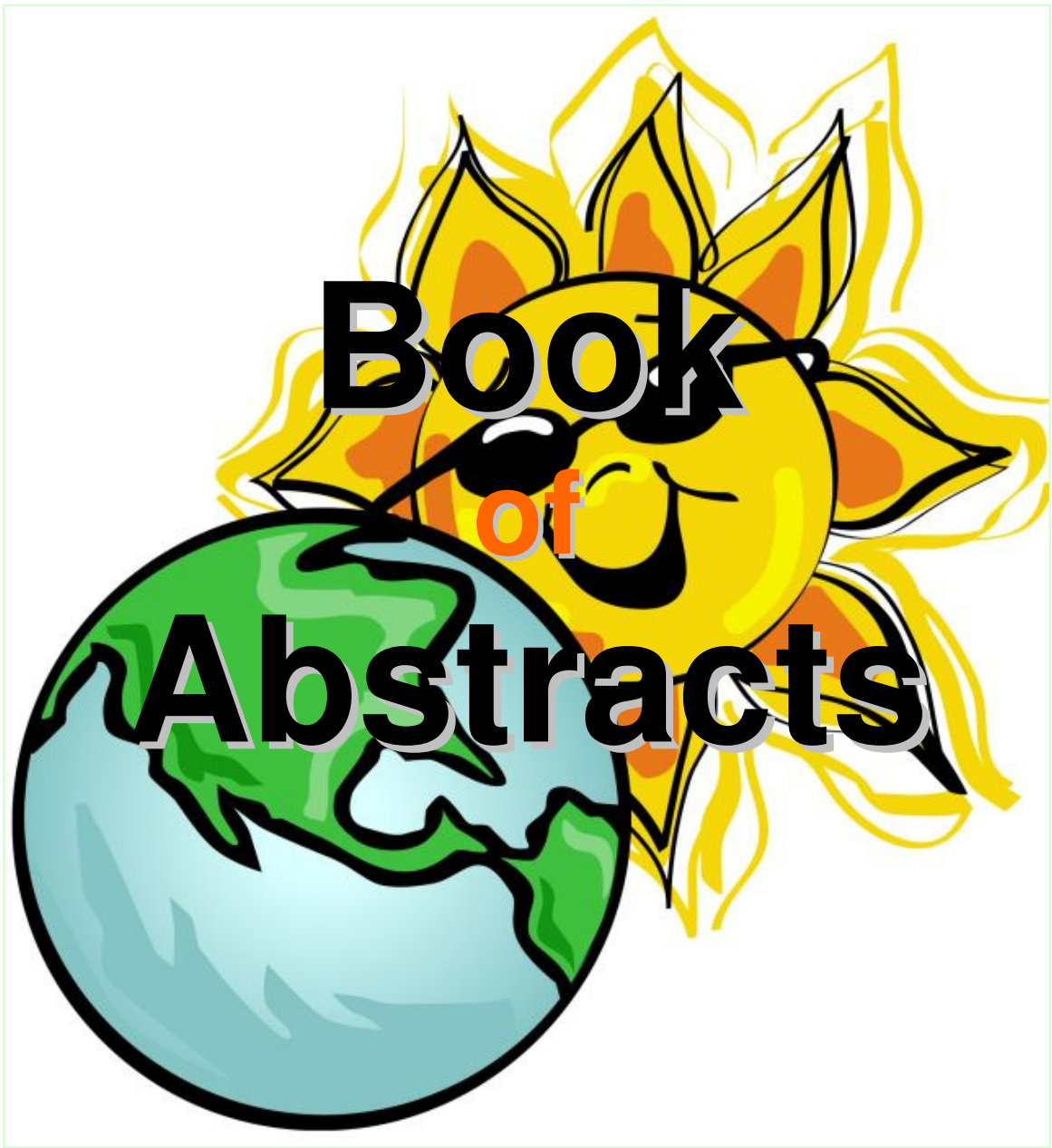
E L E V E N T H W O R K S H O P

Solar Influences on the Magnetosphere, Ionosphere and Atmosphere

Primorsko, Bulgaria, June 3÷7, 2019



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Solar Influences on the Lower Atmosphere and Climate
Data Proccessing and Modelling
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ФОНД НАУЧНИ ИЗСЛЕДВАНИЯ
МИНИСТЕРСТВО НА ОБРАЗОВАНИЕТО И НАУКАТА

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Sun and Solar Activity

Dynamic of the Occurrence Rate of the Solar Energetic Particle Events during Solar Activity Cycles 21-24

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The Catalogues of the solar proton events [1982-2016] edited by Yu.I. Logachev provide the homogeneous data series of events with intensity of solar protons >10 MeV $J \geq 1 cm^{-2} s^{-1} sr^{-1}$ beginning from 1970 up to now. The event rates behavior is rather smooth: relative to accumulated sunspot number the total number of such events is almost constant in the solar cycles 21-23 and even slightly growing in the solar cycle 24. Contrary, the total number of the most powerful (GLE) events per cycle was constant within statistical errors in the cycles 21-23, and it fell abruptly in cycle 24. We suggest that this strong decrease of the GLE events relates to the deficit of solar X-ray flares of the ≥X class.

The Generation of Monochromatic Pc4 Pulsations by the Electron Cloud

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In this work we investigate the physical nature and generation mechanism of very monochromatic Pc4 pulsations with using data of ERG (Exploration of energization and Radiation in Geospace) satellite. Such type of the pulsations is exited during very low geomagnetic activity, these pulsations are do not seen on the ground magnetometers due to damping in the ionosphere. The question about the generation mechanism of these pulsations is still open.

For the event 4 May 2017 according to the ERG satellite data the wave packet of Pc4 pulsations was registered after midnight at 08-10 UT. The pulsations are mostly seen in radial component and also in azimuthal component of the magnetic field; its frequency is about 13 mHz. On GOES-13 satellite located on higher L-shell than ERG satellite the frequency of these pulsations is about 11.5 mHz. This property (decrease of the frequency of geomagnetic pulsations with the increase of L-shell) testifies about the resonance nature of the pulsations.

During appearance of the Pc4 pulsations on ERG satellite the injection of electrons (mostly seen in 10-80 keV energetic cannels) are registered. This injection is coincide with the small increase of AE index up 200 nT. So this injection is caused by the small substorm. Thus it is found the experimental evidence that injection of electron cloud into the morning sector can be reason of the excitation of monochromatic Pc4 geomagnetic pulsations. There are some theories which can explain this mechanism.

Parameters of Thermal and Non-thermal X-ray and Gamma Ray Emission of Solar Flares, Observed onboard Coronas-F

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Based on data from the SPR-N and SONG multi-channel hard electromagnetic radiation detectors onboard the CORONAS-F space observatory and the X-ray monitors onboard GOES satellites, we have distinguished the thermal and non-thermal components in the X-ray spectrum of a number of powerful flares of 23th solar activity cycle. Temporal, spectral and energetic parameters of the flares were analyzed using the catalogs of Solar Energetic Particles and Related Phenomena (http://newserver.stil.bas.bg/SEPcatalog/).

This study is supported by the project `The origin on solar energetic particles: solar ares vs. coronal mass ejections`, co-funded by the Russian Foundation for Basic Research with project No. 17-52-18050 and the National Science Fund of Bulgaria under contract No. DNTS/Russia 01/6 (23-Jun-2017).

Preparation of Flare Situation Study above Active Region via Numerical GPU Simulation

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Understanding the solar flare mechanism, which makes it possible to establish a flare situation in the solar corona when using numerical MHD simulations and find a place for the accumulation of magnetic energy for a solar flare, can improve the forecast quality of solar flares, which have a significant impact on the Earth′s space environment. For the first time, a current-sheet model for explaining the mechanism of a solar flare was proposed in 1966 by SI Syrovatsky. The current sheet was obtained in solar corona by MHD simulation above the real active region. Basing on the mechanism of flare energy release in a current sheet I.M. Podgorny proposed electrodynamical model of the solar flare which explains main manifestations of a flare. Comparison of observations with results of MHD simulation above the active region NOAA 10365 performed in reduced time scale unequivocally is showed, that the flare takes place in corona as a result of release of energy, which is accumulated in the magnetic field of the current sheet. Detail study of the current sheet magnetic field configuration require to perform MHD simulation in real time scale. Test numerical solutions of implicit finite-difference scheme showed possibility of MHD simulation (faster x191 vs CPU computation) in real time scale using latest software-hardware optimization of specially adjusted supercomputer on the base of GPU Nvidia Tesla M2050 card.

Fluxes of Jovian Electrons and Galactic Protons in the Minimum of 23-24 Cycles of Solar Activity

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In the minimum of solar activity 2007-2008, there was an extremely long stable state of the structures of the solar wind speed, which persisted for 14 rotations of the Sun. According to the neutron monitor (Apatity), which registered galactic protons with energy >500 MeV, and the integral channel Ep>50 MeV of the EPHIN, SOHO instrument, quasi-27-day variations in the fluxes of galactic protons were studied. Periods of their variations turned out to coincide with the periods of the long-lived structures of the solar wind, 27.1 days, and anti-correlated with them. Simultaneously periodic increases in the fluxes of Jovian electrons (Je>1 MeV) were observed. At the beginning of the cycle of these variations, the fluxes of Jovian electrons and galactic protons correlated, then, a small phase shift of correlation took place at each rotation of the Sun, so that by the middle of the cycle already complete anticorrelation of these fluxes took place. This difference in the behavior of Jovian electrons and galactic protons indicates the different nature of the observed quasi-27-day variations. While for galactic protons, the explanation is in modulation of charged particle fluxes by an interplanetary magnetic field associated with periodic variations in the solar wind, for Jovian electrons, the relative position of the electron source (Jupiter magnetosphere) and the Earth and electron propagation process in Jupiter-Earth space must be took into account.

Double Filament Eruption and Associated Ribbon Flare and Halo Coronal Mass Ejection

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We present a study of a double filament eruption on 31 August 2012 that is observed close to the solar limb. During the activation, the filament slowly rose as compact body between 18:00 UT and 19:10 UT. During the eruptive phase, as observed in AIA/SDO channels, two main flux ropes (FRs) from filament body erupted consecutively. First FR eruption started at 19:10 UT and after 19:50 UT, when the upper part of FR was out of AIA FOV, two ribbon flare began to form at the filament feet. Later, at 20:20 UT, when two ribbons evolved C8.4 flare, the eruption of second FR started. The second FR eruption was followed by post flare loop development. Double filament eruption was associated with coronal wave and fast halo CME. Here we determined the kinematic parameters of two FRs, their twist evolution and discuss the possible instabilities of eruptions. We found the causal relationships between all events in the following order: first filament FRs eruption - C8.4 ribbon flare - second filament FRs eruption - coronal wave - fast halo CME - SEP event.

Effects of Non-thermal Particle Distributions on the EUV Flare Lines

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Solar flares are the most energetic phenomenon related to the solar magnetic activity. The magnetic reconnection produces high energy particles, electron beams, X-rays, and radio bursts. The high-energy particles accelerated during solar flares also affect EUV emission spectra. Recent theoretical papers and observations suggested that the electron distribution function could have a form of kappa-distributions. We calculated synthetic spectra in EUV range covered by the SDO/EVE (Extreme Ultraviolet Variability Experiment) spectrometer in wide temperature and density range for different kappa-distributions using KAPPA package based on CHIANTI database. The proposed diagnostics of the plasma parameters were applied on the observed Fe line intensities in the SDO/EVE spectra observed during strong flares. Our analysis showed that kappa-distributions have only a small effect on the diagnosed electron densities but they strongly influence temperatures diagnosed from the line ratios involving different ionization degrees. The observed relative line intensities corresponded to the presence of the strongly non-thermal electron distribution during the impulsive phase of the flare with its later gradual thermalization. The ion distributions also show signatures of presence of non-thermal distributions. The line profiles of high-temperature Fe XXIV lines observed by the Hinode/EIS (Extreme-Ultraviolet Imaging Spectrometer) during the impulsive phase of flare show broad profiles with pronounced wings and can be well fitted by a strongly non-thermal kappa-distribution. The coincidence of high-energy hard X-ray sources observed by RHESSI with the observation of non-Gaussian profiles and with the effects of the non-thermal electron distribution in the EUV line spectra is discussed.

Czech Solar Activity Observations and Forecasts

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The tradition of solar observation in Prague is pretty long and began even in the pre-telelescopic era in 1605 during unintentional using of the camera obscura for transit of Mercury. In the 19th century, Gregor Mendel began systematic observations of sunspots in the Moravian city of Brno.

Czech observations of solar activity in the recent century are mostly related to the Ondrejov Observatory founded in 1898. These first Ondrejov attempts were dated to practices of summer students who made sunspot drawings. During the WWII, regular spectrohelioscopic measurements in Ondrejov also began and were improved until early 1970ies when a patrol telescope taking white light and H-alpha images was regularly put in operation. The Ondrejov daily observations were used as an input for forecasting of solar activity iniciated by Ladislav Krivsky. He involved in this all the Czechoslovakia solar astronomy initiative most of public observatories and created a network `Photospherex`. It combined sunspot drawings from every public Czechoslovakian observatories and used for predictions. This network was ceased after SOHO satellite started observations in 1994.

Nowadays, four professional observation programs are running in Ondrejov:

- Solar Patrol Service, Solar optical spectroscopy, Flare continuum spectrographs and Radiospectrographs. Also a new amateur network for sunspot drawings CESLOPOL (Czech-Slovak-Poland database) is active and collects not only the current data but the historical data too. We bring a short survey of our recent activities of solar activity observations, forecasts, data archiving, including our participation in all the solar community cooperation and our own intents for future.

Science Objectives of the Solar-C_EUVST

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Solar-C_EUVST (EUV High-Throughput Spectroscopic Telescope) is designed to comprehensively understand the energy and mass transfer from the solar surface to the solar corona and interplanetary space, and to investigate the elementary processes that take place universally in cosmic plasmas. The proposed mission is a fundamental step for answering how the plasma universe is created and evolves, and how the Sun influences the Earth and other planets in our solar system. The two primary science objectives for Solar-C_EUVST are : I) Understand how fundamental processes lead to the formation of the solar atmosphere and the solar wind, II) Understand how the solar atmosphere becomes unstable, releasing the energy that drives solar flares and eruptions. Solar-C_EUVST will, A) seamlessly observe all the temperature regimes of the solar atmosphere from the chromosphere to the corona at the same time, B) resolve elemental structures of the solar atmosphere with high spatial resolution and cadence to track their evolution, and C) obtain spectroscopic information on the dynamics of elementary processes taking place in the solar atmosphere. In this talk, we will first discuss the science target of the Solar-C_EUVST, and discuss the science topic associated with space weather in detail.

Evolutionary and Flare Characteristics of Tightened Phases of Solar Minima

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The current 24solar cycle (SC), which opened second epoch of the lowered solar activity (SA) entered the last period of its development (≤W*=5 to the minimum), which can be prolonged of up to 1.5□2 years. According to the scenario of solar cyclicity the second epoch of lowered SA will overlap two thirds of 21 century. By phase of the minimum here is understood the interval of the time, when the smoothed values of the Wolf numbers remain within the limits W*≤ 30. The development of SC in the phases of the minimum makes it possible to isolate two groups of the SA decrease with the characteristic times (13+10/-3) and (39+0/-5) months. The first group (cycles 10÷11 and 16÷23) includes all SC of the epochs of increased SA, and 2 SC (11 and 23) of transition periods. All SC of second group (12-15 and 24) - SC of lowered SA epochs (except SC 16). The periods of beginning following SC are determined by the strength of new SC: more active (high) cycles, as a rule, begin their increase earlier (through 8 ÷ 15 months), although there were two noticeable exceptions: SC 17, and 22.

Appearance in September 2017 the flare-active sunspot group, in which were occurred 5 flare events of class ≥ X1, from which 2 were most powerful in the current SC, placed in the agenda a study of similar events of phases of the minimum previous SC for the purpose of the development of similar phenomena and possibility of their forecast.

Study on the Features of the SEP Solar Origin Based on Microwave Observations

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We present the results on the analysis of microwave (MW) emission in solar flares related to strong solar energetic particle (SEP) events observed during the previous solar cycle. The microwave emission is a sensitive indicator of particle acceleration and energy release processes in solar flares. However, MW emission is sensitive to several parameters simultaneously. For example, the flux at a maximum of the spectrum could be a result of the electron flux or magnetic field strength. The target of the work is to find criteria based on the solar flare features that would allow us to separate the SEP events into groups with more homogeneous physical/topological properties. The magnetic topology of active regions produced the flares was studied for breach of the classical sunspot group evolution laws (Hale` s law, Joy`s law et cetera) using technique suggested by Abramenko et al (Geomagn. and Aeronomy, 2018). This technique was tested for the 24th solar cycle based on the line-of-sight magnetograms provided by HMI/SDO. We discuss revealed tendencies and physical reasons for the different population appearances.

This study is supported by the project `The origin on solar energetic particles: solar flares vs. coronal mass ejections`, co-funded by the Russian Foundation for Basic Research with project No. 17-52-18050 and the National Science Fund of Bulgaria under contract No. DNTS/Russia 01/6 (23-Jun-2017).

Superflares on the Sun and other Stars

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Optical observations of largest flares on the Sun and other late-type stars are discussed. It is shown that such extremal events occur on young stars with rotational periods from < 1 day to 7-12 days. A joint analysis of data on superflares and available observations of stellar magnetic fields allows us to estimate the maximal flare energy. If we suppose that the origin of stellar superflares is similar to what leads to the most powerful non-stationary phenomena on the Sun, so the main process here is the acceleration of a huge number of particles up to high energies, which occurs near spots, in areas of strong magnetic fields. The area of the source of the flare optical continuum emission appearing as a result of the gas-dynamical response of the chromosphere to the heating by the powerful hard flux of accelerated electrons is 2-3 orders of magnitude larger than the area of white-light solar flares. Observational consequences of such a model are discussed.

Possible Interactions between Some Solar Activity Indicators for the Last Two Cycles

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In this study we investigated the possible linear and nonlinear interaction between some solar activity indicators which are MCMESI, Fl, SSA, SSN, F10.7 and TSI for the last time period of 1996-2018. Here, we used Convergent Cross Mapping (CCM) to examine the non-linear relationship and cross-correlation analysis to examine the linear relationship between the MCMESI and all other solar activity indicators. We found that FI, SSN, F10.7 and SSA show symmetrical relationship while the only TSI data show moderate asymmetric relationship with the MCMESI. The highest nonlinear relationship with the MCMESI is obtained for F10.7 data. This relationship is a symmetrical bidirectional coupling; when the library sample size gets smaller CCM score is increasing up to about 50 then it decreasing sharply. As a result, we can get information about the future of both data sets from each other`s manifold. From the cross correlation analysis we also found that the F10.7 has the strongest correlation with the MCMESI. Thus, we may argue that this relationship can be used for further dynamical modelling and prediction approaches.

Comparison of FI and the MCMESI for the Last Two Solar Cycles

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Here, we used Hα flare index (FI) data taken for the time period of January 1996 - March 2018 (total 8127 days), which covers Cycle 23 completely and almost whole cycle 24 (2009-2018). This data set compared with the maximum CME speed index (MCMESI) data that arise under different physical conditions during the studied time period. Then temporal and periodic variations of hemispheric and whole data were analyzed by using the cross-correlation analysis method, Morlet wavelet, MTM period analysis methods and wavelet coherence analysis. It is found that;

i) both north and south hemisphere FI data show the same level of correlation (r = 0.48) which is lower than the total FI data (r = 0.58), with the MCMESI,

ii) these hemispheric FI data sets also show some cyclic differences in periodicity analysis.

Comparative Study of Sequences of Causally Linked Eruptive Filaments, Flares, Coronal Mass Ejections and Solar Particle Events

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We present a detailed study of 29 sequences of solar filament eruptions (FEs), flares, coronal mass ejections (CME) and solar energetic particle (SEP) events during the Solar Cycle 24. The events in each sequence are part of the integral active region magnetic field configuration. Using precise timing, we determine the chronology of causal relations between the events involved in every sequence. Moreover, using a high spatial and temporal resolution data in all Extreme Ultraviolet (EUV) channels from Solar Dynamic Observatory (SDO) we examine the kinematic and morphological properties of FEs and CMEs to determine their specifics, which are relevant to distinct class of flares or SEP events and other activity phenomena, as well. This approach allows us to reveal some physical details of trigger mechanisms that could be evolved in such sequence of eruptive events.

About Critical States of an Artificial Satellite´s Motion in Extreme Periods of Solar and Geomagnetic Activity.

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The data of the drag of two artificial satellites moving in elliptical and circular orbits at middle latitudes (inclination of the orbits 58-60 degrees) were considered. This data includes the end of 23-rd solar cycle and the growth phase and the maximum of the 24-th solar cycle and minimum phase between them (2005-2017).

Seven periods of anomalous drag of the satellites with different durations from a month to a year were analyzed. The part of the anomalous drag periods were followed by flares on the Sun and the arrival of the CME in the near-Earth space on the monthly intervals. Significant correlation coefficients of 0.5-0.7 with solar activity indexes - solar radiation at a wavelength of 10.7 cm and Lyman alpha radiation were obtained only on time intervals per year. The largest correlation coefficients of satellite`s drag with the indices: the electron fluxes, the radiation of the Lyman alpha, and the change in the solar constant, as well as the DST index - are on the monthly intervals.

The features of the manifestations of solar and geomagnetic activity for satellites that burned in the atmosphere are being considered.

New Arguments for the Double Magnetic Cycle of the Sun

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We have analyzed some properties of the sunspots area variation: the composition of sunspot groups of different areas in the quasi-biennial oscillations (QBO) and in the 11-years solar cycles, the characteristics of the chaotic variations of the sunspots numbers at the timescales more and less than about two years. We found out some features that point on the difference of the processes that are responsible for the QBO and for the solar cycle and that these two processes are related.

The analysis of the QBO period variability by means of the wavelet transform with the Doubeshy10 mother function has shown that the QBO period does not change randomly, but gradually decreases on a course of every solar cycle and there is a linear dependence of the QBO period from the sunspots latitude, averaged for the corresponding time interval.

We suppose that the process responsible for the QBO should operate in the solar layer with a pronounced latitudinal gradient of the rotational velocity, that is more probably not tachoclyne region but higher in the convection zone or even near surface and this process possibly may result in a concentration or even amplifying of the magnetic flux generated by dynamo process in the tachocline. All discovered features are consistent with a hypothesis of the double magnetic cycle.

The Shading Effect for Doses and Galactic Cosmic Rays Fluxes Measured by Liulin Instrument, Depending on Liulin - Mars Geometry

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In this work is shown the relation between the doses and the galactic cosmic rays fluxes in the free space and the measured radiation quantities near a Mars. From purely geometric considerations follows that the measured galaxy cosmic ray fluxes close to the Mars, strongly depends on geometry LIULIN - Mars (the shading effect is 20 - 40 %). For the dose rates, the shading effect depends mainly on the distance between LIULIN instrument and Mars, but does not depend on orientation. The predicted effects are in good agreement with experimental data.

Non-stationary Properties of Quasi-periodic Pulsations in Solar Flare

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The quasi-periodic pulsations (QPP) are a frequently observed feature of the time profiles of a solar flare emission. A special attention should be given to a distinct class of the QPP signals with non-stationary parameters. The non-stationarity appears as a variation of the oscillation amplitude, period, or phase with time. It can also be associated with the presence of both different kinds of slowly varying trends and different kinds of noise. Such features could be caused by the variations of the physical parameters in the flaring site or as a superposition of several physical processes ongoing simultaneously, including power-law distributed background noise. A serious challenge in the detection and analysis of QPP is that the current analytical methods imply the stationary or slowly varying parameters of the signal. In this respect, the corresponding techniques should be appropriately tuned to adequately address the non-stationary nature of QPP. In this study, we reveal and analyze the non-stationary properties of QPP observed three solar flares, having the characteristic time scales from 15 s to 400 s. We distinguish between the real time-dependent signals and signals whose non-stationary characteristics are due to multi-mode composition. The periodic properties are analyzed using a unique combination of the analytical methods, such as the autocorrelation, Fourier periodogram, wavelet, and the EMD. Impacts of the flare trend and different kinds of noise are considered.

This study was supported by RFBR according to the research project No. 17-52-10001.

Morphology of Coronal Hole and Solar Wind Prediction Based on SDO/AIA Data in 2008 – 2014

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We present an analysis of coronal holes (CHs) morphology, combining the SDO/AIA and in situ WIND data recorded from January 2008 to December 2014. For this purpose we made a list of 297 solar wind disturbances incorporated into an online catalogue for general use. Separating the solar wind signatures on: corotating interaction regions (CIRs), interplanetary coronal mass ejections (ICMEs), interactions and complex signatures; we focused our attention on 145 CIRs (45% of all SW signatures) who can be clearly associated with a particular CH, visible in SDO/AIA 193Å and 211Å images. From a detailed analysis of CHs we estimated their onsets on central solar meridian and we also calculated the surface of CH area and CH average width from CH binary maps. This CH parameters are than compared with the solar wind plasma and magnetic field parameters using in situ observations from WIND spacecraft. As additional inspections, we also estimated the corresponding changes in geoeffectiveness and cosmic ray neutron flux.

Keywords. solar wind disturbance, stream interface, corotating interaction regions

Polarization of the White-light Solar Corona and Sky Polarization Effect during Total Solar Eclipse on 2006 March 29

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White-light solar corona observations obtained by three different teams during 2006 March 29 total solar eclipse are presented. We give a theoretical interpretation on how the polarization of the sky impacts the brightness of polarized solar corona, depending on the landscape during the totality. Moreover, it is shown that the singular polarization points of the corona are in linear dependence on the height of the Sun above the horizon.

EVE Flare Diagnostics of in situ Observed Electron Events

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We present the first comparative study between SDO/EVE flare intensity and the peak intensity of solar energetic electrons over solar cycle 24 (2010-2017). For the analysis we selected flare emission in three EUV wavelengths: 94, 133 and 304 A. Data from 103-175 keV ACE/EPAM energy channel is used to identify and analyze the flux of the in situ observed electrons. We calculate Pearson correlations between the SEP particle flux and flare EUV intensities, and compare the results with the respective correlation between particle flux and speed of the associated CME.

Radio Signatures of in situ Observed ACE/EPAM Electron Events

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We present correlation study between RSTN radio flux and the peak intensity of ACE/EPAM 103-175 keV solar energetic electrons. Data over the period 1997-2017 is considered. For this analysis, we collected the reported radio flux at all eight RSTN frequencies (in the range 245 MHz-15.4 GHz), usually at the time of the identified flare origin. Pearson correlation coefficients are calculated between the reported radio flux at each frequency and the identified, by us, electron flux. Thus, for the first time the remotely observed radio signatures of electrons can be directly compared with the in situ observed electron events over nearly two solar cycles. Comparison of the results with previous works is discussed.

Sunspot Decay on a Large Statistical Sample by Using High-resolution Data Base

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The decay of the solar magnetic field is an important question of the solar dynamo. The mentioned phenomenon was studied on low temporal resolution and few active regions by many researchers. The uniquely high temporal and spatial resolution of the SoHO-Debrecen Sunspot Data allows to investigate the decay of not only the sunspot groups but their leading and following parts. The statistical sample consists of more than two hundred sunspots. As a result of this investigation it can be pointed out that the decay rates are depend on the maximum umbral area of the group and the decay rate of the following part is larger than the leading part. There is no cycle dependency of the decay rate.

The Features of the Solar Energetic Particle Events Durig 23 Cycle of Solar Activity and their Relationship with Solar X-ray and Gamma-emission and Coronal Mass Ejections

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The study of the relationship of features of events in solar cosmic rays (in particular, the ratio of maximum proton and electron fluxes) with X-ray and gamma radiation from solar flares, as well as with parameters of coronal mass ejections was carried out. It was done on the basis of SOHO/ERNE proton event catalog (http://newserver.stil.bas.bg/SEPcatalog/) and Solar Flares Catalog based on measurements of X- and gamma-emission (>50 keV) detected by SONG (CORONAS-F - Russian solar observatory) from August,2001 till September, 2005 (http://swx.sinp.msu.ru/apps/solar_flares_cat/index.php). Solar electron flux (> 300 keV) were measured in the polar caps by MKL-instrument on board CORONAS-F satellite. The high (> 80%) correlation for maximal intensity of solar proton flux with solar flare gamma-emission fluencies was obtained.

This study is supported by the project `The origin on solar energetic particles: solar ares vs. coronal mass ejections`, co-funded by the Russian Foundation for Basic Research with project No. 17-52-18050 and the National Science Fund of Bulgaria under contract No. DNTS/Russia 01/6 (23-Jun-2017).

Investigation of Electric Current Associated with the Filament Inside the Active Region prior the Eruption

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Mechanism of instability of the electric current inside the ambient magnetic field could be applied for explanation of filament eruptions phenomena. Whether the electric current is stable against small vertical displacements depends on how fast the ambient magnetic field decreases with height. Steepness of the magnetic field decrease may be reflected using a parameter called magnetic decay index. In our study, we investigate configuration of the electric current, associated with the filament in an active region prior its eruption. The electric current was calculated from nonlinear force-free field reconstructions. Ambient magnetic field was computed in potential approximation. We found a gradual increase of the tangential component of the electric current along neutral line up to the eruption onset. We considered the electric current at the heights where magnetic decay index exceeded unity which is the critical threshold for loss of equilibrium of linear electric current. Thus, obtained results justify that mentioned mechanism of electric current instability can be responsible for the eruption.

This study is supported by the project "The origin on solar energetic particles: solar flares vs. coronal mass ejections", co-funded by the Russian Foundation for Basic Research with project No. 17-52-18050 and the National Science Fund of Bulgaria under contract No. DNTS/Russia 01/6 (23-Jun-2017)

MHD Simulation and Analysis of Observations to Determine the Mechanism of Solar Flare

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The most interesting feature of a solar flare is the explosive release of energy at altitudes of 15000 to 30000 km. The appearance of a flare in the corona is explained by the accumulation of energy in the magnetic field of the current sheet created in the vicinity of X-type singular line. Based on the mechanism of energy release in the current sheet, using the results of numerical simulation and observations, the electrodynamic model of a solar flare is proposed, explaining its main observable manifestations. The hard X-ray emission is caused by the electrons bremsstrahlung in the chromosphere, which are accelerated in field-aligned currents generated by the Hall electric field. To study the flare situation, numerical MHD simulation was performed in corona above the real active region. At setting the conditions, no assumptions were done about the flare mechanism. The simulation shows the appearance of a current sheet whose position coincides with the position of the observed source of thermal X-ray emission. The calculated spectrum of accelerated protons showed that the acceleration of solar cosmic rays occurs in the current sheet by the electric field E=-VxB/c, and not in shock waves. Analysis of the dynamics of the electron temperature of the solar atmosphere provides independent evidence of the coronal origin of the flare. For more accurate simulation in real scale of time, the parallelizing of calculations is currently underway on a supercomputer specially assembled for solving this task based on the Tesla M2050 multiprocessor GPU graphics card.

The Dynamics of the Spectra of the Periods of Major Indices of Solar and Geomagnetic Activity on the Various Phases of the Solar Cycles.

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Application of wavelet analysis method allows you to obtain data not only on the availability of key periods changes of the studied indexes, but also determine the time of their existence and character of amplitude change over time. The paper presents the results of the calculations of the spectra for periods of solar activity indices (Sp, W, F 10.7, FI, LA, SI), solar wind flow (IMF, density), disturbance state of the geomagnetic field (Ap, Kp, DST). For indexes that characterize the solar activitythe presence of long-period component is typical (2-7 years), which move from one cycle to another. Here there are also numerous short-term variations for a period of less than one year that change with the phase of the solar cycle. Changes in indices of geomagnetic activity largely reflect trends in the range of periods of solar indices. They demonstrate the existence of a long-period component with the transition from one cycle to another. Short-periodic components exist within certain cycles of activity. Changes of the periods spectrum of solar wind indexes show numerous long-period and short-periodic components of transition from one cycle to another. Changes in solar constant (SI index) show a noticeable difference from all other solar indices showing off the most varied range of periods.

VarSITI Database on in situ Electron Events and their Related Radio Emission

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Two comprehensive catalogs of in situ observed energetic electrons and their related radio emissions are presented. The solar energetic electron events detected by ACE/EPAM instrument over the period 1997-2017 at two energy ranges 103-175 keV and 175-315 keV are identified and analyzed. The onset time, peak time and peak intensity are evaluated, in addition to the associated solar flares and coronal mass ejections (CMEs). The related radio emission signature catalog is based on data observed remotely (both from satellites and ground-based observatories) using available observatory reports, quick-look dynamic radio spectra and single-frequency RSTN records. We describe the procedures utilized for both catalogs for identifying the electron events, the association to their solar origin and the corresponding radio signatures. Statistical relationships between the energetic electron events and their solar origin, in addition to the corresponding radio signatures are presented and discussed.

Investigation of Sunspot Area Dynamics in Different Categories

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In this study, sunspot areas are divided into four category according to their corrected areas in order to analyze their temporal variations and dynamics. Complexity parameter (last parameter) of the modified Zurich classification scheme is used to determine the upper and lower bounds for distinct sunspot areas of each category. Simplex Projection and S-Map algorithms are used to determine the embedding dimension and nonlinearity of each category, respectively. Cross-Correlation (CC) and Convergence Cross Mapping (CCM) methods are also applied to determine unidirectional and bidirectional relationships of these classes. Obtained results have shown that smoothing process affects the embedding dimension and nonlinearity of each category differently. On the other hand, high bidirectional interrelationship implies conversion of first and second categories to each other during the investigated time period (1875 - 2015). Although the last category sunspots are the least frequent ones, they have the highest information gain for the total sunspot area, while each category have almost the same amount of information gain for the international sunspot number.

Radiation Environment aboard ExoMars Trace Gas Orbiter in Mars Science Orbit in May 2018- April 2019

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We present recent results from measurements of the charged particle fluxes, dose rates, linear energy transfer spectra and estimation of dose equivalent rates at ExoMars Trace Gas Orbiter (TGO) science orbit (400 km circular orbit from Mars), provided by Liulin-MO dosimeter of FREND instrument aboard TGO. The obtained data from May 2018 to April 2019 show that: 1) Slight increase of the dose rate and flux from is observed, which corresponds to the increase of GCR intensity during the declining of the solar activity; 2) A strong dependence of the measured fluxes on the part of the field of view shadowed by Mars is observed; 3) There is no dependence of flux and dose rate distribution on the Martian latitude and longitude; 4) Measurements in two perpendicular directions show that the flux is about 93% (3.08, 3.18 cm-2s-1), dose rate is about 85% (350.4, 362.4 microGy day-1), dose equivalent rate is about 70% (1.55, 1.64 mSv day-1) of that in February-March 2017 in high elliptic Mars orbit; 5) A reasonable agreement between GCR count rates from different particle detectors in different locations in the heliosphere is observed.

Observations of Ionosphere and Solar Wind Turbulence Using the URAN Interferometers

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Low frequency radio waves strongly interact with plasma of the interplanetary medium and the Earth`s ionosphere that significantly distorts astronomical data collected in observations at decameter wavelengths. At the same time, the analysis of these data makes it possible to study the plasma itself. To date, a large set of the observational data have been collected during 23rd and 24th solar cycles with the Ukrainian Radio Astronomical Network (URAN) that can be used to probe remotely the interplanetary plasma and the ionosphere. In this report we describe a method of analysis of the URAN interferometric data and its application for studying turbulence of the solar wind and the ionosphere. The method effectively discriminates interplanetary and ionosphere scintillations. Detection of large-scale irregularities of the solar wind and footprints of the influence of individual solar events on the interplanetary plasma turbulence are shown.

On Polarization of Solar Decameter Spikes

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First results after spikes polarization properties analysis in the frequency band 8 - 32 MHz will be presented in the report. The analyzed data were obtained on 14 June 2012 with URAN-2 radio telescope which has been equipped with digital receiver of new generation DSP-Z since 2010. This receiver possesses high time - frequency resolution of few ms and 4 kHz respectively. In particular it will be shown that in most cases spikes have high degree of circular polarization with average values of about 50% and 20% for the bursts with right and left polarization correspondingly. However, majority of the analyzed spikes were right handed polarized (96%). Based on the leading spot rule we made an attempt to associate the observed spikes with the particular active region on the solar disk, namely NOAA 11506. We also suppose that knowledge of emission polarization will enable us to estimate the magnetic field in the place of emission generation.

The Catalog of Magnetic Storms for Odessa Magnetic Anomaly Zone, during 1987-2009 and Reaction of the Flux of Powerful Space Radio Sources in the Decameter Range on their Variation

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At the radio telescope `URAN-4` of Radio-Astronomical institute NAS of Ukraine the monitoring of flux of powerful space radio sources has been carried out since 1987.The aim of the program is the study of variable flux and their dependencies on the state of space weather.For identification of reaction of the geomagnetic activity in the area of radio telescope location the observations data from the magnetic station `Odessa` was used. The radio telescope `URAN-4` and the magnetic station `Odessa` are located near a zone of Odessa magnetic anomaly. The version of the catalog of magnetic storms for a zone of the Odessa magnetic anomaly from 1987 to 2009 which covers 22-23 cycles of solar activity is submitted. The catalog includes: date and time of the beginning and end of a storm, the storm duration, amplitude on three elements of a magnetic field are specified: H, Z, D, the characteristic of magnetic storms with the indication of the fissile periods. Catalogue of magnetic storms Observatory `Odessa` is associated with catalog magnetic storms IZMIRAN. In the period from 2017 till now the direct measurements are carried out directly in the center of the magnetic anomaly on the territory of the Astronomical Observatory of the Odessa I.I. Mechnikov National University. Examples of magnetic storms records are presented during these measurements.

Solar X-ray Variability in Two Distinct States and its Real-time Analysis Based on a Fractionally Time-series Model with a Heteroskedastic Component

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Soft X-ray emission observed at the current solar cycle in July-September of 2017 is analyzed. We have found two different states of the solar activity using a Hidden Markov Model, and we show that in the periods of high solar activity the energy distribution of soft X-ray solar flares is well described by an ARFIMA-GARCH model. Although it is assumed that higher solar activity can contain more states, in the period under study (close to the quiet Sun) this approach allows us to describe both the two states of the solar activity and the emission dynamics within a single state.

Collection and Analysis of Data on the Amount of Solar Energy Falling on the Earth's Surface during Different Periods of Time.

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With the help of the Davis Meteorological Station, Vantage Pro 2 Plus has been collecting and archiving data on solar energy for 8 years. She is of a semi-professional type, and one of its sensors is designed especially for measuring of the solar radiation. The amount of solar energy is measured in continuous mode every 15 seconds. The collected data from the sensor were integrated and the data were recalculated in order to obtain results for the solar energy that is absorbed during a certain time interval per unit Earth`s surface. The purpose of this research is to trace the repeatability during different periods. A high annual repetition provides a good opportunity to forecast of the energy yields for the coming years. The monitoring was carried out for the region of Stara Zagora.

Research on Active Solar Processes during 2019 July 2 Total Solar Eclipse

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We live in an era where scientific studies of the Sun and the solar-terrestrial interactions, being done by ground-based and orbital observatories, are more improved and wide-spread. However the total solar eclipses are still a cosmic laboratory impossible to simulate on Earth and they provide a chance for detailed studies of the corona and the active processes which affect our everyday lives.

Our research team is preparing an expedition to observe a total solar eclipse on 2019 July 2 from Chile. The current report gives details on preliminary research of choosing the location, preparing the equipment and scientific tasks to perform.

STEREOCat Speed de-projection of SEP -related CMEs

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Particles accelerated to high energies by solar eruptive phenomena can reach the Earth moving along the interplanetary magnetic field lines. We use a list of 156 SOHO ERNE 20 MeV solar energetic particle (SEP) events from solar cycle 24 (2009-2017) with identified solar origin (e.g. flares and CMEs). The aim of this study is to evaluate the 3D parameters of SEP-related CMEs and estimate if they can give us a better insight of SEP production than the previously used 2D velocities. The 3D kinematic properties of the CME set are explored using observations from STEREO SECCHI and SOHO LASCO coronagraphs based on the STEREOCat analysis tool.

RS Ophiuchi and Advection

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Binary systems RS Oph comprise a white dwarf and a closely orbiting Red giant. RS Oph (HD 162214) is a symbiotic recurrent nova which exhibits recurrent nova outbursts approximately every 15-20 years. Matter is transferred from the companion to the white dwarf, forming an accretion disk with corona (Yankova 2019). Advection in the disk contributes to dynamics in internal orbits of the disk. Therefore can be viewed as a catalyst of an activity from the collisions of the corona`s arches.

Comparing the Height Dependences of the Magnetic Field Overlying the Initial Areas of Fast and Slow Coronal Mass Ejections

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We purposed to answer one of the questions. Are there principal differences in initiation phase of coronal mass ejections (CME) with high and low velocities in field-of-view (FOV) of LASCO coronagraphs? Fast CMEs conventionally include mass ejections with linear projection velocity Vlin >1500 km/s in LASCO FOV, slow ones Vlin ≤ 600 km/s. To answer this question, we selected fast and slow halo CMEs with formation sources in sunspot groups located at no more than 60-degree distance from the solar disk center. We used data from SDO/AIA and SDO/HMI instrument, and from LASCO -2 and -3 coronagraphs for our analysis. We compared characteristics of the active regions where fast and slow CMEs occurred. Features of frontal structure kinematics of fast and slow CMEs are discussed. Vector magnetograms of the photosphere magnetic field from SDO/HMI instrument are used for nonlinear force-free field reconstruction overlying the CME initial areas before and after the onset of CME-associated flare. Our analysis of the height dependence of the magnetic field overlying the initial area of fast and slow mass ejections suggests that the decay index of the magnetic field is varied greatly.

Drift of the Erupting Flux Rope Footpoints: Theory and Observations

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Solar flares belong to the most geo-effective manifestations of solar activity. Flares are powered by the process of magnetic reconnection. Flares connected to a coronal mass ejection (CME) are called eruptive flares and many of their observed characteristics can be explained in the framework of the standard (CSHKP) model of eruptive flares. In this contribution we analyze one observational aspect which is not explained in the standard model, namely a drift of the footpoints of an erupting flux rope. This drift has been recently predicted by the extensions to the standard solar flare model in 3D and is a consequence of 3D reconnection geometries involving the flux rope field lines. We report on occurrence of this phenomenon in several eruptive flares, including two eruptions of a quiescent filament. This process has important consequences for estimating the CME mass, as well as for mapping back the footpoints of interplanetary CME onto the solar disk.

Upcoming Grand Solar Minimum and other Features of Solar Activity Derived with PCA from Solar Background Magnetic Field

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Recently discovered long-term oscillations of the solar background magnetic field associated with double dynamo waves generated in the inner and outer layers of the Sun indicate that the solar activity is heading in the next three decades (2019-2055) to a Modern grand minimum similar to Maunder one. On the other hand, a reconstruction of solar total irradiance suggests that since the Maunder minimum there is an increase in the cycle-averaged total solar irradiance (TSI) by a value of about 1÷1.5 [Wm^{-2}] closely correlated with an increase of the baseline (average) terrestrial temperature. In order to understand these two opposite trends, we calculated the double dynamo summary curve of magnetic field variations backward one hundred thousand years allowing us to confirm strong oscillations of solar activity in regular (11 year) and recently reported grand (350-400 year) solar cycles caused by actions of the double solar dynamo. In addition, we report the oscillations of the baseline (zero-line) of magnetic field with a period of about 2100 years (a super-grand cycle) derived by applying a running averaging filter to suppress large-scale oscillations of 11 year cycles. Latest minimum of the baseline oscillations is found to coincide with the grand solar minimum (the Maunder minimum) occurred before the current super-grand cycle start. These oscillations of the baseline solar magnetic field are found associated with a long-term solar inertial motion about the barycenter of the solar system and closely linked to an increase of solar irradiance and terrestrial temperature in the past two centuries.

About Productivity of the Solar Energetic Particle Events.

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It is known that solar energetic particles (SEPs) may not be related to powerful soft X-ray solar flares. On the other hand, weak flares may be associated with prominent SEP events. A reason for this could be the acceleration processes which do not manifest in soft X-rays. One of the sensitive indicators of acceleration is emission in microwaves. In our study, we reviewed a sample of 17 SEP events related to flares observed by the 4-8 GHz spectropolarimeter.

We analyzed the microwave burst parameters characterizing acceleration processes for each event. In some events despite the prominent microwave signatures powerful SEPs were not produced.

In order to investigate into this issue, we study the dependence of the SEP events productivity on active region magnetic field topology and coronal mass ejection (CME) speed. The magnetic field during the preflare stage was extrapolated in a potential approximation. The obtained results are discussed.

This study is supported by the project "The origin on solar energetic particles: solar flares vs. coronal mass ejections", co-funded by the Russian Foundation for Basic Research with project No. 17-52-18050 and the National Science Fund of Bulgaria under contract No. DNTS/Russia 01/6 (23-Jun-2017).

Solar Wind-Magnetosphere-Interactions

The Influence of Different Types of Geomagnetic Disturbances on a GIC in Electric Power Lines

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In this work it is conducted the estimations of the influence of different types of geomagnetic disturbances (SC, TCV, impulses, substorm, Pi3 pulsations) on the value of geomagnetically induced current (GIC) registered in electric power lines of Kola Peninsula and Karelia (Russia). The registration system is oriented mainly in the North-South direction. For the registration of the geomagnetic field disturbances the IMAGE magnetometer data are used.

It is commonly accepted the models of GIC in which the main source of GIC is a variations of the auroral electrojet. On the base of this notion it is considered that the geomagnetic disturbances are dangerous for the technological systems oriented in the East-West direction. In this work on the base of analyses of geomagnetic field variability is shown that noticeable contribution to the growth of GIC value can have not only auroral electrojet but also small-scale vortex current systems. Thus the GIC are dangerous also for the technological systems oriented in the North-South direction.

The Pi3 pulsations during a substorm with a vortex structure of the ionosphere current systems can lead to additional growth of the GIC value. It is shown that in individual cases GIC can better correlate with the geomagnetic field variations than with its derivate. So the high values of the GIC can be caused not only by the temporal variations of the geomagnetic field but also spatial variations of the vortex current systems connected with the field-aligned currents in the magnetosphere.

Response of the Total Electron Content to Geomagnetic Disturbances in January 2005

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This study presented the mid-latitude ionospheric response to three geomagnetic storms occurred in January 2005: the first one on 7-8 January, the second one on 17-19 January, and the last one on 21-22 January. This period has been selected, because no major sudden stratospheric warming (SSW) occurred during this month and as many scientists noted this winter is an example of a background reference case corresponding to a 'normal' year. Therefore, the observed ionospheric response to the considered geomagnetic storms could be attributed mainly to the external forcing. The reaction is explored by considering N(h) profiles registered by manually scaled ionosonde measurements at station Sofia (42.5^0N, 25^0E), which are used for calculating the total electron content (TEC) up to the F2-layer maximum (bottom-side TEC). The entire TEC data are provided by the Center for Orbit Determination of Europe (CODE)-Bern, for the nearest point to Sofia. The basic aim of this work is to compare in detail the temporal variability of the entire TEC with bought that below and up (top-side TEC) the F2- layer maximum for each of the considered geomagnetic storms. It is found that for all investigated geomagnetic storms in January 2005 the bottom-side TEC is considerably different from bought top-side and entire TEC. An explanation of the main mechanisms responsible for the observed difference has been proposed.

Long-term Variations of the Galactic Cosmic Rays Dose Rates

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The paper presents the long-term galactic cosmic rays (GCR) dose rates variations, observed experimentally by 13 Bulgarian build (Liulin type) spectrometers-dosimeters, which worked in the Earth and interplanetary radiation environment between 1991 and 2019. In March 2019, two of the instruments are still operable: Liulin-MO is on the ESA-Roscosmos ExoMars-TGO in 400 km circular orbit around Mars and Liulin-Ten-Koh on the Japanese satellite Ten-Koh at about 620 km orbit around Earth (http://kit-okuyama-lab.com/en/ten-koh/). The existing Liulin type instruments GCR dose rate data, obtained at L values larger than four in low earth orbit (LEO) and during 2 flights outside the Earth magnetosphere from 1991 to 2019 are compared with the monthly values of the modulation parameter (in MV) reconstructed from the ground based cosmic ray data, using the procedure described by (Usoskin et al., 2017). Relatively good agreement between the 2 data sets is obtained.

Common Periodicities in Earth's Rotation and Geomagnetic Activity

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The link between the long-term variations of the geomagnetic field and Earth's rotation has long been accepted in general as a manifestationof the Earth's angular momentum conservation (e.g. Le Mouel et al., 1981). In the present paper we extend this concept and look for common periodicities in Earth's rotation and geomagnetic activity. Previous observations (e.g. Georgieva, 2002) pointed to a link between the two at the solar magnetic timescale. Using a reconstructed Dst time series to ~1850, we find similar oscillations as in the variation of the geomagnetic main field, at sub-centennial (60-90 years), inter-decadal (20-35 years), and decadal timescales (e.g. Demetrescu and Dobrica, 2014) and compare them with the Length Of Day (LOD) time series. The analysis is done by means of the Hodrick and Prescott (1997) type decomposition of the signal in a cyclic constituent superimposed on a trend. The trend in the geomagnetic activity can in turn be decomposed in oscillations of periods at sub-centennial (60-90 years), inter-decadal (20-35 years), and decadal timescales, which are compared to LOD oscillations in the last 150 years.

Regular Observations of the Power Cosmic Radio Sources on the Radio Telescope URAN-4. Processing Method, Results Keeping System and their Applying in Ionosphere Investigations

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From 1998 up to present time in monitoring regime the observations of power radio sources were carried out on the radio telescope URAN-4 at the two frequencies 20 and 25 MHz with using radiometers and digital registration of data. The aim of the observation program is to investigate the flux variability of four cosmic radio sources 3C144, 3C274, 3C405, 3C461. In general this variability associated with ionosphere influence on propagating radio waves. Thus our observations are the radio astronomy method of ionosphere sounding. Measurements of the fluxes were consisted in that several passing of each radio source through radio telescope direction pattern for several hour angles were observed near culmination time during one day. During observation interval hundreds of thousands of radio sources records were accumulated. To process such volume of data the procedure was developed and computer program was composed which was allowed to obtain characteristic parameters for each record. In this report information about real observation intervals and quality of the observation material is presented. The procedure of processing of original observations, getting of flux densities and parameters of ionosphere scintillations and the organization of results keeping are discussed. Data applying in ionosphere investigations are cited as an example.

Supersubstorms, High-latitude Substorms and Space Weather Conditions

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The aim of our work is to study a possible influence of the solar wind large-scale structure on the substorm appearance. The substorms have been studied basing on the data obtained from SuperMAG and IMAGE networks. Three types of substorms have been considered: two types of the substorms observed at the geomagnetic latitudes higher ~ 70 CGCLat (`polar` and `expanded` substorms) and the supersubstorms (substorms with SML index < - 2500 nT). Different solar wind types were determined by OMNI data base and the catalog of the large-scale solar wind phenomena (ftp://ftp.iki.rssi.ru/omni/). Six based solar wind types were considered: the high speed streams from coronal holes (FAST); the interplanetary manifestations of coronal mass ejections: the magnetic clouds (MC) or EJECTA; the regions of compressed plasma before these streams - CIR and SHEATH; the slow solar wind (SLOW) streams. It is shown that the distribution of these 3 types of substorms on the different solar wind streams is almost opposite. `Expanded` substorms are observed during FAST streams, in plasma compression regions (CIR and SHEATH) and sometimes during EJECTA observed against the background of FAST streams. `Polar` substorms are observed during SLOW streams and EJECTA that occur against the background of a slow stream and sometimes at the end or the beginning of a FAST. Supersubstorms (SSS) were associated with SHEATH, MC, EJECTA and they almost did not observe during FAST and SLOW streams. Thus, the impact of the different solar wind large-scale structure controls the ground-based substorm type appearance

Space Weather Events on Three Storms: Auroral, Geomagnetic and Ionospheric Disturbances

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Satellite-borne and ground-based observations of the geomagnetic disturbances and ionospheric electron density distribution were considered during three events on September 07, 2017, on March 17, 2013 and on March 17, 2015. The first event includes two several geomagnetic storms on 7 and 8 September 2017, which associated with two consecutive solar wind structures: SHEATH with EJECTA and SHEATH with magnetic cloud (MC). The second event is the period on 17-18 March 2013 when several geomagnetic storms (the Dst index ~ -140 nT) was registered. The third event covers the interval of 15-23 March 2015, when strong geomagnetic storm (Dst dropped as strong as -228 nT) was developed. Solar wind parameters were taken from OMNI data base. The magnetograms of the IMAGE network, empirical model of auroral precipitation and observations of the Multiscale Aurora Imaging Network (MAIN) in Apatity were used as indicator of auroral activity. We used also AMPERE currents for indication of field-aligned currents location during storm. These severe geomagnetic storms led to complex effects on the ionosphere. We consider major features of the positive and negative ionospheric storms development at European mid- and high-latitudes.

Occurrence of TEC Fluctuations and GPS Positioning Errors over Europe during November 2018 Geomagnetic Disturbance

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This report discusses effects of the November 2018 event consisted of a moderate geomagnetic storm on 4-5 November (sum of Kp ~32) and a minor disturbance on 9 November (sum of Kp ~16). The study focuses on the ionospheric irregularities occurrence for 4 and 9 November. Despite a weakness of the disturbances, this event caused severe disturbances for Global Navigation Satellite Systems (GNSS)-based positioning services at high latitudes. We analyzed similarities and differences of occurrence TEC fluctuations and positioning errors for the two events. The analysis was based on GPS/GNSS observations from European stations located in auroral and subauroral zones. As a measure of the phase fluctuation activity, we use the rate of TEC (ROT) and intensity fluctuations evaluated by index ROTI. The intensity of the phase fluctuations depends essentially on longitude and it decreases equatorward. In both cases, the maximal intensity of fluctuations was observed over auroral stations and closer to local midnight. We also analyzed an impact of the geomagnetic disturbances on the Precise Point Positioning (PPP) errors. The positioning errors were determined with a 5 temporal interval using the GIPSY-OASIS software (APS-NASA). The positioning errors were found to be quite different from site to site. We found rather good similarities between intensity of the fluctuations and positioning errors. The errors occurred as short-time, segregate, and splash-like increases. The storm-time 3D position error can exceed 10m during auroral activity.

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Long-term Trends in the Ionosphere and its Relevance to Space Weather

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The Earth ionosphere presents long-term trends that have been of interest since a pioneering study in 1989 suggesting that long-term increase of greenhouse gases concentration due to anthropogenic activity would produce a global cooling in the upper atmosphere in conjunction with the global warming in the troposphere. Since then, investigation of long-term changes in the upper atmosphere, and particularly in the ionosphere, has become a significant topic in global change research. Even though anthropogenic forcing seems to be the main trend driver until now, there are also other ionospheric long-term change forcings of natural origin. Among them is the secular variation of Earth magnetic field, which affects not only electron density, but currents flowing in the ionosphere and magnetosphere, ionospheric conductivity, and radio wave propagation as well. The ionosphere, as a part of the space weather environment, plays a crucial role through the modulation of the global electrodynamic circuit, its coupling to the magnetosphere and as a key medium for communication, sounding and navigation. Certainly it could be said that space weather cannot be fully understood without reference to the ionosphere. Thus, a thorough understanding of its variability in all time scales becomes crucial. In this work, ionospheric trends are analyzed linked to their relevance for space weather. These trends, although weak, are steady and may become significant in the future and of importance for long-term space weather forecasts. Understanding them will certainly shed light on the physics of several ionospheric processes essential for space weather comprehension.

Dayside Polar Magnetic Bays under Different Interplanetary Magnetic Field Directions

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We study magnetic bay-like disturbances occurred in the dayside sector of the high geomagnetic latitudes (> 70^0S Mlat) under the positive (northward) and negative (southward) IMF Bz. It is known that as a rule, dayside polar magnetic bays are observed under the positive Bz component of IMF in the absence of the night-side auroral activity. In our previous works, we showed that the bay sign is controlled by the IMF By sign. We suppose that these bays could be caused by the enhancement of the so-called NBZ-system of the Field Aligned Currents. However, unlikely to that, we found that the dayside polar magnetic bays should be observed during the negative IMF Bz as well. In this case, the dayside bays occur simultaneously with strong night-side substorms. The IMF By sign does not control the sign of these bays. We suppose that this non-typical phenomenon was caused by the development of the global complicated system of the substorm ionospheric currents when the westward electrojet expands into the dayside sector. As the examples, we present several events from the ground-based Scandinavian IMAGE magnetometer chain, Intermagnet and SuperMAG data collections.

Global High-latitude Geomagnetic Disturbances in the Minimum of the Solar Activity: Magnetic Storm on 22 July 2009

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The 22 July 2009 magnetic storm was one of the strongest magnetic storms in the deep minimum of the solar cycle 23. In the storm main phase, when the SymH value reached almost -100 nT, the IMF became northward, and the storm recovery phase started. Two hours later, the IMF turned southward, that caused the beginning of the second step of this magnetic storm. Near the maximum of second stage, the strong IMF irregularity appeared: the IMF By abrupt changed from positive to negative, and simultaneously the IMF Bz changed from negative to positive. To study geomagnetic effects of the IMF change, we analyzed ground-based data from Scandinavian IMAGE magnetometer chain and SuperMAG global set. We found that at the same time with this change, the strong dayside magnetic bay was recorded globally, i.e. simultaneously at the day-, morning- and night-sides. Generally, such polar dayside magnetic bays are local and are observed during times of IMF $Bz > 0$ in the absent of the night-side substorm activity. However, unlikely to that, considered magnetic bay was observed during IMF $Bz < 0$ globally. We suppose that this non-typical phenomenon was caused by the development of the global complicated system of the ionospheric currents as a response to the abrupt IMF change.

Development of Different Latitude Substorms during Large Magnetic Storms

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The substorm activity at different latitudes during large magnetic storms was studied. The substorms during the main phase of two magnetic storms: on 17 March 2013 and 7 September 2017 have been examined. Data of INTERMAGNET and IMAGE magnetometer networks and OMNI data base have been used to trace the magnetic substorm development and the attending interplanetary conditions. The behavior of the westward electrojet has been studied. The conditions of substorm manifestation at high latitudes have been discussed. The magnetic substorms were observed also at middle latitudes as positive magnetic bays. The peculiarities of the substorms and their display at mid-latitudes have been analysed.

Anomalous TEC Disturbances of the South American Ionosphere before and After the Main Shocks of Some Powerful Chilean Earthquakes

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The analysis results of the large-scale space-time disturbances of the total electron content (TEC) of the South American ionosphere before and after the powerful Chilean earthquakes on February 27, 2010 (M=8.8), April 1, 2014 (M=8.2) and after the main shock of the Chilean earthquake on September 16, 2015 (M=8.3), according to GPS network station data, are presented.

It is studied the development in the quiet geomagnetic conditions of the anomalous in the daily courses of TEC values during the periods 18-27.02.2010 and 28.02-09.03.2010; 25.03-01.04.2014 and 02.04-09.04.2014; 17-26.09.2015, characterized by high foreshock and aftershock activity, with respect to the median levels during these periods (values of δTEC, %, the time interval is 2 hours) in the longitudes 45º÷105ºW (Δλ=15º) and in the latitudes 0º÷60ºS (Δφ=5º).

Estimates of the characteristics of TEC disturbances (δTEC, %, spatial dimensions of ionosphere regions with anomalous TEC disturbances, duration of the disturbances in daily TEC courses) for the considered periods are presented. It is shown that the anomalous disturbances of TEC ($|\delta TEC| \geq 30\%$) in the extended regions of the ionosphere took place both before the main shocks of these Chilean earthquakes and after them independently.

The characteristic patterns in the development of positive and negative large-scale TEC disturbances during these periods are discussed.

Strong Magnetic Storm on 25-26 August 2018 with Reference to the Solar Cycle 24 Declining

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It is well known that the CIR (Corotating Interaction Region) driven magnetic storms are typical ones for a solar cycle declining but the CME (Coronal Mass Ejection) driven storms mostly appear during the solar cycle maximum. The CMEs rare occur during the solar cycle declining because they are associated with flares or filament eruptions, both of which are relatively rare in the low part of the cycle. However, in the Sun's downward cycle 24, all strong magnetic storms (e.g., in March, June and December 2015, May and September 2017) were caused by CMEs. The strong magnetic storm on 25-26 August 2018 (Dst = -171 nT) was the last storm of this series. In this case, the CME was associated with a filament eruption on 20 August under the very low solar wind speed. Here we considered the geomagnetic effects of this last magnetic storm. The specific behavior of dayside high-latitudes geomagnetic disturbances and the Pc1 and Pc5 pulsations is discussed in association with the Interplanetary Magnetic Field and solar wind dynamic pressure variations. The strongest dayside high-latitudes disturbances and pulsations are observed in the storm initial and recovery phases. The solar cycle 24 continues to produce surprises. The cycle has not yet reached a minimum. Will be new magnetic storms or not?

Automatic MSTID Detection Based on Doppler System

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The Institute of Atmospheric Physics CAS in Prague is running four ionospheric Doppler sounders (western Czechia, northern Taiwan, southernmost South Africa and northwestern Argentina). The key Doppler sounder in western Czechia consists from three measuring paths with a central receiver in Prague and utilizes simultaneously three different frequencies, i.e. different reflection heights to get quasi-3-D pattern.

The TID detection method has been developed and we obtained various statistical results on behavior of gravity waves. Then, method of automatic TID detection to allow 24/7 monitoring was developed and tested. Automatic detection of TIDs allows to give real-time alarms and/or analyze origin of some problems in GNSS signals. The product is distributed via internet to a data center or directly to users.

We will demonstrate automatic detection and monitoring of TIDs based on ionospheric Doppler sounding, particularly shorter-period TIDs.

Long-term Trends in the Ionosphere and Thermosphere

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The anthropogenic emissions of greenhouse gases affect not only the weather and climate in the troposphere; they affect also the upper atmosphere (thermosphere and ionosphere). However, there are also other drivers of long-term changes and trends in the upper atmosphere, namely secular change of the Earth's magnetic field, long-term changes of geomagnetic and solar activity, and long-term changes of atmospheric wave activity. The state-of-the-art of knowledge and understanding of long term trends in the upper atmosphere will briefly be presented for parameters like foF2, hmF2, foE, ion and electron temperature, neutral density and neutral temperature.

Auroral VLF Hiss as a Signature of the Growth Phase of the Magnetic Substorm

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Auroral hiss is a well-known evening-nighttime natural VLF emission with a noise-like structure and the strongest intensity at the frequencies of 8-11 kHz. These VLF emissions are generated by the Cherenkov radiation above the ionosphere. The analysis of auroral hiss observed at Kannuslehto (KAN, MLAT = 64.2^0) in Finland has been performed. This receiver is located in the equatorial area of the auroral oval. During the 11 winter months in 2015-2018, there were found 207 days with the auroral hiss bursts. It was established that the majority (82%) of the auroral hiss bursts at KAN was observed during the substorm growth phase. When weather conditions allowed, the auroral hiss bursts were found to be accompanied by the equatorward movement of the auroral arcs recorded poleward of KAN. The auroral breakup (substorm onset) abruptly suppressed auroral hiss. We found that the auroral hiss occurrence is controlled by the dynamics of the Field Aligned Currents (FACs) estimated from the AMPERE facility consisted of the 66 globally distributed telecommunication satellites carrying engineering magnetometers. It was revealed that auroral hiss at the equatorial area of the auroral oval exhibits a typical signature of the substorm growth phase.

Effects of the Hemispheric Solar Cycles on the IMF and Geomagnetic Fields

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One of the well-known phenomena of the solar dynamo is the hemispheric asymmetry of the solar cycles. This means that the magnetic activities of the two hemispheres are different on middle and long timescales. The interplanetary magnetic field (IMF) formed by the outward solar wind. Thus, I looked for the effect of previously observed solar hemispheric 4 + 4 cycles (Muraközy & Ludmány, 2012, MNRAS) on different geomagnetic and IMF data bases. As a result of this study, it can be pointed out that the variations of the geomagnetic data sets are more similar to the rate of the solar hemispheric magnetic differences than the shape of the solar cycle.

Ground-Based Auroral Hiss: Wave Direction Finding

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It is known that auroral hiss emission is generated at the altitude of about 10000 - 25000 km as a result of the Cherenkov radiation of precipitating soft electrons. Electromagnetic waves propagate from the generation region to the ground at frequencies between the lower hybrid frequency and electron gyrofrequency. Ground-based observations of the auroral hiss are typically accompanied by visible aurora. The ground-based observations of the auroral hiss at two points located closely to each other′s at high geomagnetic latitudes and spaced in longitude by 400 km: Kannuslehto (Finland) and Lovozero (Russia) have been made simultaneously. Both stations are equipped with the wave direction finding system. Some experimental results of these observations will be shown. We proposed a new approach to estimate the arrival angles of the auroral hiss observed on the ground. It is shown that the ionospheric exit region of auroral hiss is located southward of the visible aurora. To explain the observed results, we applied the full-wave analysis to model the auroral hiss propagation from the generation region through the ionosphere to the ground. The model results agree with the observation results. These new results will be presented.

Pitch-angle Diffusion of Energetic Protons upon their Interaction with EMIC Waves: Comparison of Calculation Results with Satellite Data

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We analyze several cases of spacecraft observations of EMIC waves in proton and helium frequency bands in various local time sectors and L shells. We selected the events during which the energetic proton precipitation was observed by low-orbiting POES spacecraft in the conjugated region. By using the data on the spectral intensity of EMIC waves, the geomagnetic field, and the plasma density we calculated the pitch-angle diffusion coefficients of energetic protons for various energies and pitch-angles. The calculations were performed under the assumption that the ambient plasma consisted of three ion species, i.e., protons, He+, and O+ ions. The results of calculations were compared with the measured pitch-angle distributions of energetic protons in the magnetosphere and with the energy of precipitated protons. On the whole, these parameters of energetic protons are in agreement with those which can be expected on the basis of the calculated pitch-angle diffusion coefficients.

Solar Activity and Lunar Tides as Sources of Space Weather and their Combined Effect on the Earth`s Ionosphere and Atmosphere.

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Traditional meaning 'space weather' as effects of display of solar and geomagnetical activity is insufficient. Lunar inflows in the upper Earth`s atmosphere also are an essential part of 'space weather'.Observational results on a radio telescope "URAN-4" IRA NANU are the experimental to confirm this statement. Since 1987 and till the present time the program of flux monitoring of powerful galactic and extra-galactic radio sources on this telescope is carried out.Changes of a radio source flux at the time of distribution of their radiation through an ionosphere of the Earth are related to variations ultraviolet and a X-rays and corpuscular streams in a cycle of solar activity. Observational results on a radiotelescope "URAN-4" were detected 'plasma lensing' of emission of cosmic radio sources at their observation through a lunar tidal wave. Data of these observations show great spatial scales of the tidal waves in an ionosphere of the Earth. Submitted observations on the RT "URAN-4" demonstrate effects manifestation of Lunar tides, depending on the relative position of radio sources and the Moon.

Evolution of Occurrence Rate and Intensity of Energetic Proton Precipitation Related to the Ion-cyclotron Instability in Dependence on Geomagnetic Activity

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Using NOAA POES observations of energetic protons, we investigated statistical properties of localized precipitation of energetic protons (LPEP) equatorward of the isotropy boundary. More than 41000 crossings of the sub-auroral region covering all MLTs were analyzed. The global distribution of the LPEP occurrence rate was constructed. The maximum of the occurrence was found in the day-afternoon sector at L>6-7. The distribution is very similar to that obtained for EMIC waves on the basis of data of different spacecraft missions. This similarity statistically confirms the suggestion that LPEP as the result of the ion-cyclotron instability (ICI) in the magnetosphere. The global distribution of the proton flux intensity is investigated as well. The precipitating flux maximizes at L=4-5, that is not coincide with the occurrence rate maximum. The large statistics enabled us to investigate the dependence of the LPEL occurrence and intensity on the geomagnetic activity indices, magnetic storm phases, and solar wind parameters. The obtained dependencies demonstrate some new features of the ICI development under different conditions. In particular, the decrease of the LPEP maximal occurrence rate on the dayside under highest level of geomagnetic activity was noted. We explain this fact by flattening of the night side radial gradient of proton flux during strong disturbances and its effect on the transverse anisotropy of protons on the day side.

The Response of TEC to Solar Flare on 6 September 2017

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In this paper the response of TEC over Europe to large solar flares of X class (X9.3) on 6 September 2017 are presented. According to GOES, this flare started at 11:53 UT and had its peak of intensity at 12:02 UT. Solar flare effects in TEC were carried out for sun light ionosphere using IGS and EPN GPS networks. The stations are grouped around latitude of 50˚N and ranging from ~85˚W to ~100˚E. A solar zenith angle varies from 37˚ to 90˚. Direct response of TEC to solar flare can be obtained from TEC variations along satellite passes over individual stations. Sudden enhancement started ~10:55 UT. The peak of TEC enhancements is delayed about only 2-3 min relative to peak X-ray intensity. Maximal effect reached of ~2.5 TECU at solar zenith. A percentage TEC enhancement was about 20. We found out significant linear correlation between TEC enhancement and solar zenith angle. Spatial and temporal changes of TEC during solar flare we examine using TEC maps over Europe. Maximal time resolution of these maps were 5 min. The maps demonstrate sudden TEC enhancement after 12 UT over whole Europe. The larger enhancement took place at lower latitude. The recovery stage lasted more than 1-2 hour. We formed also differential maps between 5 and 6 September 2017. Five minutes differential TEC maps shows essential dynamics of TEC response to solar flare.

This investigation was supported by RFBR Grants 19-05-00570/19 and partly Program # 28 of the Presidium of RAS.

Study of Flux Variability of Radio Source Taurus a when Observing Passage through Solar Supercorona in Decimeter Wave Range

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Supernovae remnant Taurus A (Crab Nebula (3C 144)) consists from point object - pulsar and surrounding shell - plerion. On basis of flux variability observations of this radio source during its annual passage near the Sun on June 15, existence of the Sun`s supercorona - the solar wind, was determined. When such observations are usually used observations in meter wave range. The proposed program for observing variability of Taurus A flux at frequency 1.6 GHz (decimeter range) aims to detect changes in flux of point radio source and plerion, as well as determine nature of influence plasma fluxes in the solar wind as source approaches the Sun.

Observation program on RT-32 radio telescope of the Ventspils International Radio Astronomy Center (VIRAC) started in April 2019. At same time, observations of source on various elongations with respect to the Sun are planned during whole 2019. Tested method of observation consists in recording radio source as it passes through antenna`s beam and long tracking mode on source. Radio galaxies 3C 405 (Cygnus A) or 3C 274 (Virgo A) were used as reference radio sources.

Based on obtained results, next stage of observation program will be formed, ensuring most effective identification causes in flux variability of radio source 3C 144.

Work is performed within the project: Investigation of intra-day and inter-day variability of various types of extragalactic radio sources using telescopes of the Ventspils International Radio Astronomy Centre (RISE). Project no.: 1.1.1.2/VIAA/2/18/363

Relationship between Impulses in the Solar Wind Dynamic Pressure (*PSW*) and Magnetic Activity (*PC* and *AL* Indices)

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The solar wind dynamic pressure (*PSW*) impulses impacting on the magnetosphere were selected basing on the solar wind parameters measured in the Lagrange point L1 in 1998-2017. Comparison of the `estimated` *PSW* impulses reduced to the Earth`s magnetopause with the appropriate sudden impulses (SI), revealed in the ground-based 1-min *SymH* index, showed that features of the really observed sudden impulses (moment of beginning, time evolution, intensity) can be significantly different from characteristics of the estimated *PSW* impulses. Because of this the preference was given to the real SI events over the estimated *PSW* impulses.

Relationships between the positive (leaps) and negative (drops) SI events, on the one hand, and *PC* and *AL* indices, on the other hand, were examined under the various solar wind conditions, such as: growing and steady solar wind speed at negative and positive values of the IMF BZ component, fluctuating BZ and solar wind speed, steady solar wind speed and BZ=0. Analysis of SI events showed that the solar wind dynamic pressure impulses themselves are not promote (or insignificantly promote) the solar wind energy input into the magnetosphere, which is controlled by the interplanetary electric field *EKL* and is displayed by the polar cap magnetic activity PC index. When the *PSW* impulses (leaps or drops) are accompanied by the corresponding changes in *EKL* field, the PC index correlates (increases or decreases) with the *PSW* changes. Inconsistency between the *PSW* and PC behavior becomes evident as soon as the *EKL* and *PSW* courses start to diverge.

PC Index as a Verifier of the Interplanetary Electric Field *EKL* Coupling with the Magnetosphere

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Statistical relationships between *PC* and *EKL* demonstrate that time evolution of the PC index is generally controlled by variations of *EKL* field, which is estimated by the solar wind parameters fixed in the Lagrange point L1, far upstream of the Earth`s magnetosphere. Usually the *EKL* rise is followed by the *PC* growth with delay time ΔT~12-20 min. The *PC* index growth in turn determines development of magnetospheric storms and substorms.

The analysis of relationships between the `estimated` *EKL* field and *PC* index in course of isolated substorms in period of 1998-2017 showed, however, that correlation between *EKL* and PC breaks down in ~20% of events, in spite of fact that substorm onset was evidently related to the preceding *PC* growth. It implies that `estimated` *EKL* field did not come into contact with the magnetosphere in course of these events and, therefore, the solar wind, fixed in the Lagrange point, was not consistent with real solar wind coupling with the magnetosphere. In ~1.5% of substorm events the negative delay time (ΔT<0) was observed (when the actual contact of *EKL* field with magnetosphere occurred ahead of the `estimated` contact) giving evidence that real solar wind was propagated with acceleration on the way from the Lagrange point to the Earth`s magnetopause. Thus, the *PC* index makes it possible to validate the actual interplanetary electric field *EKL* coupling with the magnetosphere, and verify, in such manner, whether or not the solar wind, whose parameters are presented in the OMNI dataset, really encountered the magnetosphere.

Specific Role of Sheaths in Generation of Magnetic Storms

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On the basis of OMNI measurements of plasma and magnetic field parameters in the solar-wind (SW) and our catalog of large-scale SW phenomena for 1976-2017 (see site ftp://ftp.iki.rssi.ru/pub/omni/ and paper by Yermolaev et al., 2009), we study the impacts of interplanetary drivers on the magnetosphere: corotating interaction regions (CIRs), interplanetary coronal mass ejections (ICMEs, including both magnetic clouds (MCs) and ejecta), and sheaths as well as interplanetary shocks (ISs). Our statistical analysis shows that, in the Sheath + ICME sequences, the largest number of storm onsets fell on the Sheath, and the largest number of storms maxima fell at the end of the Sheath and the beginning of the ICME. The fact may be connected with two reasons. (1) The value of interplanetary magnetic field B in Sheaths before Ejecta is higher than B in Ejecta; and the value B in Sheaths before MCs in the beginning of phenomena interval is lower than in MCs but in the end of interval it is close to B in MCs. (2) The efficiency of magnetic storm generation (defined as relation of `output` (Dst index) to `input` (integral of electric field Ey) is 50% higher for Sheath than for ICME. The Sheath-induced storms should be identified and analyzed separately during investigation of magnetosphere reaction on the complex interplanetary drivers as `shock/sheath/ICME`. The work was in part supported by the Russian Foundation for Basic Research, grant 19-02-00177a.

Solar Influences on the Lower Atmosphere and Climate

ENSO Variations Due to Solar Activity, Expressed by N-S Solar Asymmetry

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The solar activity cycles affect all surface geosystems, including weather and climate indices, winds, rains, snow covers, mean sea level, river streamflows and other hydrological cycles. These processes are due mainly to the Total Solar Irradiance TSI variations, followed by weather and climate changes. Recently a new mechanism of climate modulation, based on cosmic rays variations, has been discovered. This mechanism explains chain processes arising from Cosmic Rays CR modulation by the heliosphere and geomagnetic field, followed by ozone production in near tropopause and water content change. The atmospheric water is the most powerful greenhouse gas and its changes produce significant variations of the temperature. The CR modulation by heliosphere depends on solar wind and solar magnetic field variations. The North-South N-S solar asymmetry is a solar index, whose variations are connected with the solar magnetic field oscillations. The shapes of decadal and centennial solar cycles are rather different from sinusoidal form, and this is the reason to generate a lot of interannual and decadal harmonics. These harmonics are visible as common cycles with periods 1-9, 12-19 and 23-33 years in various time series of Earth phenomena like mean sea level, climate and etc. The decadal and interannual cycles of N-S solar asymmetry strongly correlate with the corresponding cycles of El Nino/Southern Oscillation ENSO. The common interannual and decadal cycles of ENSO and solar activity are separated in selected frequency bands by the Method of Partial Fourier Approximation.

Water Transport and Earth Rotation Variations Due to Solar Cycles

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The solar activity affects wide range of surface processes over Earth, including weather and climate indices, winds, rains, snow covers, and mean sea level. These processes are due mainly to the Total Solar Irradiance TSI variations, followed by weather and climate changes. The ocean surface absorbs more thermal energy during solar maxima. This increases evaporation processes, atmospheric water content, clouds and rains. Some part atmospheric water is transported globally from ocean to polar regions by circulation in Hadley, Ferrel, and polar atmospheric cells. The water transfer to polar regions leads to polar ice thickness increase, synchronously with the solar cycles. This, together with the Mean Sea Level MSL decrease, changes the Earth shape and the corresponding principal moments of inertia. As the consequence, the Earth rotation is faster during the solar maxima, according to the low of angular moment conservation. The models of Universal Time UT1 and Length of Day LOD oscillations due to TSI and MSL variations are created. Common UT1, LOD, TSI and MSL cycles from selected frequency bands with interannual and decadal periodicity are presented.

The Effects of Meteorological Events and Geomagnetic Storms on Aviation and Space Flights

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Today, with the rapidly developing technology, studies and researches are carried out by many military and civil organizations to minimize the risk of accidents that depends on the factors such as human factors, technical reasons and weather conditions. Particularly in long flights, the jets and airplanes that exceed the velocity of sound flying at the top of the troposphere and the lower levels of the stratosphere are usually affected by the active weather events during the departure, climbing, approaching and descending phases. Aeronautical meteorology is a branch of meteorology that deals with aviation and covers the meteorological phenomena and parameters affecting flight activities. The meteorological events will affect all the aircraft in the atmosphere in different ways. Apart from these effects, the radiation from the space has an effect on flights as well. In this study, we conducted a statistical study of aircraft crash reports between 1920-2018. We made a separate classification of those accidents oriented from the meteorological origin. Finally, we investigated which of these meteorological accidents are related to geomagnetic storms. Since there is no such study in the literature, it is of particular importance. In the first stage, our study group has consisted of Assoc. Prof. Rositsa Miteva and the students of the Air Force Academy.

Impact of Meteorological Storm Fabienne on 23 September 2018 on Ionospheric Variability

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Severe meteorological storm system on the frontal border of cyclone Fabienne passing above Central Europe was observed on 23-24 September 2018. Large meteorological systems are considered to be important sources of the wave-like variability visible/detectable through the atmosphere and even up to ionosphere heights. Meteorological Storm event coincides with minor-moderate geomagnetic storm observed in the ionosphere. Concentration in the ionosphere decreased for two day (negative storm) represented by TEC drop of about 1.5 TECu. Significant departures from regular courses of atmospheric and ionospheric parameters were detected in all analyzed data sets through atmospheric heights. Above Europe, stratospheric temperature and wind significantly changed in coincidence with fast frontal transition. Zonal wind at 1 and 0.1 hPa changes from usual westward before storm to eastward after storm. With this changes are connected changes in temperature where at 1 hPa analyzed area is colder and at 0.1 hPa warmer. Within ionospheric parameters, we have detected significant wave-like activity occurring shortly after the cold front crossed the observational point. During the storm event, both by Digisonde DPS-4D and Continuous Doppler Sounding equipment, we have observed strong horizontal plasma flow shears and time-limited increase plasma flow in both North and West components of ionospheric drift. Vertical component of plasma flow during the storm event is smaller with respect to corresponding values on preceding days.

Collection and Analysis of Data on Atmospheric Temperature Changes Measured with an Automatic Weather Station

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For 8 years, atmospheric temperature data has been measured and collected using the meteorological station Vantage Pro 2 Plus. It is designed to directly monitor atmosphere meteorological parameters such as temperature, relative humidity, barometric pressure, rainfall, wind speed and wind direction. Additionally the solar radiation in the visible spectral range and in the ultraviolet is measured. In addition to the directly measured meteorological parameters, other characteristics of the atmosphere and the sun can be calculated and examined. For example, by integrating solar radiation data, solar energy can be determined for a certain period of time from a single area of the earths surface. For other characteristics of the atmosphere special software is provided that calculates the dew point, heat index, a rainfall coefficient, as well as about thirty other parameters.

Observations Supporting Hypothesis for Global Electrical Circuit as Mediator between Solar Events and Weather

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Recent studies demonstrate that solar events (such as SEP, Forbush events, etc.) can affect weather on the earth, for example, by influencing the atmospheric circulation, although the actual mechanisms are not well understood yet. The global atmospheric electric circuit has been suggested for long as a possible mediator implementing the considered links. This hypothesis suggests that variations in the density Jz of the electric current of the order of few pA per square meter which flows from the ionosphere to ground in fair-weather regions can influence atmospheric processes at the level of clouds. Here several experiments are considered which include measurements of the current Jz during different solar proton events. In order to obtain relatively thorough picture of the response of Jz to solar proton events, experiments performed at different (auroral, middle and low) latitudes, and at ground level (for variety of latitudes), as well as in the stratosphere (for auroral and high latitudes) are included. The initial analysis of the included experimental data supports the hypothesis that the global atmospheric electric circuit can play a role of mediator between solar proton events and formation of weather.

Manifestation and Possible Reasons for Temporal Variability of Solar Activity Influences on the Lower Atmosphere

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In this work we continue studying temporal variability of solar activity influences of the lower atmosphere and its possible reasons. It was shown that about 60-year oscillations in correlation links between troposphere pressure at extratropical latitudes (the development of extratropical baric systems) and sunspot numbers depend of the large-scale circulation regime which, in turn, is closely related to the strength of the stratospheric polar vortex. The reversals of the correlation sign were found to coincide with turning points in the evolution of the large-scale circulation forms according to the Vangengeim-Girs classification, these points accompanying transitions between strong and weak states of the vortex at the multidecadal time scale. It was shown that the vortex intensity is characterized by a roughly 60-year periodicity which may be due to long-term changes of total solar irradiance and geomagnetic activity.

Long-term Variability of Occurrence Frequencies of Magnetic Storms with Sudden and Gradual Commencements

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Long-term variations in annual frequencies of occurrence of magnetic storms with sudden and gradual commencements were studied on the base of the data from IZMIRAN and Slutsk (Pavlovsk) magnetic observatories for the period 1878-2015. It was found that occurrences of large and moderate magnetic storms with gradual commencements are characterized by a pronounced variability at the multidecadal time scale. Their wavelet spectra reveal dominant periodicities of about 36 years (the Bruckner cycle), as well as less pronounced 60-year and 90-year ones on the entire time interval under study. The occurrences of large, moderate and small magnetic storms with sudden commencements are characterized by strong 11-year periodicities, whereas long-term variations are substantially weaker. The obtained results provide evidence for a different temporal evolution of local and global solar magnetic fields responsible for solar agents (CMEs and high-speed solar wind streams from coronal holes) contributing to the development of these types of magnetic storms.

Sun Photometer Observations of Atmospheric Aerosol near Saint Petersburg.

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Atmospheric aerosols affect Earth`s climate in multiple ways. This overall effect of aerosols on the system earth - atmosphere is usually quantified in terms of aerosol radiative forcing (RF). The estimation of aerosol RF relies on the knowledge of aerosol optical, microphysical and radiative properties. Here were analyzed the measurements of sun photometer Cimel, carried out near Saint-Petersburg in 2013-2017 within the international monitoring AERONET (AErosol RObotic NETwork) network. The registered direct and scattered solar radiation provide information to calculate typical aerosol optical characteristics - the aerosol optical depth, Angstrom exponent and single scattering albedo. The magnitude of their variations was defined. Some regularities of aerosol parameters observed over the North-West region of Russian Federation are revealed. The study is extended by the joint analysis of data from the nearby AERONET observation sites in Finland and Estonia, along with the data of satellite measurements and MERRA reanalysis data. This work was supported by the Research Park of St. Petersburg State University in the use of the equipment of `Center for Geo-Environmental Research and Modeling` (GEOMODEL).

Data Proccessing and Modelling

Comparision of Liulin-MO Dosimeter Radiation Measurements during ExoMars 2016 TGO Mars a Circular Orbit with Dose Estimations Based on Galactic Cosmic Ray Models

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This presentation continues a series of publications devoted to the analysis of the results obtained with the Lyulin-MO dosimeter, which is part of the FREND device, on board the ExoMars 2016 TGO interplanetary probe. From April 2018 to the present, the spacecraft operates in a circular orbit around Mars at an altitude of about 400 km., There are presented the results of a comparison of the measurements obtained with the Lyulin-MO dosimeter for this period of time with calculated estimates based on the galactic cosmic rays model. The effect of `shading` the particles flux by Mars, the albedo particles effect on the measured values and the effect of the detectors orientation are taken into account. Satisfactory agreement between measured values of radiation dose rate and calculated values is shown., These results are important for manned mission to Mars radiation risk estimations.

The Nitric Oxide Density in the Polar Region from Ground-based Photometer Data

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The effect of the nitric oxide NO on the 5577A emission intensity during electron polar aurora is studied. It is shown that the reaction is a significant channel of the 5577A intensity suppression. This reaction reduces the contribution of dissociative recombination in the O(1S) excitation . The approach of evaluation of nitric oxygen density in the polar region using the ground based photometer data of intensity of 4278A, 5577A and 6300A emissions, is suggested based on the research. The NO density is determined using the photometer emission intensity data obtained at the Polar Geophysical Institute observatories. The NO density is between $1 \div 3.3 * 10^8$ [cm^{-3}]. It is noticed that the obtained estimations indicate the absence of correlation between the 4278 A intensity and the NO density.

The Efficiencies of O(1s) and O(1d) Excitation Mechanisms in Aurora

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Efficiencies of six O(1S) excitation mechanisms and seven O(1D) excitation mechanisms in aurora were studied using a numerical modeling with the novel time-dependent physico-chemical model of auroral atmosphere. It is shown that in interval 90-200 km the main mechanism of the 1D state excitation is electron impact on atomic and molecular oxygen. The 1S state excitation occurs mainly by electron impact on atomic oxygen and energy transfer from N2(A3).

Principle Component Analysis as a Complementary Tool in Preparing High-resolution Echelle Spectra for Cloud Model Inversion

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In solar physics models and observations produce a vast amount of data, which requires substantial computational resources. Modeling and interpretation of the chromospheric observations is a complicated task, mainly due this layer`s dynamic nature and abundance of fine structure. In the current work, we use the Cloud Model to created a database approximately 400000 Hα profiles and corresponding contrast profiles. All profiles were computed from various combinations of four basic physical parameters (optical thickness, Doppler width, line-of-sight velocity, and source function) with predefined ranges. The choice of the Cloude Model was governed by its intuitive description of complex chromospheric structures as a clouds suspended above the solar surface by magnetic fields. We apply iterative Principle Component Analysis (PCA) to reduce the dimensionality of the data base and keep only profiles, which are well represented by the first 10 eigenfunctions of the PCA decomposition. Observations in Hα were obtained in 2010 November 18-23 with the echelle spectrograph of the German Vacuum Tower Telescope (VTT) located at the Observatorio del Teide, Spain. The field-of-view include a sunspot group and a filament. Different features contained in the data provide a good testing ground for the aforementioned model. We demonstrate how the application of the PCA to the observed data leads to denoising and sorting of the contrast profiles. These results can be used to construct accurate physical maps by computing, e.g., absolute contrast, bisectors, equivalent width, etc. Furthermore, smoother profiles facilitate an improvement of the spectral line inversions later on.

The Calculation of the Intensity of the Mg I Spectral Lines in Solar Protuberances Using the Cloudy Code Model

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During the years 2014-2017 we made spectroscopical observations of several prominences in the MgI lines. These lines occurring in visible part of the solar spectrum play an important diagnostic role, complementing the UV MgII resonance lines currently regularly observed by the IRIS satellite. Our preliminary analysis of the observations shows that a rather weak MgI emission, e.g., in the 5172.6 Å line is detected, and this correlates well with the presence of extended bright areas on the solar disk that are visible in the 1600 Å SDO / AIA band (Heinzel P., et_al, 2016). However, in many cases the radiation in the 5172.6 Å line is very low, even not detectable, although a bright prominence above the limb or flare on the solar disc is observed. In order to explain satisfactorily nature of this phenomenon we have calculated several spectra of optically thin plasma with T = 5-24 000 K, N = $10^8 \div 10^{14}$ cm^{-3} using the Cloudy photoionization code (Ferland, 2017).

State Space Reconstruction for Sunspot Area Time Series

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We analyzed the sunspot area time series by means of state space reconstruction for the time period between 1875 and 2015. Low-pass filters are applied to the data for noise reduction and two different local neighborhood model, namely Simplex Projection and S-Map are employed to project state space reconstructions. Various classification schemes in the literature are then tested in these models to compare the predictive ability of multivariate and univariate time series. According to our results, multivariate time series represent the true dynamics of sunspot areas better than univariate time series, which implies more accurate predictions can be obtained if proper classification of sunspot area time series are employed and each class is predicted separately.

Analytical Approximation Investigation of Low Relativistic Electrons Resonant Acceleration in Space Plasma

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An analytical approximation model of resonant acceleration of low relativistic electrons in space plasma is examined by parallel collating of the computing results, both on the proposed model and the numerical solution of second order nonlinear nonstationary differential equations for the wave phase on the charged particle's trajectory. The calculations are performed for several initial low relativistic energies values of the electrons. Relativistic factor growth dynamics both for the analytical approximation model and the differential equations exact solutions for each chosen particle's initial energy value are presented in graphical form. The evolution of the particle's acceleration process over a time interval is discussed. The variations in electron's energy growth magnitudes obtained by both calculation patterns are analyzed. Conclusions on analytical approximation model of low relativistic electrons resonant acceleration in space plasma are made.

A Scheme to Forecast the Local UV-index over Bulgaria

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The UV-index is a measure of the erythemal effective solar radiation reaching the Earth surface. It was introduced to alert people about the need of sun protection. Therefore the UV-index has to be determined with adequate accuracy. To minimise the risk of too high levels of sunburn the UV-index is determined usually for clear sky conditions. To alert people in time the UV-index forecast is essential. Here the schemes of UV-index forecast for one day in advance are presented. Because the UV-index under clear sky conditions depends on the total ozone column over a given geographic location the UV-index forecast implicates the forecast of the total ozone column. The scheme of ozone forecast is based on satellite data. For the determination of the UV, model calculations using the radiation transfer model TUV of Madronich are implemented. The land snow cover is taken into account.

Instrumentation for space weather monitoring

Results of Ionospheric Sounding at the Akademik Vernadsky Station Using New Ionosonde

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In the Institute of Radio Astronomy of the National Academy of Sciences of Ukraine (IRA NASU) in collaboration with the Abdus Salam International Centre for Theoretical Physics (ICTP) a prototype of portable coherent digital ionosonde was developed. Currently, two prototypes have been manufactured and installed in continuous operation. One operates in Antarctica at the Ukrainian Antarctic Station (UAS) Akademik Vernadsky (65,25 S, 64,27 W) station, and the second one works at the Kharkiv region (Ukraine). A feature of this instrument consists in the use of standard programmed radio USRP as a core of hardware, which significantly reduces the cost of its manufacturing. In addition to the classical ionograms, the new prototype allows us to accumulate the information about Doppler frequency shifts and signal levels.

This paper is devoted to results of ionospheric sounding at UAS during 2017, the first year of new ionosonde operation. We propose the technique for calculating median height-time diagrams of ionospheric parameters. For our ionosonde it can be the vertical plasma velocity, signal level, and the probability of signal reflections. Those charts can be a useful tool for analyzing the background state of the ionosphere. The seasonal and diurnal variations of the ionosphere characteristics over the Antarctic Peninsula are considered using the data of old IPS-42 and the new ionosondes.

Radio Physical Determination of Neutral Temperature in D-region of the Ionosphere

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The temperature structure in the mesosphere is one of the most important characteristics of the atmosphere, determining the dynamic and photochemical processes occurring in it. In the report the method for definition of temperature in the lower ionosphere is presented. For quiet geomagnetic conditions results of observations of amplitude variations of the partial reflection radar signals (Polar Geophysical Institute, Russia, 69.0N, 35.7E) at the heights of the D-region of the ionosphere were used for determination of temperature in the mesosphere. It was found that the components of the time spectrum of the variations which corresponding to resonant frequencies of the atmosphere (the acoustic cut-off and the Brunt-Vaisala ones) in certain cases were intensified. On the basis of the theory of acoustic-gravity waves and the empirical model NRLMSISE-00 of neutral structure and temperature of the atmosphere identification of the experimental periods corresponding to the atmospheric resonances was executed and calculation of neutral temperature at the heights of the mesosphere was carried out. For the point of observations a seasonal change in neutral temperature at the height of 75 km was obtained: temperature decreases from ~ 235 K in January to ~ 210 K in April and increases from ~ 210 K in October to ~ 270 K in December.

Analysis of the First Space Radiation Data, Obtained by Liulin Ten-Koh Instrument on Japanize Ten-Koh Satellite

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On 29 October 2018 was successfully launched, at about 623 km altitude and at 98 degree inclination, the 22 kilogram mass satellite Ten-Koh (http://kit-okuyama-lab.com/en/ten-koh/), developed in Kyushu Institute of Technology by Prof. K. Okuyama, Chief Scientist of the Spacecraft. Ten-Koh`s primary science instrument is the Charged Particle Detector (CPD) developed at the Prairie View A&M University, and NASA Johnson`s Space Center of Houston, TX, USA. (https://www.pvamu.edu/raise/space-payload/charged-particle-detector-2018/). The Liulin Ten-Koh instrument is mounted on the top of the CPD. The following three primary radiation sources were expected and recognized in the data obtained with the Liulin Ten-Koh instrument: (i) globally distributed primary GCR particles and their secondary products, (ii) energetic protons in the South Atlantic Anomaly (SAA) region of the inner radiation belt (IRB); (iii) relativistic electrons and/or bremsstrahlung in the high latitudes of the Ten-Koh ISS orbit where the outer radiation belt (ORB) is situated. The obtained data is compared with data from other instruments.

Possibilities of the URAN-4 Radiotelescope as an Element of Ground-based Support of Ionospheric Satellite Missions

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The ionosphere is a complex dynamic medium that, through various physical mechanisms, is connected with the adjacent parts of the atmosphere, with a lithosphere with a geomagnetic field, with an external geospace and direct solar influence. The effectiveness of ionospheric research depends on how integrated they are both in terms of the number of measuring ionospheric parameters, and in terms of the coverage of other media and processes interacting with the ionosphere. Therefore, ionospheric satellite researches programs contain a ground-based research segments. In this work, the possibilities of using the URAN-4 radio telescope, which operates in the decameter range of radio waves, and its auxiliary systems, as part of the ground-based support of ionospheric satellite missions, are considered. Examples of monitoring of ionospheric irregularities, measuring the ionospheric absorption of the galactic noise and measuring the Doppler frequency shift of radio waves on oblique ionospheric radio path are given.

Solar Emission and Space Weather Monitoring System at Meter and Decameter Wave Ranges

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We propose and describe a system of all-day long observations of solar activity at decameter waves using the wideband sensitive low-frequency radio telescopes of new generation based on digital signal processing and properties of low-frequency wideband antenna arrays. The small test GURT subarray of 25 active antennas was used for monitoring observations of solar emissions for almost two years and proved the high perspectives of sensitive wideband antennas. We demonstrate the variety of radio emission types received during this period.

Author's List