipment Northern Sweden is in auroral zone and rather good place for the experiment on the induction of pulsating aurora by barium release into the polar ionosphere. There are ESRANGE with rockets launch facilities and IRF network of low light CCD cameras (ALIS et al), which permit to registered natural and artificial weak images of auroral effects in the upper atmosphere. The spectral observations can be provided by PGI, ESRANGE, and IRF devices. There are also satellite station for weather forecast and network of magnetometers and riometers of ESRANGE and IRF, which can be used for real time control of the current geophysical situation and selecting of the launch time. There are two necessary conditions for the time of launch. Heights of the ionized cloud release (about 180 km) must be in sunlit conditions and typical recovery phase of the substorm should be existed near the zenith of the launch station. A payload consisted of canister with chemical components and the operation system for an explosion can be prepare by Institute of Applied Geophysics, which had a great experience of this kind work. VLF observations could be provided by PGI and may be other invited participants. Long-term forecasting can be provided by the Alaska Geophysical Institute team. All theoretical and practical questions concerning the experiment, selection of carrier, assembly, integration and test of payload equipment are discussed and detailed by partners now and will be presented in the report.

Ground and ionospheric response to the beamlets in the magnetotail

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We analyze several events when isolated beams of energetic ions are detected by Cluster or Geotail satellites in the magnetotail. We search for the response in ULF magnetic disturbance on the CARISMA array of magnetic stations and UV images produced by Polar or IMAGE satellites. In many cases the transient magnetic oscillations and weak intensification of UV emission have been detected. This response is localized in the region geomagnetically conjugate to the location of the beamlet occurrence in the magnetotail.

Consequences of the interaction between Alfvén ion-cyclotron waves and ring-current ions

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We consider some effects caused by precipitation of energetic ions into the ionosphere due to the turbulent diffusion at Alfvén ion-cyclotron waves (ICW).
One of such effects is due to the dependence of the ICW generation on the precipitation via the modification of the ionospheric reflection coefficient. A variation in the ionospheric reflection can be significant due to its nonmonotonic frequency dependence related to the ionospheric Alfvén resonator. This effect can explain formation of repetitive ICW bursts with properties similar to Pc1 pearls. Observation results which are in favor of and against this model will be briefly discussed.
Another important effect of ICW related precipitation is a significant loss of the ring current (RC) ions. This loss process is localized at the interface between the RC and disturbed plasmasphere due to the dependence of precipitation on cold plasma density. It contributes to the formation of partial ring current (PRC) by generating a localized 3D current system which comprises the field-aligned current of precipitated ions, ionospheric closure currents, and the Hall current driven by the ionospheric electric field. Estimates show that the parameters of such a current system can explain storm-time subauroral ionospheric drift events (polarization jets).
Besides the fact that the discussed effects are of common physical nature and are related to the magnetosphere-ionosphere interaction, they are associated with the work of V. Yu. Trakhtengerts and serve as demonstrative examples of his deep insight into the studied problems and his eagerness to explore the natural beauty of the whole chain of causes and consequences.

Efficiency of cyclotron acceleration of radiation belt electrons by whistler-mode waves with varying frequency

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We study the gyroresonant acceleration of radiation-belt electrons by quasimonochromatic whistler-mode waves with account of particle trapping by the wave field. We perform and compare analytical estimates and numerical calculations for the net acceleration rate related to the particle motion in the trapped regime and energy diffusion related to the trapping and untrapping processes. Taking into account the nonlinear amplitude modulation in a chorus element, we obtain that the energy diffusion rate can be comparable to that of the net acceleration rate, while it is by an order of magnitude smaller for an idealized wave packet with constant amplitude. Analytical estimates and numerical results for the acceleration parameters are in agreement with each other. Analytical estimates of the overall acceleration efficiency yield that a fraction of up to 10^{-3} of energetic particles can be involved in the regime of nonlinear acceleration for the plasma parameters corresponding to the region just outside the plasmapause.

The goose-like Pc1 pulsations

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The analysis of the new types of geomagnetic pulsations in the frequency range of Pc1 pearl waves observed by Finnish network has been fulfilled. The observed new types of Pc1 pulsations is characterized by the narrow spectrum width which look likes the goose's beak at the beginning of the event and the broad spectrum width in the processes of development of the event ("the wings of the goose").The events have been divided on the three types: (a) the events with the spectrum width broadening down (to the lower frequencies), (b) the events with symmetrically broadening spectra in relation to the beginning frequency of event and (c) the events with the

spectrum width broadening up (to the higher frequencies). The interpretation of these events may be connected with different mechanisms. The possible mechanism of the first type wave's generation can be associated with the nonlinear three-wave interaction. After certain amplitude reaching the electromagnetic ion cyclotron (EMIC) waves may decompose into an ion sound and EMIC wave of lower frequency. This process leads to a "cascade" of the Pc1 series with the decreasing frequency. The interpretation of the second type is based on the quasilinear development of the EMIC waves and the energetic anisotropy protons interaction, resulting the symmetrical spectrum broadening. The spectrum of the third Pc1 type consists of both: the falling tones, corresponding to the frequency dispersion of the magnetosonic (R-) waves, and of the rising tones, corresponding to the frequency dispersion of the Alfven (L-) waves. Moreover, unlike the classic pearl pulsations, the dynamic spectrum of third type consists of the parallel elements. We can suggest that each wave pocket is a new generating one not bouncing between conjugated ionospheres. In this case, the interpretation of such phenomenon more corresponds to the model of pearl formation, in which long-period Pc 3-5 geomagnetic pulsations modulate the Pc 1 growth rate. We suppose that the observed R-dispersion in the beginning of the event, occurring due to the antisymmetrical harmonic (second harmonic) of the long-period pulsations, can provide the appearance of the proton fluxes with relative mean velocity v_0 directed along the background magnetic field. The interaction of such proton beams with EMIC waves leads to the instability, which allows the fastest growth of the electromagnetic oscillations with the dispersion of R-wave type. When the velocity of the proton beam decreases ($v_0 \approx 0$), R-waves become attenuated and L-waves (for the proton temperature $T_\perp > T_\parallel$) will be amplified. This instability is the reason for the generation of the classic Pc1 pearl pulsations with the usual dispersion and allows explaining the transition of the dispersion from R- to L- waves.
The ionosphere effect in the signal formation is determined by the Ionospheric Alfven resonator harmonics providing the frequency filtration – amplification or suppress of the signal amplitudes only. It can define the frequency range of the signal dynamic spectra, but not the internal signal structure.

Slow drift mirror kinetic instability in bi-Maxwellian plasmas

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It is known that in nonuniform plasmas of nonzero electron temperature, besides the ordinary drift mirror (DM) modes, the so-called slow drift mirror (SDM) modes could exist. Frequencies of these SDM-modes are less than frequencies of DM-modes, but growth rates of SDM in anisotropic plasmas could get comparable or even more than those for DM-modes. In addition, the values of ion temperature anisotropy necessary for mode excitation could appear less in the SDM case.
For the SDM modes under kinetic approximation, two instabilities were previously found: hydrodynamic and kinetic ones. Hydrodynamic instability arises if the ion anisotropy exceeds some threshold; below this threshold, the hydrodynamic instability is impossible. However, in this case the kinetic instability can develop. Previously this kinetic instability was investigated close to the hydrodynamic instability threshold; the more distant area was assumed to be analysed involving numerical methods.
Here we have presented the analysis of the kinetic slow drift mirror (SDM) instability in high-β bi-Maxwellian plasma just in this area distant from the hydrodynamic instability threshold. We succeeded in deriving rather simple analytical expressions for frequencies and growth rates of the SDM modes, which allowed us to carry up numerical exploring of their dependencies on different plasma parameters for the more wide variation range. The results were applied to the real Earth's magnetosheath conditions.

Slow drift-mirror kinetic instability in non-Maxwellian space plasmas

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The generalized Lorentzian (kappa — κ) distribution is known as a good representation for the high-energy tail particle population of natural space suprathermal plasmas; loss-cone features of ion and electron velocity distributions observed in cosmic plasmas are usually accounted with the additional factor of perpendicular velocity in a degree of an integer ($2l$).
For such distributions in the kinetic treatment, we obtained analytical expressions for the frequency and the growth rate of the slow drift-mirror (SDM) instability. The dependence of the SDM instability growth rate on various plasma parameters was then numerically analysed. Results for the κ-distributions displayed a marked difference

from those based on the bi-Maxwellian distribution function, albeit tending to match with it in the corresponding limit ($\kappa \to \infty$, $l = 0$). The growth rate for the κ -distributions appeared to be greater than for the bi-Maxwellian one, besides frequencies corresponding to growth rate maxima were shifted to their lower values. Some decrease in anisotropy instability threshold for the κ -distributions should be noted. Variations in loss-cone parameter l did not affect substantially on the growth rate values.

On the possible effect of the sudden shock compression of the terrestrial magnetosphere on the geomagnetic perturbations

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On the basis of interplanetary and geomagnetic data the presence of distinct connection between the SSC and positive geomagnetic impulses with an arrival of solar fast shock waves and/or tangential discontinuities to the Earth magnetosphere is confirmed. The generation of negative geomagnetic impulses due to the appearance of refracted slow shock waves in the magnetosphere due to an oblique incidence of the solar fast shock wave is also indicated. Besides it is also paid an attention to the influence of secondary fast rarefaction waves arising in the magnetosheath on the geomagnetic field perturbations and long-period geomagnetic pulsations.
The first author is grateful to the support of the program OFN-16. The second author is grateful to the support of the RFBR grant 06-05-64374 and Program No16 of the Presidium RAS.

V.A. Troitskaya- the pioneer of geomagnetic pulsations study

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Valeriya Alexeevna Troitskaya was one of the first who more then 50 years ago has paid attention to the very small oscillations in geomagnetic field, termed later as geomagnetic pulsations. At that time these waves could be observed only by the Earth (telluric) current measurements. In 1957, as the scientific Secretary of the IGY Soviet Committee, she took steps to create in Russia 19 new temporal geomagnetic stations including Borok, Lovozero, Petropavlovsk-Kamcatsky. After that she pushed many young Russian scientists into the geomagnetic pulsations problem because she understood the importance of these waves in the physical processes of the magnetosphere plasma. Only her enthusiasm and persistence allowed perform the first Soviet-French experiments (1964-1979) at the conjugated points Sogra-Kerguelen. This collaboration brought very important findings of the properties and the nature of the different types of geomagnetic pulsations and VLF emissions. For instance, it was discovered the Pc1 (pearl) pulsation bounce between two hemispheres. The new type of non-bouncing Pc1 pulsations was found and termed as IPDP. Later V.A. Troitskaya organized the conjugated measurements of pulsations at the geomagnetic pole stations Thule-Vostok, and discovered the dayside polar cusp pulsations signature consisting of Pc3 enhanced oscillations and specific long period IPCL pulsations. There are many “the” in which Troitskaya was the first. As the President of YAGA Committee, she helped the Russian Scientists to attend different International Meetings. Due to her leadership, the international geomagnetic pulsations study collaboration of the Russian institutions with the scientist from different countries (France, Finland, Norway, England, USA) became successful, that deepened our knowledge of the pulsations physics. Now V.A. Troitskaya is living in Australia. She celebrated her 90-years jubilee on November 15, 2007.

Registration of EM signals from controlled powerful generator

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A testing registration of the vertical component of the electric potential variations (E_D) in tree trunks was realized at three points situated at tops of triangle at distances 6-8 km each from other near st. Lehta (Karelia) during September, 2007. For E_D component measurements two electrodes were used. The electrodes were placed inside a tree at 7-10 m distance along a tree trunk. During the experiment additionally three component of magnetic field variations (H, D, Z) and two horizontal electric field variations (Ex, Ey) were synchronously registered at these three points.

The controlled powerful generator was connected with more than 100 km line of electric power transmission situated at a north part of the Kola Peninsula (~500 km from the st. Lehta). The generator produced 50-180A current in the line (controlled source of EM waves) with different frequencies (0.094, 0.194, 0.382, 0.642, 0.942, 1.942, 3.822, 6.422 Hz).
Using of three points magnetic and electric data gave an opportunity to construct gradient vectors indicating to a source of variations. Results of processing throughout the entire magnetic and electric data show to good coincidence of the magnetic and electric vector directions to the controlled source.

Thermal convection overlapped by velocity shear: Fluid experiment

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Complexity of plasma dynamics restricts usual considerations to relatively simple elementary processes. Not only the processes itself but and interactions between the processes are interesting too. Many analogies between plasma and fluid dynamics are known, partly, convective processes. Here we present first results of laboratory observation of fluid thermal convection overlapped by velocity shear. The velocity shear was orientated perpendicular to the temperature gradient. The fluid used is oil with aluminum dust. The fluid motion has been recorded by digital HD video camera. The structure of the convective cells has been extracted by gradient filter. Visco-elastic features of the convection structure in the region of reconfiguration of thermal convection cells to shear motion have been considered. Gradual decrease of the fluid temperature gave us possibility to follow an increase of the shear motion zone with increase of viscosity. Possible analogies of observed structure with events in the auroral ionosphere are discussed.
This work was partly supported by the Division of Physical Sciences of Russian Academy of Science through the Program 16.

The effects of polarization of the ELF-VLF waves in the waveguide “the Earth – ionosphere”

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Ground based registration of ELF-VLF waves has been performed at frequencies from 0 to 10 kHz in November 2006 in Kannuslehto, Finland. Monitoring showed different behavior of waves with right-handed (R) and left-handed (L) circular polarization in vicinity of a critical frequency. Critical frequency is the frequency of the first transverse resonance (~ 2 kHz). From 1 to 1.8 kHz the L-polarized mode power was much greater than that for R-polarized mode, whereas between 5 and 10 kHz R and L powers were equal.
For analysis we calculated the attenuation of R- and L-polarized modes on the basis of the wave equation

$$\frac{d\mathbf{e}}{dz} = ikT\mathbf{e}, \qquad (1)$$

where $\mathbf{e} = \begin{bmatrix} Ex \\ Ey \\ Bx \\ By \end{bmatrix}$ – vector of amplitudes of wave field components, z – height in ionosphere, k – wave vector, matrix T depends of parameters of ionosphere. The ionospheric model IRI was used for calculations. If we have in right side of inhomogeneous wave equation source of wave field, this equation describe processes of generation, propagation and linear transformation of waves. Boundary conditions of the problems consist of radiation conditions in the upper ionosphere and conditions for ideal conductor for the Earth. Problem has unique solution when the condition

$$\begin{vmatrix} E_{x1} E_{y1} \\ E_{x2} E_{y2} \end{vmatrix} \neq 0 \qquad (2)$$

is satisfied. Here E_{x1}, E_{y1}, E_{x2}, E_{y2} – amplitudes of tangential component of the wave, was resulting after downward integration of equation from upper ionosphere to the Earth. Equation

$$\begin{vmatrix} E_{x1} E_{y1} \\ E_{x2} E_{y2} \end{vmatrix} = 0 \qquad (3)$$

for the wave without source describes eigen waves of the waveguide "the Earth-ionosphere".
Waves with R and L polarizations correspond to ordinary and extraordinary modes in ionosphere in presence of the Earth magnetic field. R-polarized waves (O mode) have long skin length and large attenuation. In contrast, L-polarized wave (X mode) in ionosphere has less skin length and less attenuation. Zeros (roots) of equation (3) gives eigen values of the waveguide "the Earth-ionosphere". When the Earth magnetic field is taken into account the one branch of zeros (which exists without the Earth magnetic field) splits into two branches. We may call the branches as R- and L-branch. L-branch has minimum attenuation for the propagation wave. The feature of the attenuation in vicinity of the critical frequency provides an explanation for the behavior of the wave polarization in waveguide.

Small-scale drift-Alfven vortices observed by the Cluster spacecrafts in the cusp

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The Cluster observations reveal in the cusp the existence of small-scale drift-Alfvén vortex structures with the impedance and characteristic spatial scale of the order of the Alfvén speed and the ion Larmor radius, respectively. These structures have been identified as the vortces of the drift- Alfvén waves. The previous theories of nonlinear vortex structures in a magnetized collisionless plasma have been restricted by consideration of the relatively long wavelength limit when the perpendicular spatial scale L is much larger than the ion Larmor radius ρ. To generalize the theory of nonlinear vortices with arbitrary ratio L/ρ and reveal at which conditions the vortex structures with spatial scales comparable to the ion Larmor radius can exist particularly in the near Earth environment is the aim of the present analysis. We shown that in the quasi-stationary regime a set of equations describing the nonlinear dynamics of the drift-Alfvén waves are reduced to a single equation that possesses a solution in the form of the dipolar vortex. The variation of the vortex spatial scale versus component of the vortex velocity perpendicular to the ambient magnetic field is analyzed. It is found that the vortex structures propagating faster than the diamagnetic ion velocity possess the spatial scales greater than the ion Larmor radius, and vice versa. The variation of the vortex impedance as the function of the vortex velocity is investigated. It is found that when the vortex speed is close to the electron drift velocity the drift-Alfvén and the electron-drift modes are coupled. Due to this coupling the vortex impedance can have a minimum value. The existence of the minimum in the vortex impedance provides the most favorable conditions for the generation of the drift-Alfvén vortex structures. The theoretical results obtained allow us to modify the existing interpretation of the vortex structures in the cusp region. The existence of the structures at the ion Larmor radius scale in the cusp can be explained as the result of their preferable generation in the vicinity of the vortex impedance minimum. Our theoretical results are in a reasonable agreement with the Cluster observations of the drift-Alfvén vortices.

Bursts of geomagnetic pulsations in the frequency range of 0.2-5 Hz generated by strong pulses of the solar wind pressure

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On the basis the Interball spacecraft observations of the solar wind ion flux with 1-s resolution along with

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

Modelling quasiperiodic ELF/VLF emissions and related variations in energy distribution of energetic electrons

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Generation of quasi-periodic ELF/VLF wave emissions in the Earth's magnetosphere due to the whistler cyclotron instability is studied on the basis of self-consistent quasilinear theory taking into account the evolution of distribution of energetic electrons in pitch-angles and energies.
Numerical simulations based on this model confirm that taking into account realistic energy distribution results only in quantitative, but not qualitative, differences in the generation regimes compared with the simplified model assuming monoenergetic energy distribution. Dependence of generation regime and related variation in 2D-distribution of energetic electrons on the parameters of electron distribution in the source is studied.
Special attention is paid to analysis of characteristics of a step-like distortion formed on the distribution function along resonant parallel velocity, as dependent on the spread in the distribution over energies.
The updated model allows us to study temporal evolution of energy distribution of precipitated electrons causing auroral pulsations, which is important for comparison of the model with observations.

Nonlinear mirror waves in space plasmas

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A theory of finite-amplitude mirror type waves in non-Maxwellian space plasmas is developed. The collisionless kinetic theory in a guiding center approximation, modified for accounting the effects of the finite ion Larmor radius effects, is used as the starting point. The model equation governing the nonlinear dynamics of mirror waves near instability threshold is derived. In the linear approximation it describes the classical mirror instability with the linear growth rate expressed in terms of an arbitrary ion distribution function. In the nonlinear regime the mirror waves form solitary structures that have the shape of magnetic holes. The formation of such structures and their nonlinear dynamics has been analyzed both analytically and numerically. It is suggested that the main nonlinear mechanism responsible for mirror instability saturation is associated with modification (flattening) of the shape of the background ion distribution function in the region of small parallel particle velocities. The width of this region is of the order of the particle trapping zone in the mirror hole. Near the mirror instability threshold the saturation arises before its width reaches the ion thermal velocity. The nonlinear mode coupling effects in this approximation are smaller and unable to take control over evolution of the space profile of saturated mirror waves or lead to their magnetic collapse. This results in the appearance of quasi-stable solitary mirror structures having the form of deep magnetic depressions. The relevance of the theoretical results to recent satellite observations is stressed.

Observations of regular auroral pulsations in Barentsburg observatory

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It is well known that irregular geomagnetic pulsations Pi1 and Pi2 always are accompanied by idem auroral pulsations, but the regular, or continuous pulsations Pc1-5 are considered by researchers to be a wave train in the cold magnetosphere plasma. In December 2007 the parallel auroral and magnetic pulsation measurements were

carried out at Barensburg observatory in Spitsbergen. Several events of synchronous occurrence of both regular pulsations were recorded in this polar cap station at time, when the auroral zone is alight. The polarization of geomagnetic pulsations on the Scandinavian net is examined with point of view of a geomagnetic observatory location relatively aurora position.

Resonance interaction of protons with VLF waves

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The resonant interaction between VLF waves and energetic electrons in the magnetosphere has been a subject of intensive studies during a few decades. This interaction is believed to account for many phenomena related to the wave propagation in the magnetosphere, such as growth of signals, emissions of varying frequency, and electron precipitation into the ionosphere. All theoretical works dealing with the mentioned phenomena include, as the main condition of interaction, the resonance between particles and a wave: $\omega - k_{||} v_{||} = n\Omega$, where ω, $k_{||}$ are the wave frequency and parallel wave number, respectively, $v_{||}$ is particle velocity along the ambient magnetic field, Ω is cyclotron frequency, and n is an integer. However, the same resonance interaction between VLF wave and energetic protons was not expected to play any important role, either in the wave evolution or in the evolution of the proton distribution. The reason for this is readily apparent. Since the proton cyclotron frequency Ω is much less than the wave frequency ω, the resonance velocity for a small number resonance is of the order of electron Cerenkov velocity, which for protons corresponds to overly high energies. Clearly, using large number resonances ($n \sim \omega / \Omega$) resolves this problem. However, these resonances are known to be ineffective unless the particle velocity is of the order of the wave phase velocity ($\omega \sim k v$). This requirement is similar but not identical to the Cerenkov resonance condition ($\omega = k_{||} v_{||}$) and is often met more easily. Even in this case, a single resonance wave-proton interaction is much less effective than that for electrons, because of the mass ratio. That is why the observed proton precipitation caused by the VLF wave had not been predicted theoretically and even was a surprise. Finding an efficient mechanism for proton interaction with VLF waves, and explanation on this basis the proton precipitation induced by VLF transmitter signal, has been stimulated by Victor Yur'evich Trakhtengerts who clearly formulated this problem in his lecture on the Conference in 1984. The corresponding mechanism is the central point of the scientific part of the present report. It is based on the fact that electron dominance in the wave-particle interaction is true only for one single resonance. Since the distance between resonances in velocity space $\Delta v_R = \Omega / k_{||}$ for protons is m / M times smaller than for electrons, they have a preference from the viewpoint of crossing of multiple resonances. Accordingly, suggested mechanism of proton interaction with a VLF wave consists in particle crossing of multiple cyclotron resonances in an inhomogeneous magnetic field, which leads to the proton pitch-angle diffusion. The corresponding diffusion coefficients together with the precipitating flux have been evaluated. The results obtained provided the basis for the explanation of proton precipitation observed experimentally.

Peculiarities of the ULF emission spectra at high latitudes based on the "North Pole-30" drifting station data

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Dynamics of geomagnetic noise and fluctuations in the ULF (ultra-low frequency) range f= 0.001-0.3 Hz at high-latitudes is analyzed on the basis of the high sensitive quantum magnetometer measurements. The data were obtained in the cusp region on the drifting research station "North Pole-30" (Φ=75^o) during an experiment of April 1989. The digital step of the data was 1.3 s, which allowed us to analyze the spectral properties of ULF emissions in the Pc1-Pc6 frequency range up to f_{max}= 0.3 Hz. It is found that the power spectra of ULF emissions have often the scaling $1/f^{\beta}$ form with β depending on the level of geomagnetic activity. Sometimes the narrow bands of geomagnetic pulsations Pc 3-5 appear over such a scaling (fractal) background. The peculiarities revealed show that in the dynamics of the magnetosphere – ionosphere system, both regular and random (stochastic) components are presented and their relative contribution in the geomagnetic field variations depends on the rate of magnetosphere disturbances. Physical interpretation of the results obtained is given on the basis of the SOC (self-organized criticality) consideration.

VLF chorus emissions observed by CLUSTER satellites inside the generation region: Comparison with the backward wave oscillator model

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VLF chorus emissions are the most intense and puzzling VLF signals in the Earth's magnetosphere. They are observed as a succession of repeating discrete elements, typically with rising frequency. A mechanism of chorus generation based on the backward wave oscillator (BWO) regime of magnetospheric cyclotron maser was suggested by Trakhtengerts (1995, 1999). According to this mechanism, a succession of whistler wave packets is generated in a small near-equatorial region owing to an 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 characteristics of chorus emissions observed by the Cluster spacecrafts with those predicted by the BWO model of chorus generation.
The multicomponent measurements of chorus emissions by Cluster spacecraft demonstrate that the wave source is indeed located within the near equatorial region of about 2000 km along the field line. Moreover, variations in the central position of chorus source region within a few thousands of kilometers were found (Santolik et al., 2004). These features of chorus source are in agreement with the BWO model. The BWO model explains the motion of chorus source by deviation of the magnetic field minimum (the local "magnetic equator") during periods of enhanced geomagnetic activity. In agreement with the model, such a deviation correlated with the motion of the chorus source was found by using Cluster magnetic-field measurements.
We have analyzed the characteristics of chorus elements, i.e., the amplitudes, frequency spectrum, the frequency sweep rate, the time intervals between chorus elements. Using measurements of warm and cold plasma onboard the CLUSTER spacecraft these chorus parameters were estimated from the BWO model, and reasonably good agreement with the observations was found. The frequency sweep rate of chorus elements increases with the wave amplitude and with a decrease in the cold plasma density, in accordance with expectations for the BWO regime of chorus generation.

STARE-EISCAT study on the vector mapping of irregularity drifts in the eastward auroral electrojet

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The purpose of the present study is an inspection of the basis of the STARE stereoscopic vector measurements, which is the irregularity flow velocity dependence versus the flow angle $\Theta^{N,F}$ and the line-of-sight (los or l-o-s) electron flow magnitude, V_{ExB}^{los}, (superscript N and/or F means the STARE Norway and/or Finland radar, respectively). We found that in the afternoon-evening sector the flow angle dependence of multi-pulse ACF Doppler velocities, $V_{irr}^{N,F}$, was similar and much weaker than suggested. In a band of flow angles $45^o < \Theta^{N,F} < 85^o$ it can be reasonably described as $\left|V_{irr}^{N,F}\right| \propto A_{N,F} C_s \cos^n \Theta^{N,F}$, where $A_{N,F} \approx 1.2\text{-}1.3$ are weakly monotonically increasing functions of V_{ExB} and the index n is ~0.2 or even smaller. A mark of the low flow angle dependence can be revealed in STARE evening data during intervals with extensive unstructured echoes. That is a regular CCW rotation of the merged drift velocity vectors going from the east to west edge of the STARE field of view. The present study (a) does not support the conclusion by Nielsen and Schlegel (1985), Nielsen et al. (2002, [18]) that at the flow angle of more than ~60^o (or $\left|V_{irr}^{N,F}\right| \le 300$ m/s) the STARE Doppler velocities are <u>equal</u> to the component of the electron flow velocity. We also found (b) that for any bin with the l-o-s electron flow magnitude, V_{ExB}^{los}, the largest STARE Doppler velocities are always inside a bin with the largest flow angle. In this bin the Doppler

velocity is also larger than its l-o-s electron flow velocity component, $\left|V_{irr}^{N,F}\right| > \left|V_{ExB}^{los}\right|$. Both features (a and b) and the too weak flow angle dependence are experimental proof that the l-o-s electron flow velocity cannot be the single factor, which controls the motion of the backscattering ~1-m irregularities even at the large flow angles. An important fact for this study is also that the intense backscatter was collected from altitudes, where aspect angles were $\sim 1^o$ (or more) and flow angles were $\Theta \geq 60^o$, i.e. there, where the linear fluid and kinetic theories cannot explain the excitation of irregularities. All the facts can be reasonably explained involving the nonlinear wave-wave coupling developed and described by Kudeki and Farley (1989) for the equatorial electrojet and studied in numerical simulation by Otani and Oppenheim (1998, 2006).

Fractal analysis of ULF emissions registered along 210 GM

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Now it is recognized that the extended dissipative dynamical systems, which consist of a number of interactive elements, evolve naturally to the SOC (Self-organized criticality) state. In the SOC state the system is very sensitive to any external perturbation hence the big avalanches (strong events) could be excited in this system. Magnetosphere-ionosphere organization can be attributed to such SOC systems. The principle feature of the SOC state is fractal organization of the output parameters both in space (scale invariant structures) and in time (flicker noise or 1/f fluctuations). So we can apply fractal methods to magnetosphere-ionosphere spatiotemporal parameters to analyze the dynamic state of that system (i.e. the rate of criticality). Here we apply fractal methods to ULF geomagnetic data obtained along 210 geomagnetic meridian with resolution of 1 second. We have compared three fractal methods of data analysis: PSD (power spectral density), Burlaga-Klein and Higuchi approaches. We have concluded that Higuchi method is the most informative one in our case. The profile of five stations (Chokurdakh, Magadan, Paratunka, Moshiri and Guam) covers the wide region from very low latitude (Guam, Φm = 4,6º N) up to auroral zone (Chokurdakh, Φm =64,7º N). In this presentation we compare the fractal characteristics of ULF emissions over the 1993-1994 year period and discuss the results obtained in the frame of the SOC theory.

Subauroral proton auroras visualize the source of geomagnetic pulsations in the Pc1 range

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Recent observations from the IMAGE spacecraft revealed several types of proton aurora equatorward of the main auroral oval. These auroras are due to precipitation of energetic (E>20 keV) protons. It was suggested (but not proved) that the precipitation is the result of scattering the ring current protons into the loss cone after the interaction with electromagnetic ion-cyclotron (EMIC) waves in the equatorial plane of the magnetosphere. In this report we prove this suggestion for three types of the subauroral proton aurora (proton spots in the day-morning sector, proton flashes on the dayside, and proton arcs in the evening sector). The consideration is based on comparison of the IMAGE observations with ground-based observations of geomagnetic pulsations Pc1, which are a signature of EMIC waves.

1) We found that when the proton spot is nearly conjugated with the ground station equipped with a pulsation magnetometer, the station always observes narrow band Pc1 emissions. The frequency of this Pc1 varies inversely with the proton spot latitude. Moreover, there is a good agreement between appearance/disappearance of the spot and beginning/end of the associated Pc1.

2) The proton aurora flashes well coincide in time with pulses of wide-band Pc1 at the nearby ground station. The upper frequency cutoff in the Pc1 pulse anti-correlates with the lowest latitude of the proton aurora.

3) The intensity maximum of the IPDP power is associated with the location of the subauroral proton arc, and the increase of the IPDP frequency correlates with equatorward movement of the arc.

This strong correlation between proton auroras and ground pulsations in the Pc1 range (and its violation when the ground station is away from the location of the proton aurora) clearly indicates that, indeed, the ion-cyclotron interaction is the source of proton auroras. We conclude that the subauroral proton auroras are images on the ionospheric “screen” of magnetospheric regions where the ion-cyclotron instability develops leading to an intense scattering of energetic protons into the loss cone.

The relationship between subauroral proton flashes and Pc1 pulsation bursts

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

Спутниковые электромагнитные измерения в ионосфере над областями запуска ракет

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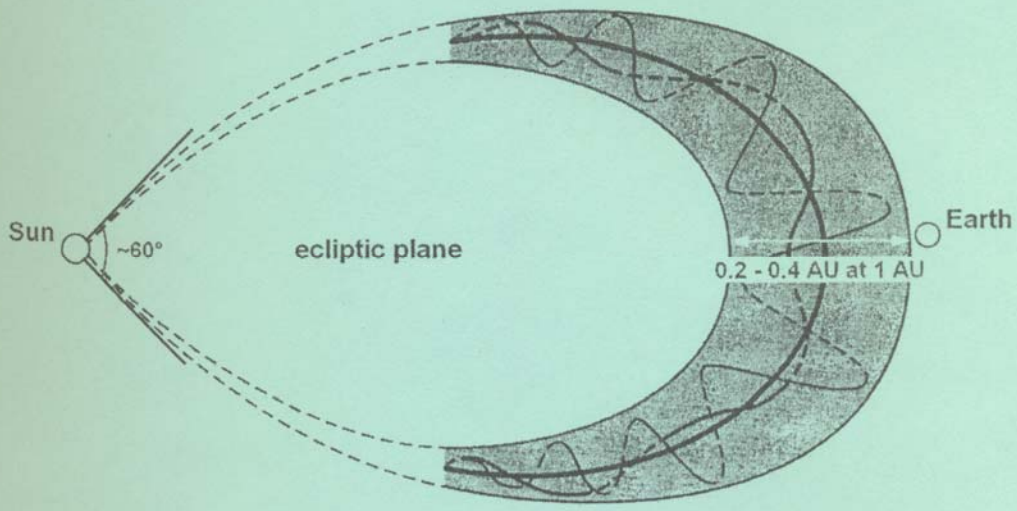
Приведены результаты архивных данных плазменных и волновых измерений на спутниках Ореол-3 и Космос-1809 над областями запуска мощных ракет. При пролетах через несколько десятков минут после запуска в пределах 1-2 тысяч км от ракетного полигона обнаружено локальное усиление ионосферной турбулентности и электростатических шумов в диапазоне от нескольких десятков до сотен Гц.


Sun
~60°
ecliptic plane
Earth
0.2 - 0.4 AU at 1 AU

The new GLE modeling technique for the relativistic solar cosmic ray study

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The worldwide neutron monitor (NM) network may be considered as a multidirectional solar proton spectrometer in the relativistic energy domain. The new modeling technique of the NM responses to an anisotropic solar proton flux is developed, which allows deriving the characteristics of primary solar protons outside the magnetosphere from comparison of modeling responses with observations. The new modeling technique differs from former versions by account of the contribution in response, besides vertical, oblique incident on a NM particles. The modeling consist of several steps:
1. Definition of asymptotic viewing cones of the NM stations under study by the particle trajectory computations in a model magnetosphere Tsyganenko (2002). To account the contribution of oblique incident particles we calculate beside a vertical, 8 trajectories of particles launched at zenith angle 20^o and 8 equally distanced azimuths.
2. Calculation of the NM responses at variable primary solar proton flux parameters.
3. Application of a least square procedure for determining primary solar proton parameters: rigidity spectrum, anisotropy axis direction, pitch-angle distribution outside the magnetosphere by comparison of computed ground based detector responses with observations.
With the new modeling technique the characteristics of relativistic solar protons for 15 large GLEs occurring from 1956 to 2006 have been obtained.

Neutron multiplicity measurements in Barentsburg during December 13, 2006 GLE

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The neutron multiplicity measurements on the neutron monitor in Barentsburg (Spitsbergen) during the GLE December 13, 2006 has been studied. The neutron monitor in Barentsburg was put into operation on April, 2003. In 2006 it has found the complete configuration 18-NM-64. The new data collecting system based on a digital ADLINK 7233 card allows to register both pulses, and intervals between them. On the basis of this device the multiplicity recorder is realized to register the count rates on multiplicities (2-10). During the GLE a significant increase of the count rates of multiplicities from 2 up to 4 was detected. The multiplicity spectrum changes are compared with the solar proton spectrum dynamics during event. The spectra of relativistic solar protons was derived by modeling technique from the worldwide neutron monitor network.

Relativistic solar protons in the GLEs of August 16 and October 19, 1989

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Using the data of ground based neutron monitor network the parameters of primary solar protons during GLEs of August 16 and October 19, 1989 by a modeling technique have been obtained. Our recent modeling technique takes into account the contribution in the neutron monitor response not only vertical, but also oblique incident particles. This kind of analysis requires the data of no less than 20-25 ground-based cosmic ray stations, and includes few steps:
1. Definition of asymptotic viewing cones of the NM stations under study by the particle trajectory computations in a model magnetosphere Tsyganenko (2002) with a step in rigidity of 0.01 GV
2. Calculation of the NM responses at variable primary solar proton flux parameters.
3. Deriving with a least square procedure solar proton parameters (namely, energy spectrum, anisotropy axis direction, pitch-angle distribution) outside the magnetosphere by comparison of computed ground based detector responses with observations.
The choice of the mentioned above events was connected with the fact that one of them (GLE 41) has occurred before, and another (GLE 43), after the superevent of 29.09.1989, which has been widely discussed. Nevertheless, the obtained characteristics of solar protons and their dynamics in these “ordinary” events, demonstrate a number of interesting features connected with particle generation and propagation in the IMF.

Modernization of the registration of the detailed information in the regular balloon monitoring of cosmic rays in Apatity and Dolgoprudny and the abrupt periodical drops of the count rates

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We describe the changes in the hard- and software in recording the detailed information (DI) in the regular balloon monitoring (RBM) of cosmic rays. The results of the DI recording by the old and new complexes (programs and analogue-to-digital converters, ADC) are compared as well as the standard information obtained by all three methods (using electronic selector and programs RBM_DI and COUNTER with ADC). The development of the phenomenon of the abrupt periodical drops in the RBM counting rates in 2007-2008 is also will be discussed.

Solar proton spectra in the 20 January 2005 GLE: Comparison of simulations with balloon and neutron monitor observations

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Using the GEANT4 we simulated solar proton transport through the Earth's atmosphere and estimated angular and energy distributions of secondaries (protons, electrons, positrons, muons, photons and neutrons) at various atmospheric levels. These Monte Carlo simulation results were compared with the results of cosmic ray balloon and neutron monitor measurements during 20 January 2005 solar proton event. The solar proton spectra in the energy range from 100 MeV to a few GeV which best fit the balloon and neutron monitor observational data are presented.

MHD simulation of multiple current sheet creation for series of elementary flares

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The new approach is developed for finding the position of a current sheet above an active region before the flare. It is shown that during appearance of several current sheets their influence on the general field configuration above the active region can be essential, and X-points positions found in the potential magnetic field can strongly differ from positions of created current sheets. For the MHD simulation of flare situation in the corona all conditions must be taken from observed magnetic field distributions on the photosphere. SOHO MDI maps are used. For setting initial conditions the method of numerical Laplace equation solving with inclined derivative as the boundary condition is developed. The initial magnetic field above the active region is potential one. It is calculated before new magnetic flux emergence. To stabilize the numerical instabilities a number of numerical methods are developed and programming realized in the PERESVET code. The finite-difference scheme for MHD equations is absolutely implicit, and it is conservative relative to the magnetic flux. Also new method of approximation of MHD equations by finite-difference scheme is developed, which permit to decrease errors of divB. According to this approximation behavior of divB in the time evolution is described by diffusion equation. Calculations for active regions with different sizes show, that to take into account all singularities it is necessary to perform simulations in large region with the size 4×10^{10} cm. MHD simulations show that several current sheets are appeared during the evolution, and their number is changed in time. The current sheets are created as in already existing singular lines of the potential field, as in the singular lines appeared due to emergency of new magnetic field. The current sheets appeared earlier move slowly toward the area of weak field and then disappeared due to dissipation. The magnetic field near the X-points emerged from-under the photosphere is much larger, then magnetic field near the already existing X-points situated higher. So these CS must produce more powerful flares. The sheets appeared near the emerged X-points are almost vertical ones. So the flares in these sheets can produce CME, because the $\mathbf{j}\times\mathbf{B}$ force, which accelerates plasma in the sheet, is directed away from the Sun. The multiple current sheet creation explains the appearance of series of elementary flares during an active event. The typical time of magnetic energy accumulation for a flare is

several days. During this time the magnetic North and South fluxes through an active region increase in 10^{21} - 10^{22} Mx.

Hard solar flare radiations

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For a long time the main solar flare phenomena have been considered to be associated with visible radiation, but visible radiation can not be representative one for such powerful explosive phenomena as solar flares, where atoms are high ionized. Dramatic change in flare understanding occurs because of X-ray measurements with space crafts Yohkoh and RHESSI and discovery of two components of solar cosmic rays in the energy range up to 20 GeV. The prompt cosmic ray component is generated during main energy release. It brings information about the most energetic phenomena in the flare. The exponential spectrum of these protons is in agreement with particle acceleration by Lorenz electric field along the magnetic singular line in a current sheet that appears in the corona above an active region. The similar effect has been observed in the thermonuclear laboratory experiments with high power linear discharge - pinch discharge. Such experiments permit to measure the plasma velocity, the magnetic field, and energy of charged particles that accelerated in the Lorenz electric field up to 300 keV. The acceleration takes place along a singular line that coincides with the discharge axis. The similarity and difference of particle acceleration in a linear pinch effect and in the current sheet is discussed. The flares produce also a delayed component. Apparently, it can be associated with spectrum deformation during diffusion in the turbulent magnetic field. The space craft measurements demonstrate thermal X-ray inside a current sheet above an active region and electron acceleration in the field-aligned currents up to hundreds keV. Precipitation of these particles on the solar surface is analogous with particle precipitation in aurora, but demonstrates high energy phenomena.

Complex radiation detector array for environmental studies

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The project of radiation detectors array for the complex monitoring of basic components of penetrating radiation in environmental space is offered. The composition of penetrating radiation at the surface of Earth has complex structure. On the one hand it is formed by secondary cosmic rays (neutrons, muons, electrons and gamma - rays). Another origin of radiation at the ground are radionuclide of natural and artificial sources. Latter can be found out on a gamma –radiation. The widespread neutron monitors are capable to register only neutrons with energy > 50 MeV. At the same time, the large bio-efficiency have the thermal and suprathermal neutrons. For which monitoring the project suggests using one section of leadless neutron monitor. Monitoring of muons and energetic electrons will be carried out with a telescope assembled of standard plastic detectors. Gamma ray background (energies from 20 up to 200 KeV) will be measured with a detector on the basis of a crystal NaJ (Tl) with a photo multiplier.
The created array will ensure nowadays requirements for monitoring of a dynamical radiating background in the Arctic and sub Arctic regions.

Extremely collimated solar particle beam on muon hodoscope MEPHI and neutron monitors observations

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A wide-aperture MEPHI hodoscope URAGAN registered muon rate increase during GLE of December 13, 2006 at six sigma level. The time of maximum was observed earlier than in neutron monitors data. The muon hodoscope

URAGAN was capable to obtain 2D-pictures of muon flux and for the first time the spatial-angular dynamics of GLE event was measured. Due to that asymptotic viewing cone of the hodoscope appeared looking precisely along IMF it has traced in details evolution of a shortlived and highly collimated relativistic particle beam in the initial phase of event. Direction and angular width of a beam nearly coincided with a direction of a symmetry axis and characteristic width of pitch-angular distribution of solar protons derived from neutron monitor network data by modeling technique.

Flow solar wind structure in the minimum of solar cycle

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The flow structure of solar wind (SW) in the near-Earth cosmic space has the well known global features: coronal hole fast flows, heliospheric plasma sheet, sporadic coronal mass ejections (CME), the most effective in geomagnetic storm generation flare flows, the slow SW flows above solar-spot activity regions in the situation of flare absence, the compressed flows in co-rotating regions (CIR), presumably on the leading boundary of high speed streams. Sporadic and recurrent processes of solar activity are the two general, well distinguish solar activity phenomena Sporadic short-lived phenomena of solar activity (flares, coronal mass ejections, filament emissions) introduce to the picture of long lived phenomena (solar spots, active regions, background fields, coronal holes, heliospheric plasma layer) some complexity during diagnostics of solar wind variations.
The solar activity minimum is the useful time interval for study an individual flow phenomena in the situation of low solar activity level. Radial escaping of solar wind with interplanetary magnetic field beyond 10 R_{Sun} into all over space of the heliosphere is the manifestation of the open solar magnetosphere – it is the most regular in the minimum of solar cycle.
The analysis of SW parameters may be studied by means of fractal method proposed T.Higuchi (1988). Fractal dimension (FD) calculations of plasma and IMF parameters of SW near the Earth give FD variations, reflecting flow SW structure and transformation. Wind data are used in our study. The time digitization equals ~95 s, the sliding-scale window equals 6 hours, and the step – 3 hours.
Fractal dimension calculations allow us to classify SW flows in connection with its affiliation to general above mentioned SW flow types. So, the measure FD~1,7-1,9 corresponds to fast coronal hole flows, the transition of heliospheric plasma layers shows the sharp fall down to FD~1,5. Co-rotation regions have the fast variation of FD values ahead the fast SW arrival. CME and flares are infrequent in minimum. The individual FD variations of sporadic flows, connected with compressed plasma layers and complex interplanetary magnetic field variations, reveal the detailed structure of geo-effective flows. Fractal evaluations help us to classify SW flows and intermediate boundary regions in SW.

Эффекты в ионосфере при взаимодействии земной магнитосферы с изолированными потоками солнечного ветра

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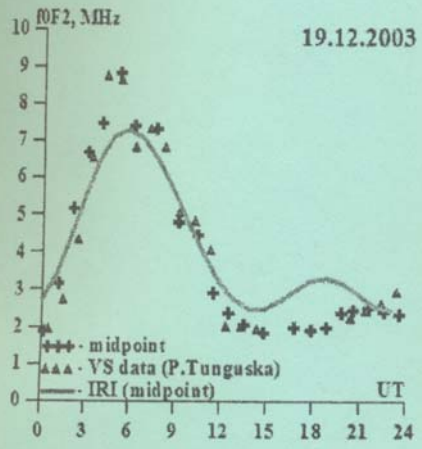
Исследовались эффекты возмущений в E- и F-областях ионосферы при взаимодействии земной магнитосферы с квазистационарными коротирующими потоками солнечного ветра: высокоскоростной поток от корональных дыр (КД), спокойный гелиосферный токовый слой (ГТС), поток с некомпрессионным увеличением плотности (NCDE). Характеристики параметров ионосферы (отклонение критической частоты в области F2 от ее уровня до начала возмущения (ΔfoF2); fbEs - частота экранирования слоя Es) рассматривались в ночном секторе овала в периоды авроральных возмущений, связанных с этими параметрами, по данным обсерватории Лопарская. Исследовались зависимости этих ионосферных характеристик от параметров солнечного ветра (плотности n и электрического поля Ey). Получено, что для каждого типа потоков солнечного ветра параметры ионосферной возмущенности имеют свои определенные средние значения, которые являются суперпозицией функций от Ey и n. Этот результат позволяет определить относительную роль основных геоэффективных параметров солнечного ветра в ионизации разных областей ионосферы.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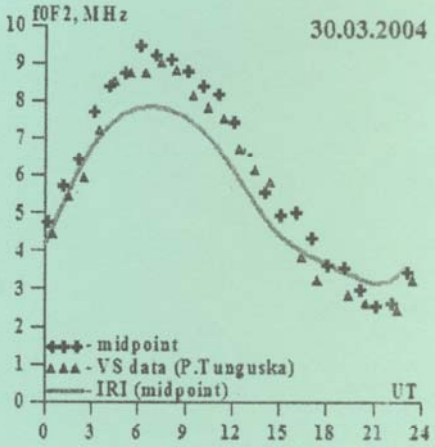
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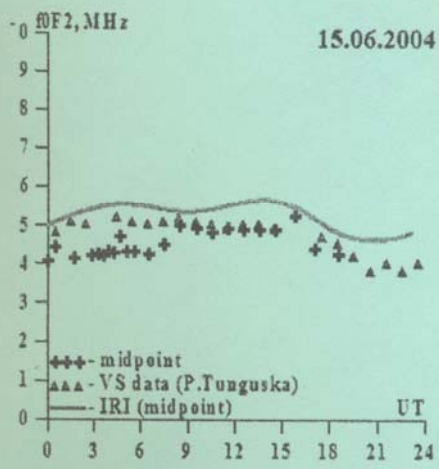
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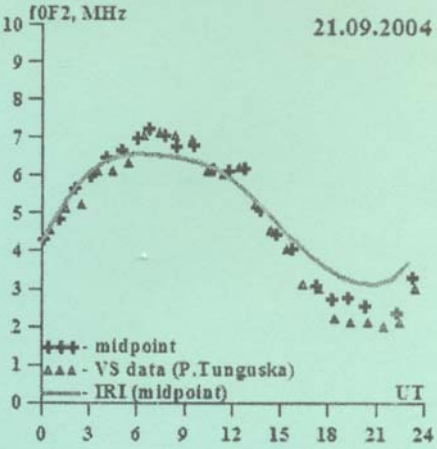
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UT

Occurrence rate of SAR-arcs during the 23rd solar activity cycle

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By data of photometric observations at the Maimaga station (57N, 200E, geomagnetic coordinates) at the Yakutsk meridian the occurrence rate of subauroral red arcs (SAR-arcs) for the 1997 to 2006 period has been investigated. The observations were carried out during winter-spring periods at moonless nights under favorable atmospheric conditions. For~370 nights of observations (total duration is~3170 hours) 114 cases of SAR-arcs occurrence (~500 hours) have been registered. The occurrence rate of SAR-arcs have been determined as a ratio of the number of registration hour intervals of SAR-arcs to the summary observation time in hours for particular months. Subauroral red arcs have been registered every year both in the maximum and in the minimum of the 23 rd solar activity cycle. The most observation occurrence of red arcs is registered on the rise (~27%) and decay of the maximum of the solar activity cycle (~36%). The average occurrence rate of SAR-arcs during these years was less than in the 22nd solar activity cycle and is equal to ~16% of the total observation time. The occurrence rate of SAR-arcs observations corresponds to the changes of geomagnetic activity during observation periods.

Neural networks technique of layer F2 critical frequency forecasting above station Gakona (HAARP) at the account of near-Earth space parameters and geomagnetic disturbance

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In offered research on the basis of developed neural network technique nonlinear correlation dependences of ionospheric layer F2 critical frequency above station Gakona (HAARP) from Solar-magnetospheric subset are established. With the help of created Elman artificial neural network (ANN) numerical experiments on forecasting values of critical frequency for intervals from 0.5 till 3 hours are carried out.
A change of critical frequencies of a high-latitude ionosphere is caused by its structural features during different time of day. As a result the solution of a problem of critical frequency forecasting has demanded the division of a full daily interval on day and night time. For realization of such division classical architecture of ANN has been added with the "lock" block, developed under the given problem. This «lock» performed functions of a key, providing submission on an input of network various heliogeophysical parameters depending on time of a day. The number and type of such parameters were determined proceeding from the general accepted physical ideas about the processes which are taking place in subauroral ionosphere, as well as with the help of preliminary linear correlation researches. The data on Solar wind and interplanetary magnetic field parameters, geomagnetic field components and indices SYM and ASY were accepted equally effective for day and night times. The data on X-ray and ultra-violet radiation and values of a zenith angle have been referred directly to day time parameters. The data about precipitation of low-energy particles and as values of Kp and bi indices have been referred to night parameters. It is necessary to note that for each of used parameters it has been established (with help of the same ANN) time of AU, AL, SYM, ASY indices forestalling which is taking into account development of general magnetosphere-ionospheric physical process. Maximum effectiveness of ionospheric layer F2 critical frequency forecasting in sub-auroral area using offered method are 93% and 83% for the forecast at 0.5 and 1 hour, accordingly. For long-term forecasting at 1.5 and 2 hours corresponding efficiency are 75% and 67%.
The work was executed under the financial support of the RFBR (grant 06-05-64482).

Auroral proton precipitations during substorms revealed from Hα spectral measurements

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Polar Geophysical Institute performs hydrogen Hα measurements at Apatity with a ground based spectral device, which consists of the spectrograph and the intensified CCD camera. The field of view of the device is ~1º×80º, the spectrograph input slit is oriented along the geomagnetic meridian, the optical axis is pointed to zenith. During the 2006 – 2007 dark season, in spite of weather machinations, a number of the proton precipitation events, connected to the magnetospheric substorms, were registered. The results of these measurements and the proton fluxes behavior during the substorms are presented.
This study was partly supported by RFBR (grant 06-05-65044) and by the Program for Basic Research of the

Local thermospheric neutral density and temperature variations during extreme solar events – The young Sun connection

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The CHAMP satellite is a low Earth orbiting (LEO) mission with the objective of a precise determination of the Earths gravity and magnetic field. Among other instruments it carries a high-precision accelerometer on board which is used in this study to investigate the temporal and spatial variation of the atmospheric density in a height of about 400 km. We further compare the absolute density values from the in-situ measurements with the Mass Spectrometer Incoherent Scatter 1990 (MSIS90) model. In particular we focus on the variation of the neutral atmospheric density and related temperature at about 400 km altitude during the extreme solar events occurring at the end of 2003. These so-called Halloween events caused periods with magnetic activities up to Kp values of 9. These atmospheric disturbances originated from CMEs associated with a solar flare of magnitude X17.2 and caused density enhancements up to about 400% which may lead to temperatures up to 5000 K compared to quiet solar conditions. An analysis of these events is used for the investigation of the connection between such extreme solar events and the activity of solar proxies with different age. This is important for studies which are related to the evolution of the early Earth atmosphere and for Earth-type atmospheres of exoplanets orbiting around active stars.

Influence of the small-scale ionospheric plasma disturbances on the HF synthetic aperture radar sounding

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During last years, the ground penetrating radars (GPR) based on the orbiting spacecrafts are successfully used for subsurface investigation of the interior structure of the planets [1]. Two well-known effects in fact limit the instrument performance: side clutter caused by the reflection of the signal from the rough surface and phase distortions, introduced in the signal by the ionosphere. Various signal processing techniques, like the aperture synthesis and so other, allow to partially eliminate the destructive impact caused by both these mechanisms.
The systematic phase distortion of the signal, introduced in the radio wave by the regular layered ionosphere, is the most studied at the moment. This subject is widely discussed in the literature, and a number of algorithms are proposed for adaptive compensation of the phase shift [2]. The side clutter is now a less studied problem, however, there can be found many papers treating the problem with more or less simplifying approximations.
The small-scale irregularities of the ionospheric plasma density due to turbulence, gravity waves etc. scatter the waves in many directions and can therefore produce effects like side clutter reflections. However, rigorous analysis of the problem requires very extensive computational work. As a consequence, papers devoted to the phenomenon almost lack now, except of some that treat the problem very qualitatively.
In the present paper, results of the numerical simulations of the subsurface sounding with synthetic aperture radar (SAR) at the HF frequencies are demonstrated. Quantitative assessments of the SAR signal degradation due to wave diffraction on the small-scale stochastic irregular structure of the ionosphere are given. Effects of the anisotropy of the correlation function of the small-scale plasma irregularities are studied. Side clutter coming from the rough diurnal surface of the planet is also discussed. Adaptive algorithms for systematic phase shift compensation, proposed earlier, are tested for stability with respect to the side clutter and ionospheric plasma disturbances. Simulated subsurface radargrams are presented.
This study was partially supported by Russian Fundamental Research Fund (RFFI grants 05-05-65145 and 06-05-64988). The author is grateful to the MSU computing facility (SRCC) for granting access to the computational resources.

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Deviations in GPS signals in polar regions and auroral activity

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In a study designed to determine the temporal development of deviations of GPS signal in auroral region in magnetic storm periods. The data sets consisted of Antarctic network of GPS receivers data, published in (Shagimuratov et al, 2006) and our measurements by GPS receiver in Murmansk in 2006-2007. Diurnal variations of polar patches activity associated with TEC fluctuations observed in Antarctic stations (Mawson, Davis, Mac-Murdo and Casey) were compared with positions of the auroral oval. This comparison permits us to make conclusion that a level of phase fluctuations of GPS signal depends on auroral oval position. Temporal and spatial variations of the GPS data including data on position of receiver in geographic coordinates and its altitude in Murmansk were compared with auroral and geomagnetic variations in the Barents region by ground-based optical and magnetic measurements and satellite data. Hard ware (GPS Garmin 128, GPS Garmin 172) and soft ware, used during experiments, allow us to get information on GPS data in NMEA protocol and then make all needed calculation. It is shown dependence of deviations of obtained GPS parameters on auroral activity. Possible advances of this kind experimental work and results concerned GPS positioning are under discussion.

I. Shagimuratov, I. Efishov, Yu. Ruzhin, N. Terenitsyna, Storm-time occurrence of TEC fluctuations associated with polar patches using GPS measurements, Proceedings XXIX Annual seminar "Physics of Auroral phenomena", Apatity, p.61-64, 2006.

Peculiarities of the topside ionograms at the high latitudes

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The features of the ionograms of the topside sounding on board of the Intercosmos-19 satellite concerned with an irregular structure of the high latitude ionosphere were analyzed. The regions of the polar cap (polar hole), day side cusp, trough of the ionization located equatorward of the cusp, night side auroral oval, main ionospheric trough are considered. The prominent structure in the form of the F-spread band in the frequency range of 8-10 MHz and in the altitude range from the satellite height to the reflection height was revealed. This structure is regularly observed in the day-time high-latitude ionosphere. It is shown that in the day side cusp region the satellite passes the irregularities at the low altitudes (500-700 km) but at the high altitudes (900-1000 km) the irregularities are situated below the satellite. In the main ionospheric trough the additional traces concerned with the reflection off the trough walls and with the waveguide propagation are observed. The strong increase of the noises below critical frequency is observed on the ionograms obtained at the equtorial wall of the trough. It is concerned with penetration of the ground-based transmitters signals along the magnetic field lines passing the trough minimum where an electron concentration is less than the one at the satellite height. The reasons of the observed features are discussed.

On a detection of short-period global waves from nightglow observations

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The OH (6-2) and O_2 Atmospheric (1-0) airglow have been measured at Maimaga (63^{o}N, 127^{o}E) and Zvenigorod (57^{o}N, 36^{o}E) in the same 8 nights. For the 4 nights the frequency power spectra for rotational temperature at both sites show strong peaks at close frequencies in the ~ 1-3 h period range. It is thought that those peaks are caused by global waves, such as high harmonics of solar tide and/or short-period atmospheric normal modes.

Artificial modulation of particles precipitation inferred from the riometric measurements during SPEAR heating campaign in Spitsbergen archipelago in February-March, 2007

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Complex heating experiment was in February-March 2007 in Barentzburg (Spitsbergen) carried out. During that campaign 38.2 MHz narrow band riometer, All-Sky camera and other geophysical instruments were used in PGI's Barentzburg observatory. Riometer antenna was directed to the area of the expected ionospheric modification by SPEAR HF transmitter. Special program on noisy riometer data preprocessing was developed. This allowed to detect modulation frequency of heating transmitter in riometer's spectra. This result confirmed the possibility to modulate precipitated particles flows by SPEAR heating facility from one side and to register it with riometer from the other side.
The authors are grateful to PGI's and Barentzburg observatory's staff for help in carrying out auroral experiment.

Angle scattering and forming the hydrogen Doppler profile in proton aurora

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The main patterns of the proton precipitation in the atmosphere were described already in the 1970s. The blue-shifted Doppler profiles of hydrogen lines are usually associated with proton precipitations. It is accepted that these profiles contain information about distribution in the precipitated particle flux. However, some peculiarities of these profiles, namely, the red-shifted wing are not well understood. This red wing is usually explained by large angle scattering at the collision energies less than 1 keV. However, this assumption contradicts with available information about cross sections.
Here we analyze the forming of the hydrogen Doppler profile by detailing individual scattering reactions and electronic states. Theoretical estimations are tested by a new version of a transport code modeling penetration of the proton-hydrogen atom flux in the Earth's atmosphere. The Monte-Carlo method with a collision-by-collision algorithm has been used. The results have been compared with available observations.
This study was partly supported by RFBR (grant 06-05-65044) and by the Program for Basic Research of the Presidium of RAS №16.

Adaptive data processing of Fabry-Perrot interferometer image and first results from ionosphere heating experiment in Svalbard

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The reason of use of Fabry-Perrot Interferometer (IFP) in ionosphere heating experiments is that this device may be utilized as a narrow-band optical filter thus greatly increasing sensitivity to optical emissions. The drawback of this is that device parameters are easily affected by temperature and air pressure variations which makes image processing rather complicated. We built up an adaptive image processing scheme which involves watershed computational approach to find the position of rings at concentric ring image pattern. These positions have been used to restore IFP response and apply it to statistical processing of images. We used a Fabry-Perrot Interferometer (FPI) coupled with a first-rate EMCCD camera to detect and possibly evaluate the optical emissions initiated by ionosphere heating experiment. FPI was used as a narrow-band optical filter at 630.0 nm with about 0.3 nm bandwidth. During the SPEAR ionosphere heating campaign in February-March 2007 the meteorological situation at Barentsburg, Svalbard was not too good (except of one night) for investigating optical effects due to almost permanent cloudiness and misty air. Fortunately during the night on 03-04 March the meteorological and geomagnetic conditions were simply excellent. The transparency of Earth atmosphere was good despite a slight interference from the moon light scattering. The aurora lights were exceptionally small compare to night airglow. It

let us to assume that the interference from the moon, nightglow and other sources together with CCD noise is stationary while optical emissions produced by heating follow transmitter on-off schedule. The usual way to detect optical effects is to test the null hypothesis H0: there is no difference in intensity of 630,0 nm emission during "transmitter on" and "transmitter off" time periods against its alternative H1: such difference exists. Firstly we sum our recordings over two hours according to schedule. As far as the noise appears as a smooth elevation at CCD camera image while Fabry-Perrot output looks like sharp rings we fit polynomial surface to noise and subtract it from original image. Then we subsequently integrate rings over azimuth, sum over rings and apply two-sample t-test. It shows that the null hypothesis must be rejected at significance level less than 0.1. Regrettably we can not evaluate the absolute value of how much transmitter yields to nightglow because of lack of absolute calibration but we are able to assess the yield relative to nightglow intensity. Our estimate gives that the optical effect of ionosphere heating in 630.0 emission is in average 30-40 times less than intensity of nightglow.

Excitation of Alfvén vortices in the ionosphere by the magnetospheric convection

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

Model integration in the Framework Atmosphere Model (FrAM)

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This work continues the description of the Framework Atmosphere Model (FrAM), which is being developed on the basis of the global Upper Atmosphere Model (UAM), for the research of interrelation of the broad range of various processes and the phenomena in the upper atmosphere. Our previous publications reported about a high-level architecture of the FrAM as an open framework, consisting of the controlling Model Manager and the set of independent Models of separate atmospheric regions and processes, and about the FrAM data structure. Now we present the unified model interface description. Using this interface the Model Manager organizes the information exchange of the connected Models and controls the execution of the modeling process according to the task configuration prescribed by a user.
Functionally each Model represents a method of obtaining the values of physical parameters in the spatial grid nodes. Models can exchange data using the standardized interface. The Manager organizes this data exchange: provides every Model all necessary data from other Models and receives new data calculated by the Model in order to transfer it to other Models. The Models' execution order can be arbitrary. The user sets it in the task configuration stage and during the model run stage the Manager executes Models according to this order.
The key structure of the FrAM model interface is the Dataset object that was described in our previous article. The universal form of data exchange between the Models is a passing of Datasets. The Dataset is an array of parameter numerical values in grid nodes. The Model fills its internal Dataset array by calculated parameter values according to its own method and data structure. But the Model interface block can control which of these parameters to pass to other Models. This separation is realized through using of another external Dataset and selective passing of data to it. It allows the usage in modeling run of alternative Models of the same processes and regions (with the same physical parameters) in any possible combination in order to switch on/off some physical interrelations and feedbacks. Another possible problem of inter-Model communication is the spatial grid difference. The FrAM system

includes special modules for data interpolation. Formally these modules are designed as another Models – they return parameter values in another grid nodes.

Long-term variations of mid-latitude 557.7 nm atmosphere emission in the 18-23 solar cycles

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Variations of the 557.7 nm airglow intensity (emitting layer height is 85-115 km) in the 23-rd solar cycle are analyzed. The experimental data of the 557.7 nm atomic oxygen emission obtained at ISTP Geophysical observatory near Irkutsk (52°N, 103° E) are used.
The feature of observed 557.7 nm intensity variations is an infringement of direct correlation dependence of the emission intensity and solar activity level (F10.7) in separate years. Also the results received in the 18th-22d solar cycles at the other mid-latitude stations are analyzed. It is revealed, that the features of long-term variations of 557.7 nm intensity in the 23-rd and 20-th solar cycles are the most similar. The possible reasons of interannual variations of 557.7 nm atmospheric emission that are not correlated with solar activity are discussed.
This work was done under RAS Presidium Program №16 (Part 3) and joint Russian-Bulgarian "Atmos" project support.

Observation of ionosphere response to HF heating at Barentsburg

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

A model study of the large-scale modification of the nocturnal middle-latitude F layer by powerful HF waves with different powers

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To predict the large-scale F-layer modification by high power, high-frequency radio waves, a mathematical model of the ionosphere, developed earlier in the Polar Geophysical Institute, is applied. This model is able to take into account artificial heating of the ionosphere by powerful HF waves. The model produces the time variations of the electron density, positive ion velocity, and ion and electron temperature profiles within a magnetic field tube over an ionospheric heater. In this study, simulations are performed for the point with geographic coordinates of the “Sura” heating facility (Nizhny Novgorod, Russia) for autumn conditions. The calculations are made for different cases in which the effective absorbed power (EAP) has distinct values belonging to the 5-100 MW range. Simulation results indicate that appreciable variations of the electron temperature, positive ion velocity, and electron density profiles can be produced by HF heating during the period of 5 min in the nocturnal middle-latitude F region, with the maximal amplitudes of variations depending significantly on the values of the EAP. It appears that the more the EAP is, the higher values of maximal amplitudes of variations of ionospheric quantities, produced by HF heating, ought to be.

Vertical ULF components in Barentsburg and Lovozero

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Near identical measurements of all three magnetic components of ULF emissions in frequency range of 0.1 – 10 Hz are carried out at Barentsburg in Spitsbergen and at Lovozero in Kola Peninsula observatories. Features of the vertical component variations are investigated. The ratio of the vertical total amplitude to the horizontal one is different in both stations: at Barentsburg it is averaged as 0.7 – 0.9, and in Lovozero it is equal to 0.3-0.5. At Barentsburg observatory the vertical component is positively correlated very well to the N-S component, but at Lovozero the correlation is bad with the both components. For the 8-Hz Schumann frequency the correlations and the ratio of the amplitudes differ from ones for total amplitudes.

Some peculiarities of observations of the ionospheric Alfven resonator signatures on Svalbard

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The signature of the ionospheric Alfven resonator (IAR), so called spectral resonant structures (SRS) in the spectra of the electromagnetic noise in the range of 0.1-10 Hz is rather often observed with a search coil magnetometer at observatory Barentsburg on Svalbard (L=15). In this report we discuss the peculiarities of diurnal occurrence of SRS at this high latitude station. We show that the pronounced minimum of the SRS occurrence around noon can not be explained by the diurnal variations of the solar zenith angle (illumination of ionosphere). We conclude that the SRS occurrence minimum is the result of the enhanced variability of ionospheric parameters when the observing point enters (during the Earth's rotation) the region of the ionospheric projection of the dayside cusp and its vicinity.
In contrast to the auroral zone observations, those realized in Baretsburg showed that the resonant structures are rather often seen during geomagnetic pulsations PiB. The interpretation of this fact is that SRS are due to IAR overhead, while PiBs observed at high latitudes are due to the ionospheric waveguide propagation from the remote source. This remote source of PiB co-locates with the region of the substorm auroras and electrojet. This interpretation is confirmed by the substorm-related electrojet observations. It is shown that the minimal distance between the substorm region and the point of the SRS observation is 100-200 km. This determines the characteristic horizontal size of the IAR region responsible for SRS at given point.

Responses to the earthquake on 26 May 2006 in the lower high-latitude ionosphere

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The ionosphere represents the dynamic environment which is subjected to influence of different disturbances, including lithosphere processes in the Earth's crust at the stage of preparation of earthquakes.
Earlier, we considered experimental data of partial reflections radar (Tumanny, Russia, 69.0ºN, 35.7ºE) and vertical ionospheric sounder (Sodankyla, Finland, 67.37ºN, 26.63ºE) during the strong earthquake with the magnitude 7.7 which occurred on 17 July 2006 at 08:19:25 UT in the western seaside of Indonesia (-9.33º S, 107.26º E) to the depth of 10 km at the very quiet geomagnetic field ($\sum Kp = 5.7$) and at small (background) flares of the class A .
In the given work the received experimental data at the same stations during another strong earthquake on 26 May 2006 at quiet geomagnetic field ($\sum Kp = 6.3$) are analyzed with the aim to reveal the general tendencies of ionospheric responses to earthquakes. Both earthquakes on 26 May 2006 and 17 July 2006 occurred, when the polar day was in the high-latitude ionosphere.
The strong earthquake with the magnitude 6.2 occurred on 26 May 2006 at 22:53:59 UT in the southern hemisphere at the island Java, Indonesia (-7.94º S, 110.32º E), to the depth of 10 km. The analysis of experimental data shown that the reaction of the high-latitude ionosphere to the strong earthquakes at the quiet geomagnetic field and at small (background) flares of the class A was seen both on 26 May 2006 and 17 July 2006 basically in parameters of the lower ionosphere. At the moment of the beginning of the earthquakes and later in amplitudes spectra of the ordinary components of partly-reflected signal the internal gravity waves with the periods of some hours were observed, which are related to the earthquakes.
The work was partly supported by RFBR (grant N 07-05-00012).

VHF scintillations, orientation of the anisotropy of F-region irregularities and direction of plasma convection in the polar cap

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

Using high-orbit navigation satellites for measurement of the total electron content in ionosphere modified by a powerful HF-wave

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The report presents results of satellite radio wave probing of ionosphere modified by powerful HF-waves from transmitter “Sura” (Vasilsursk, Russia) in August 2007. For the first time, variations of the total electron content (TEC) were measured by signals from high-orbit (about 20 000 km) navigation satellites (GPS/GLONASS) passing over the heated region. Previously, such experiments were carried out using low-orbit (about 1 000 km) satellites. The software complex for calculation of TEC, trajectories of satellites, angles between “satellite-receiver” ray and geomagnetic field lines, size of the heating region, etc. is described. The results for two modes of the heating facility operation (*pulsed* and *quasi- uninterrupted*) are presented. Oscillations of TEC were mainly observed with pulse mode and under high electron concentration in ionosphere E-layer. Power of TEC oscillations depended on the heating region size and properties of ionosphere layers. Value of TEC-level decreased within the heating region (ohmic effect) during the facility operation with quasi-uninterrupted mode. Also during the quasi uninterrupted mode the fixing of stationary magnetic-zenith effect (when the narrow in cross direction and long stretched in geomagnetic field direction ionospheric irregularities were appeared) was achieved (fig.1).
Although the TEC measurements by high-orbit satellites contain both spatial and temporal variations, the spatial variations of the electron density are mainly determinative.

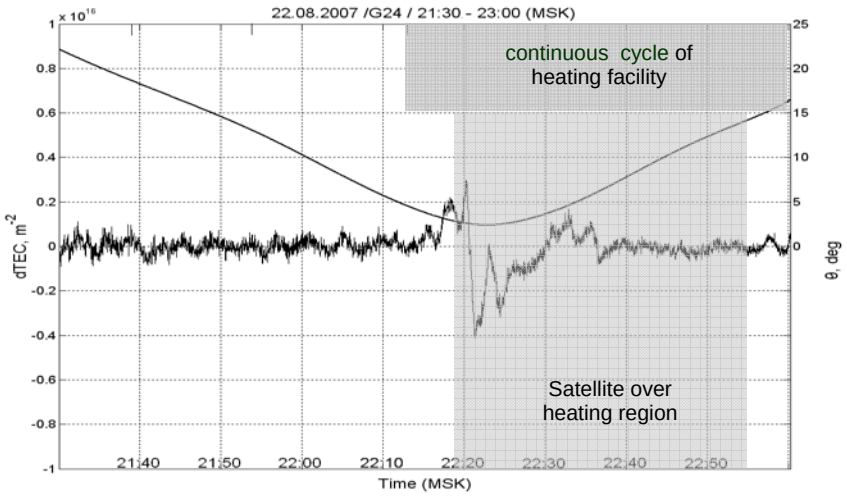

Fig.1. TEC variations of GPS-satellite G24 (noised curve).

Angle between “satellite-receiver” ray and geomagnetic field lines (smooth curve).

The theory for scattering of radiowaves from refractive index fluctuations in the polar ionosphere

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The theory of single scattering of high-frequency electromagnetic waves on refractive index fluctuations in ionospheric plasma is examined. In approximation of weak scattering the general formulas for total cross sections of Fresnel and Thermal Scatter of radiowaves in the polar ionosphere are received most. The possibility of using them to determine of parameters of D-region of the polar ionosphere by methods of incoherent scattering and partial reflection of radiowaves is discussed.
The study was supported by the RFBR grant № 07-05-00012.

Structure of the D-region of the winter polar ionosphere during powerful solar flares

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In the work the behavior of the D-region of the polar ionosphere is considered during powerful solar flares in January, 2005, and in December, 2006. It is known, that in winter during powerful solar flares the intensive reflections on frequencies of medium (MF) and very high-frequency (VHF) radiowaves, which have named the Polar mesospheric winter echo (PMWE), are observed. It is considered that the reason of PMWE appearance is presence of irregularities in the polar mesosphere, which are sufficient for reflection of the radiowaves. Mesospheric irregularities can have forms of sharply limited thin layers or any other formations. Reflections from the structures can have as mirror, and diffuse character. Till now the nature of these irregularities is not clearly understood. On the basis of medium wave sounding data of the high-latitude ionosphere it is shown, that in absence of strong ionizing factors such as solar flares and corpuscular intrusions from the magnetosphere, during the day the lower border of region of reflections is at heights of 75-80 km. During flares the height of the lower border of unlit areas of the D region practically does not change. But the lower border of the alight area falls up to 55-60 km and electron concentration at these heights sharply increases and reaches values of $2 \cdot 10^3$ cm^{-3}. Simultaneous observations VHF of reflections on the radar in Andenes (Norway, 69.17°N; 16.01°E) have shown multilayered structure in the alight area of the polar mesosphere. According to the geophysical data the area of the ionosphere above the MF radar (Tumanny, Russia, 69.14°N, 35.82°E) was near the area of a field-aligned current outflow. As a consequence it could be increase in concentration of mesospheric plasma and formation of several layers of metal and other ions.
The study was supported by the RFBR grant N 07-05-00012.

The electric field and currents during dipolization of the Earth magnetic fields

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The appearance of the currents and electric fields in the ionosphere and magnetosphere of the Earth during the expansive phase of the substorm have been studied in this work. It has been shown that the formation of the field-aligned currents and westward Cowling currents in the ionosphere can be generated by dipolization of the magnetic field lines. In the work the density of the field-aligned currents and electric field in the midnight sector of the auroral ionosphere has been estimated within the adiabatic approach.

Aberrations reduction for S-180 imaging meridional spectrometer.

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An imaging meridional spectrometer intended for studying night airglow and aurora emissions and evaluating their absolute or relative intensities was recently developed in Polar Geophysical Institute RAS. It demonstrates good sensitivity and spectral range suitable for most physical problem but is not free of aberrations. The major aberration appears due to defocusing mostly caused by temperature fluctuations. It manifests itself in line broadening and makes measurement of emissions intensities difficult because of adjacent lines overlapping. In order to resolve this problem a mathematical model taking into account both optical aberrations of the spectrometer and spectral characteristics of the camera was developed. An algorithm of resolution enhancement by reducing line overlapping was created. This algorithm was successively utilized to resolute the emission lines both of the N_2 First positive system and O_2 Atmospheric system and to obtain its intensities.

A model study of the FAC2 influence on the night-time N_e variations over the Millstone observatory during the April 2002 magnetic storms

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We continued to investigate the F2-layer behaviour during the April 2002 magnetic storms using the Upper Atmosphere Model. The model ionospheric parameters were compared with the data of seven incoherent scatter radars and the IRI-2001 values. The worst agreement between the numerical results and the observation data took place in the night hours on April 16 when the UAM strongly underestimated the IRI and ISR electron density. The numerical experiments showed that the reason of this underestimate was connected with the difference in the electric field variations over Millstone Hill calculated by the UAM and observed by ISR and thus with the difference of the plasma drift velocities. At night on April 16 over Millstone Hill the ISR electric field caused the converging zonal plasma flow whereas the UAM field agreed with the classic convection pattern with diverging zonal plasma flow and decreasing increasing electron density.

Aurora research at high-latitude Barentsburg station during SC event

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The behavior of aurorae after SC on November 28, 2000 at 05:31 UT was analyzed using all-sky TV camera data at high-latitude Barentsburg station (BAB, Φ'=75.15° N; MLT=UT+2.5). WIND spacecraft observations show that SC was caused by rapid enhancement of solar wind dynamic pressure from 2.5 nPa to 8 nPa. The peculiarity of this interplanetary disturbance is characterized by simultaneous rapid changing of the IMF Bz component from southward to northward and backwards for about 30 min. Before SC the interplanetary Bz component was relatively constant of about –4 nT. During this period the aurora were observed southward of BAB zenith at ~71-72° CGL. Just after the SC moment a new rayed auroral arc with long rays appeare northward of previous auroral forms. The maximum brightness of this rayed auroral arc was observed in 5 min. The duration of auroral intensification was about 9 min. At 05:40 UT practically all auroral luminosity disappeared possibly as a consequence of positive IMF Bz component influence.

Тепловой режим и проблема экваториального минимума термосферной плотности

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Для исследования влияния различных механизмов нагрева и охлаждения на формирование дневного экваториального минимума температуры и плотности нейтрального газа, обнаруженного по данным

спутника CHAMP, был проведен ряд численных экспериментов с помощью глобальной численной модели верхней атмосферы Земли UAM, в ходе которых из уравнения теплового баланса последовательно исключались члены, отвечающие за нагрев и охлаждение термосферного газа. Исключение из уравнения теплового баланса Джоулева нагрева, тепла химических реакций, а так же магнитосферных источников энергии и импульса приводит только к изменению форм изолиний и абсолютных значений температуры и плотности нейтрального газа. Показано, что формирующую роль в образовании приэкваториального минимума температуры и плотности нейтрального газа на дневной стороне играет солнечное ионизирующее излучение.

Физическое объяснение и математическое моделирование ионосферных предвестников землетрясений

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В работе представлено исследование аномальных возмущений в ПЭС (полном электронном содержании) ионосферы как предвестников сильных (магнитудой M5 и более) землетрясений. Выдвигается и проверяется гипотеза, что наблюдаемые возмущения ПЭС могут быть вызваны вертикальным дрейфом ионосферной плазмы в F2-области под воздействием зонального электрического поля сейсмического происхождения.
Проверка гипотезы осуществляется методом математического моделирования с помощью глобальной численной нестационарной трехмерной модели верхней атмосферы Земли (UAM). Сейсмогенные источники моделировались путем задания дополнительных источников потенциала электрического поля, размещенных в зоне землетрясения (у эпицентра или симметрично ему), различающихся геометрическими конфигурациями и магнитудой. Проведены численные эксперименты для дипольных и монопольных (положительных) источников величиной в ±10kV и ±20kV. Модельные данные сравнивались с данными GPS наблюдений ПЭС для землетрясения в Греции, имевшего место 8 января 2006г. с магнитудой M6.8 и эпицентром (36.3N, 23.36E). Установлено, что дополнительные источники потенциала дипольного типа для рассмотренных конфигураций и величин лучше других воспроизводят наблюдаемые вариации в ПЭС ионосферы.

Проблема ночных повышений плотности плазмы в среднеширотной F2-области ионосферы и ее исследование методом математического моделирования

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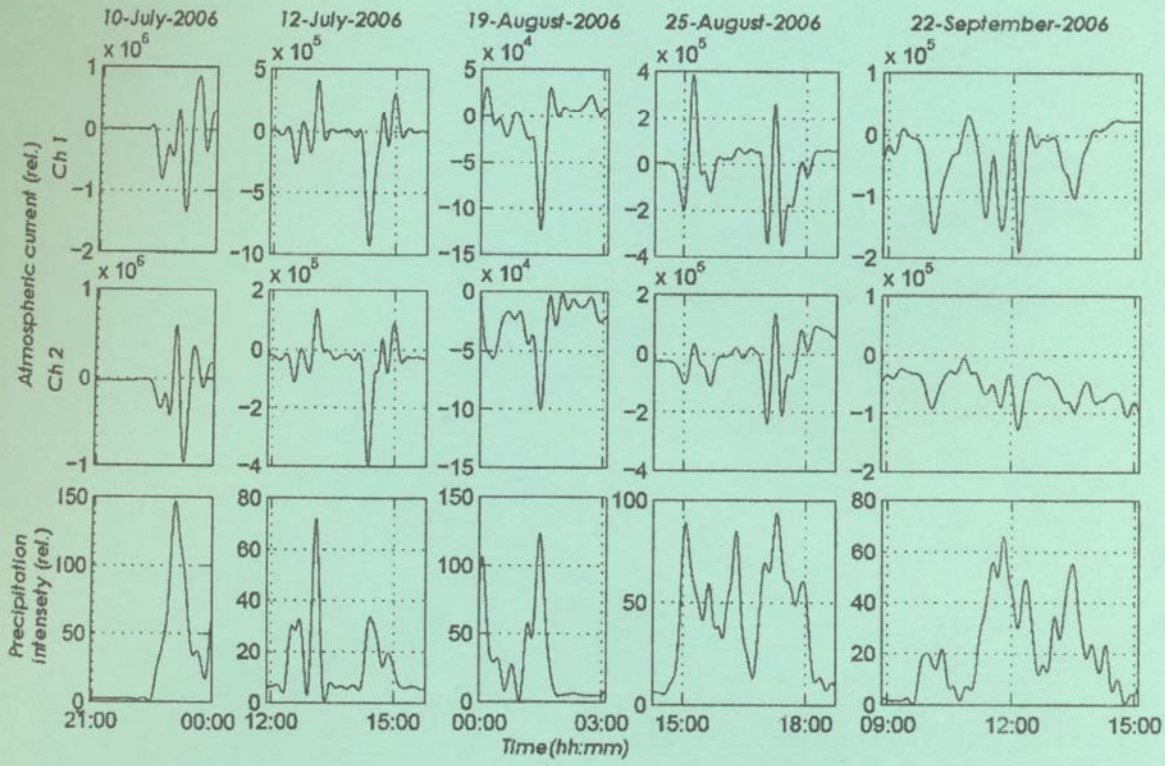
С помощью глобальной численной модели верхней атмосферы Земли UAM исследованы механизмы формирования ночных повышений плотности плазмы в среднеширотной F2-области ионосферы. Показано, что области повышенной плотности плазмы могут простираться до высот плазмосферы Земли. Установлено, что механизм их формирования связан с действием термосферного ветра, направленного преимущественно к экватору на ночной стороне. Этот механизм подтверждается в модельных исследованиях зависимости этих областей от сезонов и уровней солнечной и геомагнитной активностей. Найдено, что электрические поля влияют только на особенности широтно-долготного распределения областей повышенной плотности плазмы на высотах F2-области ионосферы.

Low Atmosphere, Ozone



Global thunderstorm activity in 2007 according to observations of the 1st Schumann resonance intensity on the Kola Peninsula

M.I. Beloglazov, O.I. Akhmetov, and A.N. Vasiljev *(Polar Geophysical Institute, Apatity, Russia)*

The thunderstorm production processes are at the centre of the atmospheric electricity problem. Besides it is considered, that the intensity of the atmospheric electromagnetic noise at frequencies of Schumann resonances is able to serve as a certain indicator of the global thunderstorm activity.
The measurements of the electromagnetic ELF field in the frequency range of 0.1-10 Hz are carried out in observatory Lovozero (a central region of the Kola peninsula) of the Polar Geophysical Institute during many years. Multiturns ferrite-cored solenoids (about 200,000 turns) oriented both along and transversely to the magnetic meridian are used as measuring elements. The digital recording with sampling rate 40 Hz is used.
To analyze daily variations of the ELF magnetic field amplitude at 1st Schumann resonance frequency (SR-1) the calculation of amplitude for two horizontal components for 20-minute intervals was performed, and the power spectra were constructed by a method of Welch's modified periodograms.
Diurnal and seasonal variations of SR-1 amplitude during 2007 are discussed as well as the localization of SR-1 sources. In particular, the presence of the amplitude maximum in the X-component at 14-15 UT caused by thunderstorm region in Central Africa is shown. The SR-1 amplitude maxima in the Y-component are at 08-10 UT (the Southeast Asia thunderstorm region) and 20-22 UT (the Southern and Central America thunderstorm region). The extremely strong dependence of intensity on a season is found out in both components: the summer amplitudes are larger than winter ones in 2-3 times. Besides, in summer the Asian maximum shifts to later hours (12 UT). The ratio between Asian and American maxima varies during the year. The Asian maximum of the SR-1amplitude prevails over the American one during most of months, but they become approximately equal in July - October.
The work is carried out under support of the RSA DPS Program No 12 " Physics of atmosphere: electrical processes, radiophysical methods of researches " (project 4.5).

Ozone destruction in rain precipitation and fogs

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

The average ozone decrease in the rain precipitation and fogs on is less than 5 ppb. This conclusion had been found using data of ozone measurements at the Lovchorr mountain (Khibiny, 1095 m asl). The ozone concentration decrease is much greater (up to 10-15 ppb) in the surface layer in the inversion conditions. However the ozone decreases in this case is caused by synchronous action of heterogeneous chemical reactions with aqueous aerosol and by decrease of the turbulent flow of ozone into the surface layer from the free atmosphere.
The estimation of contribution of the ozone destruction by the aqueous aerosol in rain precipitation and fogs in diurnal variations is too high, when the dynamical processes are ignored.

Detection of the mountain ecosystem dynamics in the Khibiny by technique of comparison of modern and old photographs

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The natural changes of the landscapes in the Khibiny mountains during last 120 years have been studied by the comparison of the modern and old photographs. The first photos of the Khibiny have been made during the research expedition of V. Ramsay in the 1890-1891 and have been published in the "Fennia" magazine (№ 2, 1891). In 2007 the repeat photography at the same districts has been made. The comparison of the old and new photos of valley of Yumgorr river in the West of the Khibiny indicates that the present-day upper limits of the forest is approximately 100 m higher, than 120 years ago. At the end of the 19th century the valley has been occupied by the sparse second growth wood and tall-grass meadows. In present time the valley is overgrown with birches and spruces which have a height of 10-12 m. The rocky slopes of valley are overgrown with birches and spruces too.
The changes of landscape zone in the other districts of the Khibiny Mountains are similar. The districts of tundra vegetation are replaced by forest-tundra, and forest-tundra is replaced by forest. This can be an evidence of warmer present-day temperatures in comparison with previous centuries. At the same time the reaction of the landscapes on the climatic change is considerably more complex. For example, the modern upper forest limits is higher than in the

1930's while the temperature conditions in the region have not changed.

Medical and ecological aspects of the vertical ozone distribution in the mountain regions

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

The natural increase of the ozone concentration in the troposphere with altitude up to values exceeding the standards of the World Health Organization is an additional problem of the recreational use of the mountain regions. There is the necessity of considering of the presence of ozone-rich air at high altitudes under planning of rest, tourism and sports in the mountain regions. For example, ozone concentrations at altitudes of 1-3 km are 120-200 ppb, while concentrations at attitudes of 7-8 km reach to 200-600 ppb. Such ozone concentrations cause the dangerous physiological disorders.
Attention is drawn to the fact that a number of attributes of the high-altitude illness and symptoms of ozone poisoning are similar (irritation of tunica mucosa of mouth, nose, eyes and throat, dry mouth, dry cough, bronchitis, decreases of respiratory impairment, decrease of pulmonary ventilation, decrease of visual acuity, impairment of peripheral and night vision and accommodation, cephalalgia, dizziness, decrease of the arterial pressure, cardiac performance disorders, neurotic disorders, liver disorders). It is possible to make the conclusion on the basis of this fact that ozone causes to aggravation of clinical effects of the high-altitude illness. For this reason ozone should be included in the list of unfavorable factors of the vital functions in the mountains regions.

Influence of vertical air motions in the boundary layer on surface ozone variations in the Arctic

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The estimation of the contribution of the large-scale vertical air motions (corresponding to weather systems) in the boundary layer on the surface ozone variations in the Arctic (Kola Peninsula) has been carried out using data of ozone measurements in the mountain regions, ozone sounding and the calculated values of the vertical velocity. It is shown that direct contribution of these motions on diurnal ozone variations in the flat country on average is less than 10-15 % at a height of 1 km and is less than 2-3% in the surface layer. The effect of these motions on the diurnal ozone variations in the Arctic is 4-5 times less than in the temperate latitudes.

Fast variations of thermal emission of a middle atmosphere in a line of ozone at frequency 110.8 GHz on plateau Shatzhatmas – Kislovodsk

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Ground and onboard microwave radiometry is the major method of research of ozone and minor constituents in a middle atmosphere. The main advantage of this method in comparison with others is the continuity of measurements with the high temporal resolution. The circumstance has allowed finding out to us in due time rapid (less than one hour) variations of the ozone content at heights above 20 km in a polar atmosphere [1, 2]. V.Y. Trakhtengerts and his colleagues were offered the dynamic approach to interpretation of fast ozone variations [3].
In the last year (09.07.07 - 18.07.07) measurements of stratospheric ozone at frequency of 110.8 GHz in Kislovodsk on high-mountainous scientific station of Institute of Atmospheric Physics Russian Academy of Science - plateau Shatzhatmas (43.7°N, 42.7°E) height above sea level ~ 2070 meter have been executed. In observations has been used unique mobile microwave ozonemeter [4]. Parameters of the device allow measuring a spectrum of a line ozone emission for 10-15 minutes (altitudes 22-60 km).
In continuous microwave observations were found out fast variations of thermal emission stratosphere (altitudes 22-60 km) in a line of ozone at frequency 110.8 GHz with the period about 25 minutes. Duration oscillatory beatings has made about two-three hours. The possible reason of occurrence these fluctuations was passage terminator on sunrise.
The study was supported by the grants 06-05-64734, 07-05-10042 of Russian Foundation for Basic Research.

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A model study of the transformation of the global circulation of the lower and middle atmosphere during the period from June to December

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To investigate how the seasonal variations of the neutral gas temperature affect the transformation of the lower and middle atmosphere circulation, the mathematical model of the global neutral wind system of the atmosphere, developed in the Polar Geophysical Institute, is applied. This model produces three-dimensional global distributions of the zonal, meridional, and vertical components of the neutral wind velocity and neutral gas density at levels of the troposphere, stratosphere, mesosphere, and lower thermosphere. In the model calculations, the vertical component of the neutral wind velocity is obtained by means of a numerical solution of the appropriate momentum equation without whatever simplifications of this equation, with the hydrostatic equation being not utilized. Moreover, the model does not include the internal energy equation for the neutral gas. Instead, the global temperature field is assumed to be a given distribution obtained from the NRLMSISE-00 empirical model. Global distributions of the atmospheric parameters were calculated for conditions corresponding to seven dates, which belong to seven different months beginning from June. Simulation results indicate that the horizontal non-uniformity of the neutral gas temperature, which is distinct in different months, influences considerably on the transformation of global circulation of the lower and middle atmosphere during the period from June to December.

Planetary waves and zonal winds in the Earth atmosphere

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A novel mechanism for the short-scale Rossby waves interacting with long-scale zonal flows in the Earth's atmosphere is studied. The model is based on the parametric excitation of convective cells by finite amplitude Rossby waves. We use a set of coupled equations describing the nonlinear interaction of Rossby waves and zonal flows which admits the excitation of zonal flows. The generation of such flows is due to the Reynolds stresses of the finite amplitude Rossby waves. It is found that the wave vector of the fastest growing mode is perpendicular to that of the pump Rossby wave. We calculate the maximum instability growth rate and deduce the optimal spatial dimensions of the zonal flows as well as their azimuthal propagation speed. A comparison with previous results is made. The meander generation in the field of the zonal winds was investigated with use of the satellite monitoring of the Earth atmosphere.

Observation of a polar stratospheric cloud above Murmansk on 29 January 2008

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On 29 January 2008 during the period from 11.30 till 14.00 UT above Murmansk it observed a polar stratospheric cloud. Occurrence of such clouds in our latitudes is a rare event. The similar phenomenon above Murmansk has been fixed in 3 December 2003. Other cases of occurrence of stratospheric clouds are known also.
In PGI during 2.5 hours photographic observation of this unusual cloud has been carried out. Photographing of this cloud was made on the digital equipment during all the period of the observation with the interval of 1-3 minutes.
First the cloud was small on the size, having iridescent painting. Eventually the cloud changed the form and painting, increased in sizes, thus additional structures of various scales have appeared. Some of these structures had wavy appearance. Visually the cloud was observed up to 14 UT. Shortly before it the cloud has got a pink shade.

Preliminary evaluation of the height of the stratospheric cloud shows that the height is about 30-35 km.
Interest to studying stratospheric clouds is connected to circulating processes and both thermodynamic and dynamic conditions in the stratosphere. Last years this interest has amplified in connection with influence of stratospheric clouds on the total ozone content in the atmosphere. Nitric acid trihydrate is one of the components which take part in forming of stratospheric clouds. As a result of active interaction of ozone with nitric acid trihydrate it occurs reduction of total content of ozone.

The first results of microwave observations of stratospheric ozone above St.-Peterburg

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Microwave researches of stratospheric ozone in University of St.-Peterburg were begun from middle of February, 2007. At university the modern equipment for measurement of ozone in millimeter wave band was installed.
The instrument consists of an uncooled millimeter-wave receiver and multichannel spectrometer. The receiver is set up on fixed frequency. Observation frequency: 110.8 GHz. Relative frequency instability 10^{-7}. Image channel filter – other-worldly wave guide. System noise temperature (single sideband) – 2500 K. The multichannel spectrometer represents a bank of filters (32 channels) with spectral bandwidth 240 MHz and the variable frequency resolution: 1.0 – 10 MHz. Parameters of the instrument allow to receiving the information (for 10-15 minutes – time resolution) on vertical distribution of ozone at heights from 22 up to 60 km. The measurements of spectra of atmospheric emission were carried out both by the method of variation of zenith distance and by the method of its calibration on hot and cold reference loads.
The data of ozone variations at heights more than 22 km from 14.02.07 till 10.04.07 are received. The data of ground-based microwave measurements of vertical structure of ozone (altitudes 22-60 km) are compared with satellite devices TOMS and MLS.
The study was supported by the grants 06-05-64734 and 06-05-64902 of Russian Foundation for Basic Research

Can long-term weather parameter changes account for surface ozone concentration trends?

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Based on long-term (11 to 16 years) high-quality observations from 8 German stations included in the EMEP network, the features of changes in daily surface ozone concentration, temperature, relative humidity and parameters of horizontal air masses transport have been evaluated. At all the stations the increase of daily mean surface ozone concentrations is statistically significant, the trends being different and generally varying between 3 and 10 % for 10 years with maximum daily concentrations being on the average about 1.5 times as low. The highest values for trends in mean daily and maximum daily surface ozone concentrations are observed in winter-spring period, while in summer the values decrease, with those at some of the stations becoming practically insignificant. Regression ratios connecting daily surface ozone deviation from the norm with similar weather parameter deviation have been evaluated. The deviation of surface ozone concentration is observed to be in the closest relation with the deviations of maximum daily temperature and the direction of air masses transport. A considerable portion of surface ozone concentration trends are associated with trends of weather parameters such as temperature, relative humidity, and direction of horizontal air masses transport, the calculated values of the former ones for most stations significantly decreasing when the influence of weather parameter trends is allowed for. It has been concluded that in analyzing the causes of surface ozone concentration changes one must take into consideration the changes in weather parameters influencing surface ozone formation.

Seasonal and diurnal variability of ozone and other trace gases in atmosphere of city and rural stations

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Seasonal and diurnal variability of surface ozone (O3), nitrogen oxides (NOx) and carbon monoxide (CO) is examined. Variabilities of O3 in a city (Moscow) and the near rural locality (Danki station; 100 km to the south from Moscow) are compared. Their largest difference is observed in the night time. Variabilities of O3, NOx and CO at Czech rural station Kosetice are compared with Moscow ones, too. The main differences of the seasonal and diurnal variability of O3 in city and rural stations are found that are firstly related to pollution from transport cars. It is shown that relations between O3, NOx and CO in cold and warm seasons are influenced by different atmospheric processes. The largest correlation is observed between morning CO maximum and daily O3 maximum. Their time lag is near 8 h; their correlation coefficient is negative in the cold season and positive in the warm season.

Терригенные аэрозоли: генерация, эволюция и характеристики

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Вклад терригенных аэрозолей в общее их содержание составляет примерно 40%, но для больших высот (z > 10 км) он может бы ещё больше, в первую очередь за счёт аэрозолей вулканического происхождения. В последние годы достигнуты весьма внушительные успехи в прогнозе как землетрясений, так и вулканических извержений, в первую очередь основанные на наблюдениях за различного рода предвестников этих событий. Основными внешними (геофизическими и космическими) факторами триггерного воздействия на возникновение землетрясений и вулканических извержений могут являться: 1) солнечная активность, 2) скорость вращения Земли, 3) земные приливы, 4) различные геомагнитные явления и 5)метеорологические факторы. Наиболее существенный вклад в изменчивость оптических характеристик атмосферы вносят мощные вулканические извержения эруптивного типа. Наблюдается определённая связь между солнечной активностью – количеством солнечных пятен и извержениями. Выброшенный в стратосферу вулканический материал по актинометрическим наблюдениям существует в ней более года. Масс-спектрометрический анализ показывает, что вода составляет 95% от всех газов вулканического происхождения. Морская вода в случае быстрого «катастрофического» раздвижения участка коры и образовании гигантской полости заполняет последнюю Заполнение этой полости водой, а не магмой, обладающей значительно большей вязкостью реализуется при расслаивании плиты. Последующий нагрев воды и высокое давление среды ведут к изменению физико-химических свойств воды: она приобретает свойства кислоты и растворяет дно плиты, утоньшая её. Обнаружена связь между цунами и эруптивными извержениями: отставание извержения от цунами примерно на 3-5 лет. Наблюдается корреляция между изменениями скорости вращения и интенсивностью эруптивных извержений.

Памяти К.Я. Кондратьева

Аэрозольное воздействие на климатические процессы

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Климатическая система Земли существенно изменилась за время, прошедшее с начала промышленной революции. Проблемой является отсутствие убедительных количественных оценок вклада антропогенных факторов, в частности аэрозолей, в формирование глобального климата, в изменения состава и структуры атмосферы. Установлено: прогревание приземного воздуха сопровождается потеплением тропосферы и похолоданием стратосферы (спад восходящего потока длинноволновой радиации от тропосферы); более быстрое потепление на суше, чем в океане; более быстрее потепление в высокогорных районах (за счет "альбедной" обратной связи); обусловленное аэрозолем выхолаживание атмосферы сдерживающее повышение приземной температуры воздуха (ПТВ); возрастание среднеглобального содержания водяного пара в атмосфере, усиление осадков и испарения, а также интенсификация глобального круговорота воды; интенсификация "режима Эль Ниньо", что сопровождается сдвигом зон осадков на восток; ослабление термохалинной циркуляции (ТНС), порождающее ослабление потепления в Северной Атлантике;

интенсивное проникновение потепления в глубину океана в высоких широтах.
Модельные расчеты не объясняют потепление климата при учете только антропогенных факторов, но оказываются вполне адекватными, если принять во внимание как природные, так и антропогенные воздействия (за счет парниковых газов и сульфатного аэрозоля). Усиление потепления климата в высоких широтах СП - характерный признак антропогенно обусловленного глобального потепления. Главной причиной неадекватности моделей климата является неучет в первую очередь атмосферного аэрозоля. Не учтено также то обстоятельство, что климатическая система открыта по отношению к внешним космическим воздействиям.

Метеорологические и синоптические условия образования перламутровых (полярных стратосферных) облаков 29 января 2008 года в районе города Мурманска

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29 января 2008 года в районе города Мурманска наблюдался редкий вид стратосферных облаков – перламутровые. Стратосферные облака обычно формируются зимой на высоте 15-25 км в полярных широтах. Изучение морфологии и динамики перламутровых облаков представляет научный интерес в связи с ускоренной потерей озона при их развитии. В докладе детально проанализирована синоптическая ситуация над Кольским полуостровом 29 января 2008г., изменения метеорологических параметров на гидрометеорологической станции Мурманск, а также данные температурно-ветрового зондирования атмосферы, полученные с аэрологических станций Мурманск и Кандалакша. Построены диаграммы изменения характеристик температуры, влажности, скорости и направления ветра по высотам. 29 января 2008 года погоду Кольского полуострова определяла южная часть глубокого циклона (давление в центре 965 мб), располагавшегося в 15 часов мск на юго-западе Баренцева моря. Фронтальные разделы, связанные с циклоном, проходили через районы Кольского полуострова в течение ночи 29 января. Во второй половине дня наблюдалась малооблачная погода без осадков, температура воздуха у поверхности земли была –1-3˚. По Мурманской области наблюдался юго-западный ветер, скорость которого в районе Мурманска составляла 17-19м/с. По данным радиозондирования за 15 час мск 29.01.2008 г. над Кольским полуостровом в тропосфере наблюдался сильный западный перенос – скорость ветра достигала 24-32 м/с. На высоте 25.5 км в широтном направлении располагалось струйное течение, ось которого проходила через южные районы Мурманской области. Максимальная скорость на его оси составляла 73 м/с. Данные радиозондирования показывают, что в 15 часов в атмосфере отмечено три тропопаузы. Выше уровня тропопаузы сохранялись ветры западного направления, скорость которых достигала от 30 до 52 м/с. Температура воздуха в диапазоне высот 10-22 км понижалась.. При этом регистрировался очень низкий уровень влажности (около 1-4%). В работе обсуждаются метеорологические условия возникновения перламутровых облаков 29 января 2008 года и представлен сравнительный анализ метеоусловий, при которых перламутровые облака наблюдались ранее (1).

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Основные генераторы глобальной геоэлектрической цепи по данным наблюдений приземного электрического поля на ст. Восток

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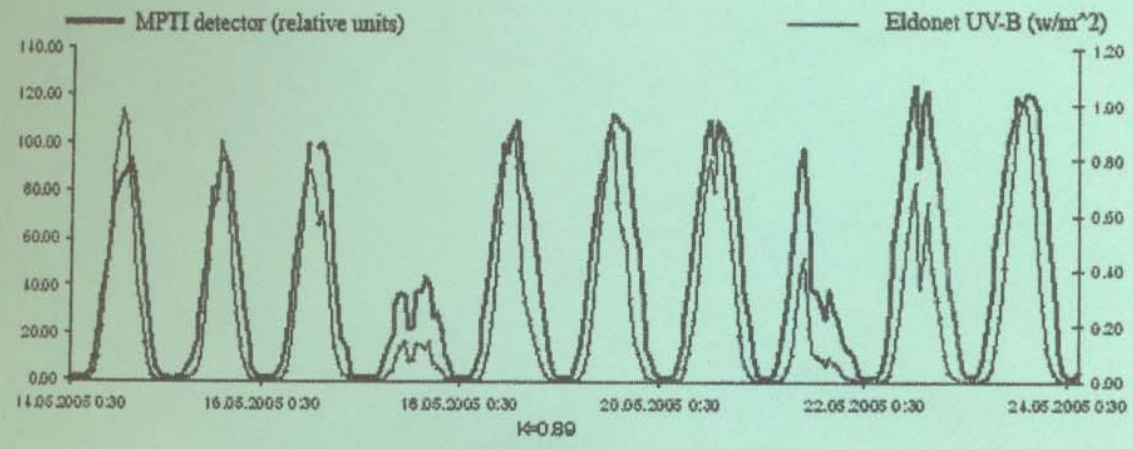
Проводимые на ст. Восток в Антарктиде наблюдения атмосферного электрического поля, позволили количественно оценить вклад основных генераторов в величину этого поля. Показано, что классическая кривая суточного хода (кривая Карнеги), наблюдаемая в периоды с «хорошей» и погодой, испытывает существенные вариации, обусловленные изменением распределения потенциала ионосферы.

В настоящей работе мы проанализировали данные измерений вертикальной составляющей приземного электрического поля E_z, полученные на внутриконтинентальной Антарктической станции Восток, где с 1998 года в рамках работ по совместному Российско-Австралийскому проекту проводится непрерывная регистрация вертикальной тсоставляющей электрического поля. Показано, что основной вклад в величину приземного поля дают тропические грозы (суточный ход поля хорошей погоды соответствует известной кривой Карнеги), однако основным генератором являются не молниквые разряды, а стационарные грозовые образования. В приполюсной области существенное влияние на величину вариаций атмосферного электрического поля оказывают ионосферные электрические поля, возникающие в результате взаимодействия солнечного ветра с магнитным полем Земли. Показана связь вариаций приземного поля с межпланетным магнитным полем и с потенциалом ионосферы, рассчитанным по эмпирической модели Веймара. Прведены модельные расчеты и сопоставление с экспериментальными данными влияния мощных приземных вариаций электрического поля, наблюдаемых в периоды с сильным ветром (метель, поземок), на вариации ионосферного электрического поля.

Heliobiosphere



The main results of model experiments to evaluate the influence of thermal neutrons' flux on living organisms with dormant eggs of *Artemia salina*

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Intensive researches to find environmental factors influencing on biological and technical systems function were carried out during tens years. It seems the corpuscular radiation (including thermal neutrons) is the most perspective besides electromagnetic field of different origins. The present study was devoted to estimation of the influence of thermal neutrons' flux on living organisms. The dormant eggs B of A. Salina were used as biosensor. Its were irradiated by thermal neutrons with different intensity of fluxes. The difference in dissipation of thermal neutrons between living and dead eggs were observed. It was found the water protons mobility was depended on intensity of neutron flux. This dependence is stronger for dead eggs than for living eggs.
This fact may be used for estimation of metabolic level of dormant eggs, that provide for adaptation of the living systems to corpuscular irradiation.

Immune system, variations of geomagnetic field and cosmic rays

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Modulation of functional state of biosystems by cooperative effect of the variations of Geomagnetic field (GMF) and Cosmic rays(CR) was revealed in our research [1,2,3]. Moreover, we found, that the final results of exposure of biosystems to variations of GMF and CR are determined by "dose" ratio of the active agents [4,5]. By subsequent analysis of correlations between functional state of the peripheral blood of healthy adolescents, GMF and CR variations, the main targets for separate impact of GMF and CR variations were emerged. Direct significant correlations ($p < 0,05$) were found between indices of geomagnetic activity (rH max, delta H and etc.) and indices characterizing of hyper activation of immune system (stab neutrophils, plasmocytes, the activation of neutrophils in peripheral blood, as determined by the oxidative capacity to reduced Nitro-blue Tetrazolium (NBT)). Besides, we found, that of hyper activation of immune system under increase of geomagnetic activity accompanied by increase of erythrocyte sedimentation rate, which relates to activation of neutrophils estimated by NBT-test. On the other hand it turned out, that content of phagocytes and monocytes in peripheral blood were increased in according to increase of high energetic particle fluxes in near Earth's space and increase of neutron intensity near Earth's surface. The functions of such general characteristics of unspecific resistance of organism as content of lymphocytes and segments are modulated by agents of multifactor nature, including intercellular interactions and cooperative effects of GMF and CR. Hyper activation of the immune system in healthy adolescents under abrupt disturbance of GMF and the inhibition of immune functions in according to increase of the neutron intensity near Earth's surface were found.

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Properties of water are modulated by variations of geocosmical agents

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Evolution of life on the surface of terrestrial planets is closely related with presence of water. Such properties of water as its structure, temperature of phase transition, intensity of radiolysis determine the biochemical processes rate and the effectiveness of intermolecular interactions. The physic-chemical water properties in its turn are determined by planetary environment and activity of Sun-like stars. Our task was to be answer of the question: how much properties of water depend on environment and especially on the variations of geocosmical agents associated with solar activity. We have discovered that properties of water, estimated by measurement of temperature difference (ΔT) [1,2] vary during the days. In this research the values of ΔT were compared with indices of geocosmocal agents, which are able to penetrate through electric isolated calorimeter in which sealed water in the quartz ampoule was placed. Such agents could be only electromagnetic and corpuscular radiation. Therefore we have selected suitable data from Geostationary Operational Environmental Satellites GOES-8 (75°W) and GOES-10 (135°W). In these data were included variations of GMF(four parameters), fluxes of nuclear-active particles in near Earth's space and also the data of neutron count rate near Earth's surface at the Jungfraujoch (46 32N 7 08 E), Moscow (55,28°N, 37,19° E) and Apatity (67.57°N, 33.4°E) stations were selected. Data about local variations of GMF were selected from data base of Surlary (44.68°N, 26.25°E) and Nurmijarvy (60.51°N, 24.66°E). The all data were correlated by using local time. We found that the values of ΔT correlate with magnitude of total magnetic field, with nuclear-active α-particles in energy range of 2560-3400 MeV (GOES-10), with energy >3400 Мэв (GOES-8) and protons with energy >700 MeV (GOES-8). Significant correlations were also found between values of ΔT and data of neutron count rates. However significant correlations were not found between ΔT and local variations of GMF. Our results manifested that variations of global geocosmical agents associated with solar activity essentially affect on the water properties. Since modulation of water properties by variations of geocosmical agents is extend on planetary level, the cyclic changes of water properties on planetary scale could be promote biochemical evolution and finally, evolution of living systems. Hence, variations of geocosmical agents associated with solar activity could be consider as external motive power of evolution.

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Relation of Maranta leuconeura «Fascinator» leaf movements with variations of the Gravitational and Interplanetary magnetic fields

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The "geocosmical tropism" of the plant Maranta leuconeura «Fascinator» was revealed under study of leaf movements and variations of geocosmical agents [1,2]. In this connection, dynamics of leaf movements had significant correlations with variations of geomagnetic field (GMF), neutron count rate near the Earth's surface and other agents. On the other hand, it was found the relationships between the dynamics of some biochemical reactions and λ_D-*function* describing the regular variations of the gravitational field under combined influence of the Sun and the Moon [3,4]. Subsequent research had aim to study the relation of the dynamics of Maranta leuconeura «Fascinator» leaf movements with gravitational disturbances of Solar origin (GDS), variations of interplanetary magnetic field (IMF) and solar radio emission (SRE) at 2800 MHz frequency. In result of comparative study of the dynamics of the four leaf blades average daily deviation (ADD) of the of Maranta and variations of GDS, IMF and SRE, the significant correlations were found. Negative correlations were found between ADD of the four leaf blades and GDS, whereas positive correlations were found between ADD and IMF. Correlations between ADD and SRE were positive and weak. When the data were smoothed by 9 points and linear trends were deleted, the correlations between ADD, GDS and IMF have been stronger. However the correlation coefficients between ADD and SRE did

not really change by such procedure. Hence, one can assume that the gravitational and interplanetary magnetic fields could be global modulators of the biological effectiveness of the local geocosmical agents.

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Effects of diurnal spectral changes in ambient UV on experimental plants

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The ambient UV and PAR have an important significance in boreal plants adaptation to severe environment and in long-tern productivity of northern ecosystems. The aim of the work was the search for unified biosystem for UV indication. The system in question should be of small reaction time and have a sufficient spectral performance within UV and PAR wave bands. To monitor the summer diurnal UV time-course in Apatity in summer 2006 we used cultural varieties of *Cucumis sativus* plant. As it was shown earlier by N. Kondo and M. Kawashima (2000), for this species have been found extremely rapid biochemical response to UV-B. In our work responses were measured in terms of plant phenolic accumulation in foliage induced by solar exposures. The mature *C. sativus* plants var. "Buran" cultivated under lab conditions and not UV irradiated before were undergone to ambient solar radiation for a 2 h temporal interval for a various diurnal hours. The modifications in phenolic pool for a various times were compared with UV-A, UV-B and PAR data recorded with "*Eldonet*" system. As it was found for the morning hours of 14 June 2006, 10.00 to 12.00 h LT, the induced accumulation of UV-B shielding substances with the maximum absorption near 300 ÷ 310 nm was as higher as 1.3 rel. units in relation to control samples in non irradiated plants. The plant exposure to ambient radiation within diurnal spans: 12.00 to 14.00 LT, and 14.00 to 16.00 LT were resulted in 1.7 and 1.8 phenolic grows, respectively. The reciprocal inversion of prevailing UV-A on UV-B components about 13.00 LT which took place according to UV running data resulted in more intensive phenolic biosynthesis after the noon. Thus, the sufficient spectral performance in terms of plant biochemical changes in relation to UV-A and UV-B radiations for the *C. sativum* is shown. The induced changes might be regarded as a kind of biochemical adaptation to fluctuation in ambient UV radiation and used for simple biological indication of both their intensity and spectral composition.

Some seasonal aspects of the magnetic storms influence to myocard infarctions

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Our previous analysis of the 85,800 events of Moscow ambulance calls in 1979–1981, related to the myocardial infarction (MI), demonstrated strong season variation with the profound summer minima and winter maxima. Similar results we have obtained analyzing the 25 year (1970-1995) statistical monthly data on the death from infarction in Bulgaria. That strong correlation suggests their common reason. It is well known that the maximum of magnetic storm occurrence is attributes to equinox, not to winter. However, there are a great number of clinical and statistical studies confirming the MI number rises during geomagnetic storms. But nobody has analyzed the seasonal biotropic efficacy of the magnetic storms. During the analyzed time interval there were 129 geomagnetic storms with Dst from –50 nT to –250 nT, 75 storms were observed in spring/autumn, 32 – in summer, and 22 – in winter. We found that about of 80% of the spring/autumn and about of 90% of the winter magnetic storms were

accompanied by MI enhancement, but only less then 5% of the summer magnetic storms showed the MI enhancement. We also found that the different magnetic storm phases demonstrate the different MI influence. As usual, very seldom the storm main phase was accompanied by MI enhancement, except the events when the storm main phase was developed on the recovery phase of the previous storm. But the storm recovery phase typically leads to MI increasing as well as Pc1 and Pc5 pulsations occurrence enhancement. The stronger is magnetic storm, the stronger are these effects. However, in summer both the storm main and the storm recovery phase did not accompanied by MI increasing even though there were strong Pc1 and Pc5 pulsations. We continued the investigations the negative influence of Pc1 pulsations to the seek people. It was found some human adaptation to the Pc1 occurrence in the series of succeeding days. The number of MI enhancement was observed only in the first day of Pc1 occurrence and later this number continuously decreased. But that did not observed in summer. All these facts mean that in summer there is some very important MI influence factor. We suggest that a seasonal variation of the production of the pineal hormone melatonin leads to a stronger summer stability in the human organisms to the "negative" influence of magnetic storms and geomagnetic pulsations.

Effect of heliogeophysical activity on the functional state of human hardiovascular system

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To reveal the effect of heliogeophysical activity on the functional state of cardiovascular system of a human being, the experiment on the measurement of conductivity of biologically active point (BAP) connected by the anatomical-informative relationship to the heart and vasculars using the method of electric–acupuncture diagnostics by Voll with the electronic device "Diafol" has been carried out. The joint consideration of the number of medical emergency calls for sick people suffering from the cardiovascular pathology in Yakutsk and conductivity indices of BAP has shown that the diagnostics of the cardiovascular system state is possible using the Voll method. The comparison of slow changes of BAP conductivity indices with the K-index has testified to the coincidence of trends with a high value of correlation coefficients. The analysis of personal data of participants has shown that the age and sex of persons under test have not the group changes.

Analysis of some solar wind and interplanetary magnetic field (IMF) parameters correlation with cardiovascular mortality indices

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In the context of our previous studies concerning the geliogeophysical factors effects on public health in Murmansk region, the assessment of such factors as solar wind and IMF influence onto the cardiovascular mortality has been carried out from 1984 till 2006 (22 years). We selected the several activity ranges for solar wind pressure (SWP) and Bz (negative values) and there combinations. Daily data were averaged to the monthly and annual values over hours amount from the appointed range. Furthermore the sequences of data on Dst (<-100 nT), Sunspot number (R), cosmic ray flow (Apatity) and $F_{10,7}$ cm were assessed. The annual data analysis included the Kp (>50 nT), K (Sodankylä) and number of SSC also. For the same period the database of cardiovascular mortality in Apatity was set up. Since the monthly data has a normal distribution we used the standard parametric methods of the mathematical analysis (Statistica). The obtained results revealed the most marked biotropic effect was found for SWP at 0-5 nPa and Bz from -1 to 1 nT and for combination of these indexes ranges. At that the main contribution belongs to the SWP values in 0-2 nPa range. Significant differences were observed for intensive and standardized cardiovascular mortality indices by sex and age.

Preliminary resuts of EM monitoring at biological ground Laly (Komy republic)

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During spring and summer seasons of 2007 the EM monitoring was fulfilled at biological ground of Institute of Biology of Komy SCRAN (st. Laly) using geophysical complex GI-MTS-1 (producted by SPbF IZMIRAN). The geophysical complex had registered three components of magnetic field variations, two components of telluric currents and variations of vertical component of electric potential (E_D) in trunks of four tree species (pine, fir, birch, aspen). Monitoring of cambia growth was simultaneously realized in the same tree species.
Preliminary analysis of ULF variations of electric potential E_D in trees and geomagnetic and telluric variations made it clear that the main reason of the E_D variations along the tree trunks were obviously caused by inner biological processes into the trees. Nevertheless the problem of inducted currents in the tree trunks and an influence of extreme solar events require more detailed consideration.
A structure of E_D variations in the coniferous trees (pine, fir) distinctly distinguishes from the variations of E_D in the deciduous trees. Variations of E_D in the pine and fir have similar character. They have daily periodicity. Maximum of the electric potential difference (E_D) is observed during after midnight and morning hours LT. In the deciduous trees the quasi-daily E_D periodicity is less evident and at times it is no visible. In contrast to the coniferous trees the structure of E_D variations in the birch and aspen can be strong distinguish. The structure of E_D variations before and in the beginning of vegetative period (April – May) is distinguished from the structure of E_D variations in summer months. More distinct 24-hour periodicity was manifested during an active phase of the vegetative period (end of June – July). This time the E_D daily periodicity was deduced in data of throughout the entire investigated trees.
Preliminary results are evidence that a monitoring of E_D variations into trees can give additional information about inner biological processes inside different tree species. For an analysis of season E_D variations a registration of E_D during autumn and winter season is very important.

Daily variations of the water properties are revealed by original equipment

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Cosmic rhythms have been discovered in the all Earth's envelopes and in biosphere [1]. Inasmuch as the water is the basic substance of living systems, it is important to examine do the cosmic rhythms manifest in the water properties. Investigations on assessment of water properties were carried out in the Institute of Physics of St.-Petersburg University, St.-Petersburg, Petergof (59.53° N, 29.54° E). The temperature of the renovated water was picked out as the tested parameter. The sample of sealed water in the quartz ampoule was putted into calorimeter. The heat-insulated brass cylinder with the effective heat capacity is equal to water was putted in the same place. Electric isolated soldered joints of differential thermopair were placed in the ampoule and in the cylinder. Thermal e.m.f. of the thermopair was measured by semi-automatic bridge of the direct current with
accuracy class 0,001. This peculiarity allows detecting the changes of thermal e.m.f. with precision of 10 nV, that correspond to change of the temperature difference ($\Delta\mathbf{T}$) between the ampoule with water and the brass cylinder about 0.001^{o}C. Registration of the time dependence of $\Delta\mathbf{T}$ was performed by x-y-recorder. The temperature difference ($\Delta\mathbf{T}$) was continuously detected in the course of five days. The analysis of the curve of the water property changes revealed the daily variations of $\Delta\mathbf{T}$ with maximum values about 5,80 ± 0,49 hours in accordance with UT and 7,4 ± 0,4 ч in LT. As is well known, the daily variations of the diverse parameters of the Earth's envelopes and biosphere are the basic rhythms associated with the Earth's rotation around hers axis. Therefore, one can assume, that rhythmic changes of the water properties could be related to biological rhythms.

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Assessment of frequency appearance and types of magneto-sensitivity among different group of human population

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It was yearly established that average values of systolic and diastolic arterial blood pressure of the group of healthy persons increased during geomagnetic storms development as well as on the day before and two days after them [1].
Purposes of this investigation:
-Estimation of personal sensitivity degree of physiological parameters to geomagnetic activity and meteorological factors.
-Assessment of frequency appearance of magneto-sensitivity among different group of population.
-Analysis of specific features of magneto-sensitive persons.
We analyzed results of arterial blood pressure long-term monitoring of the following groups of persons:
-77 healthy volunteers examined in autumn 2001 and in spring 2002 in Solar-terrestrial Influences Laboratory of Bulgarian Academy of Sciences;
-33 patients with arterial hypertension and 12 healthy volunteers in A.Miasnikov Center on Cardiology in Moscow examined during different periods of 2001-2002;
-10 healthy volunteers performing self-monitoring of arterial blood pressure during December 2007- January 2008 in Moscow.
We used the following methods combination for data of each person for estimation of statistical relationship between ABP and GMA indices: a) calculation of correlation coefficients; b) regression and variance analysis; c) method of superimposed epochs. All of the magneto-sensitive persons can be divided into three groups according to their maximal physiological reaction to GMF disturbances: “preliminary”, “synchronous” and “delayed”. Frequency of the “synchronous” and “delayed” reaction did not depend on age, gender and taking medications. Frequency of “preliminary” reaction was higher in males and in person taking medications in comparison to respectively females and persons not taking medicaments. It is also significantly higher for persons at age more than 50 and for hypertensive persons.

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