VarSITI — Variability of the Sun and Its Terrestrial Impact

Second VarSITI General Symposium

ABSTRACTS

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Session 1: SOLAR AND HELIOSPHERIC DRIVERS OF EARTH-AFFECTING EVENTS

WAVE DYNAMICS IN UMBRAL FLASHES

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We study the spatial distribution of oscillation sources EUV emission in different temperature channels SDO/AIA above sunspot umbra. For the first time the high-resolution imaging are employed to study the wave processes in magnetic structures with different spatial and heights scales, connected with short-term energy release as an umbra flashes (UFs). We used the pixelized wavelet filtration (PWF-analysis) for obtain temporal dynamic of waves as well as prepared the space-time diagrams. It is shown that UFs sources mainly localized near the footpoints of magnetic loops along which waves propagated with 3 min periodicity. We find two types of the UFs sources - pointed and extended. The first type of sources connected with the footpoints of open field lines, the second with closed lines. Temporal dynamics of flashes shows the increasing of three-minute oscillations before UFs peak within low-frequency wave train. It is shown that the maximum oscillations trains coincide with the peak intensity of umbral flashes. Fine spatial structure of magnetic waveguides during UFs was observed. It is shown that UFs are short-term wave activity at footpoints of selected coronal loops, rooted in the sunspot umbra. We suggested that depending from the inclination angle of magnetic tubes to the solar normal there are various modes of propagating waves. This relationship defines the UFs lifetime, their power, and angular size of the sources.

A STUDY OF TROPICAL CYCLONES OVER INDIA (BAY OF BENGAL AND ARABIAN SEA) AND SOLAR INFLUENCE ON IT

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A prominent example of extreme weather event in India is cyclonic storm. In this paper annual variation of tropical cyclonic storm (CS), severe cyclonic storm (SCS), very severe cyclonic storm (VSCS) and super cyclonic storm (SuCS) over Bay of Bengal (BOB) and Arabian Sea (ARS) during last 20 years (1990–2009) have been analyzed. The analysis revels that the total number of cyclone (TNC) has increased with high rate (gradient being +1.67 per year) and although CS is more over BOB than that over ARS. The rate of increase of CS over Arabian Sea is more than that over Bay of Bengal. Furthermore, two interesting features have been noted: (i) Monsoon tends to prohibit the formation of CS; (ii) cyclonic storm (CS) increases with the increase of global sea surface temperature (GSST) during said period. Attempt has also been made to find out the influence of solar activity on these extreme weather events. Keeping in mind that the Sun Spot Number (SSN) is an indicator of the strength of solar effects, it has been

found that in most of the times the high value of SSN is associated with small number of total cyclone (CS). Specifically, when only the years of high Suns spot number (approximately greater than 90) are taken into consideration then correlation coefficient (CC) between SSN and number of cyclones comes out to be quite high (–0.78) significance at 99.99.

ON THE MECHANISM OF PARTICLE ACCELERATION IN SPACE

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The possibility of particle acceleration in space is considered in dozens of books. All these works are based on unproven assumptions that cannot be confirmed by long-term observations. The solar cosmic rays discovery and the information received from the measurements with the worldwide network of neutron monitors and with spacecraft beyond the Earth's magnetic field allow us to conclude that the solar cosmic rays are accelerated in solar flares. It is shown that the observed spectra of protons are created due to current sheet decay. These phenomena are well described by the electrodynamical solar flare model built on the basis of observational data and numerical MHD simulations using the initial and boundary conditions taken from observations of active regions before the flare. The main factor determining the formation of the solar cosmic ray pulses recorded near the Earth is the interplanetary magnetic field. The undistorted spectrum of accelerated protons arriving to Earth is observed only in the front of a proton pulse of the flares that have occurred in the western part of the solar disk. These particles come without collisions along the magnetic field lines of the Archimedes spiral. However, the distribution of protons recorded with delay has a diffusion character indicating the development of the beam instability. New information about the solar cosmic rays puts forward the important question: can the mechanism of acceleration of solar flare protons explain the acceleration of the particles of galactic cosmic rays. The problem of the solar cosmic ray prediction is also not solved.

FLARE POSITIONS FOUNDED FROM MHD SIMULATION RESULTS AND X-RAY SOURCES ABOVE THE ACTIVE REGION 10365

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Numerical MHD simulation demonstrates the current sheet creation in the solar corona above an active region before the flare. Solar flare appearance and its observational manifestations can be explained by fast release of the energy stored in the current sheet magnetic field when the current sheet transforms into an unstable state. Intensive magnetic field dissipation causes plasma heating and therefore the appearance of the thermal X-ray emission source. The magnetic field configuration in the corona cannot be obtained from the observations. The magnetic field configuration in the corona is found by numerical solving of MHD equations using the observed magnetic field distribution on the photosphere for setting boundary

conditions. The finite-difference scheme which is stable for large steps is developed to accelerate calculation. This scheme is upwind, absolutely implicit, and it is conservative relative to the magnetic flux. The graphical method for search the flare position and study of magnetic field in the solar corona has been developed. This method uses the property of the current sheet, according to which the local maximum of the current density is located in the center of a current sheet. The results of numerical simulation of flares May 27, 2003 at 02:53 and May 29, 2003 at 00:51 permit to conclude that the current sheet position coincides with the position of the thermal X-ray source. The RHESSI measurements are used. The magnetic field configuration near the current sheet in the corona above the active region 10365 for flares May 27, 2003 at 02:53 and May 29, 2003 at 00:51 shows that the physical meaning of the processes of accumulation and rapid energy release of the flare are demonstrated by the lines that perpendicular to the force vectors. These lines are located in the current sheet configuration plane.

MULTIFRACTAL DETRENDED FLUCTUATION ANALYSIS OF SOLAR WIND PLASMA AND INTERPLANETARY MAGNETIC FIELD DURING GEOMAGNETIC STORMS

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We have analyzed the data of solar plasma parameters and interplanetary magnetic field during intense geomagnetic storms. The analysis for solar wind plasma and interplanetary magnetic field is very importance for the better understanding of various phenomena in the environment of sun and its connection with the space weather conditions. For this purpose wavelet based advanced multifractal detrended fluctuation analysis (MFDFA) method was used in this work. The behavior of solar plasma parameter and interplanetary magnetic field are quantitatively described by the Scaling Function, Hurst exponent, Mass exponent and multifractal spectrum. This method derives the phenomena of intermittence in data during intense geomagnetic storms and also provides some interesting deterministic and chaotic features. The results of analysis gives the confirmation of non-uniform nature of solar plasma turbulence which driving the plasma emission process and its connection with the interplanetary magnetic field.

FLARING ENERGY RELEASE AND PARTICLE ACCELERATION IN THE LOWER SOLAR ATMOSPHERE

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New challenges to the standard model of solar flares motivated by modern observations with the spacecraft and ground-based telescopes are presented. The most important are in situ heating of chromospheric loop footpoints up to the coronal temperatures without precipitating particle beams from the corona, and the sunquakes which are unlikely to be explained by the impact of energetic particles producing hard X-ray emission. The long-standing 'number problem' in the physics of solar flares is also unresolved problem. It is shown that modern observations favored an important role of the electric currents in the energy release processes in the low solar atmosphere. Particle acceleration mechanism in the electric fields driven by the magnetic

Rayleigh-Taylor instability in the chromosphere is proposed. The electric currents $I \geq 10^{10}$ A, needed for the excitation of super-Dreicer electric fields in the chromosphere are determined. It is shown that both Joule dissipation of the electric currents and the particles accelerated in the chromosphere can be responsible for in situ heating of the low solar atmosphere. The Alfven-Carlqvist model of the solar flare based on the electric circuit approach is developed. Interaction of a current-carrying loop with the partially-ionized plasma of prominence in the context of particle acceleration is considered. The role of sub-THz and THz emission in the study of flaring activity is discussed.

EARTH-AFFECTING CMEs AND ASSOCIATED GEOMAGNETIC STORMS

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Initially Earth-directed coronal mass ejections (CMEs), which usually look like a halo from the Earth, are believed to be the most probable candidates of Earth-affecting CMEs. However, not all of initially Earth-directed CMEs can encounter the Earth, and moreover, not all of Earth-encountered CMEs can cause a geomagnetic storm. In this talk, starting from a sample of full halo CMEs during 1997 March – 2012 May, we show that (1) even for full halo CMEs, they were not necessary to propagate along the Sun—Earth line; the deviation angle could be larger than 45 degrees, (2) the apparent speed observed in a coronagraph may differ largely from the true value for the CMEs propagating within 45 degrees of the Sun-Earth line and slower than 900 km/s, (3) the deflection and interaction of CMEs in interplanetary space may further influence the possibility of a CME encountering the Earth as well as their Earth-arrival time. Further, by investigating the ICMEs and Dst index from 1995 to 2015, we show the statistical properties of these Earth-encountered CMEs and their capability in causing geomagnetic storms. Although isolated CMEs are the major source of geomagnetic storms, shock-CME interacting structures demonstrate an increasing role in causing stronger geomagnetic storms.

QUIESCENT FILAMENT ERUPTION AND ASSOCIATED FLARE ON 29 SEPTEMBER 2013

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We present here the evolution of a quiescent filament during 26 August to 29 September, 2013. For the evolution of filament we have used the data from Solar Dynamics Observatory (SDO), STEREO and GONG H-alpha. After the survival of nearly one month, it was erupted on 29 September, 2013 around 21:15. The eruption was associated with GOES C 1.6 flare, coronal mass ejection (CME), and type II radio bursts. The Kinematics of filament eruption and CME is also discussed here. In order to discuss the magnetic causes of filament eruption, we have used the magnetic field data from HMI onboard SDO satellite. We have observed the magnetic flux cancellation at filament's footpoints, which could be possible reason for its eruption. Finally, we have interpreted our observations in light of eruption models.

GEOEFFECTIVENESS OF SIRs FROM 1995 TO 2015

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Stream Interaction Region (SIR) which is caused by the interaction between a fast solar wind stream and a slow solar wind stream ahead of it. SIRs are thought to be a main source of the minor geomagnetic storm especially in the declining phase and around solar minimum. In this paper, we extend the time period of Jian Lan's SIR catalog, which cover the time range from 1995 to 2009, to the end of 2015. In this catalog, we have totally 37 SIR events. Studied the *Dst* index from WDC geomagnetic index center, we found that 54.4 % (401) of SIR events caused geomagnetic storms with $Dst_{min} < -30$ nT, while 3.3% (24) of SIR events caused intense geomagnetic storms with $Dst_{min} < -100$ nT. Meanwhile, for all SIR events, we find 186 (25.2 %) SIR events contain little flux rope. We compare the geoeggectiveness of SIRs with flux ropes and SIRs without flux rope, and find that the percentage of SIR with flux rope events caused intense geomagnetic storm is higher than that of SIR without flux rope. In addition, we also compare the geoeffectiveness of SIRs in solar cycle 23 and solar cycle 24.

THERMAL INSTABILITY OF CURRENT LAYER AS A TRIGGER FOR SOLAR FLARES

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The modern satellite observations of flare arcades in solar flares demonstrate a consistent increase in the brightness of individual coronal loops. We have solved the problem of the small perturbations stability of a homogeneous longitudinal reconnecting current layer in the MHD approximation. The suppression of the plasma thermal conductivity by the magnetic field inside the current layer provides an instability. The instability increases in a radiative cooling time scale of the plasma in the linear phase. A periodic structure of hot and cold fibers arranged transversely to the direction of the electric current are formed as a result of the instability. The proposed mechanism of the thermal instability can be useful for an explanation of the consistent increase in the brightness of individual coronal loops in solar flares.

PHOTOSPHERIC MAGNETIC FIELD VARIATIONS DURING THE 7 JUNE 2011 M2.5 FLARE

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From the vector measurements of the photospheric magnetic field with the SDO/HMI instrument, we study the field variations within the 2011 June 7 eruptive event related to a filament eruption, flare, and coronal mass ejection. Analyzed were the variations in the magnetic strength modulus (B), radial (B_r), and transversal (B_t) a component, as well as field line inclination (α) to the radial direction from the Sun center. The field line time variations within different sites of the eruptive event were studied in detail. The field line inclination was revealed to decrease in its channel surroundings during the filament slow emergence, whereas, in the flare region, near the magnetic polarity inversion line (PIL), the inclination angles (α) dramatically increase after the flare onset. Besides, in the flare region, after its onset, the magnetic strength magnitude and its transversal component increase. Diverging flare ribbons are shown to be located over the photosphere regions with the field modulus local maxima and with deep minima of the field line inclination. Near PIL, the photospheric magnetic field azimuth decreases after the flare onset, which implies a decrease in angle α between PIL and the magnetic strength vector projection onto the sky plane, or, in other words, the shear increase. Far from PIL, on the contrary, the azimuth increases, and, correspondingly, the angle α also increases. The magnetic field gradient averaged separately in the field with positive and negative polarity in the domain, where B, B_t, and α increase, dramatically decreases starting with the GOES peak X-ray flux.

VARIATIONS IN THE CHARACTERISTICS OF THE SUNSPOT UMBRA MAGNETIC FIELD DURING FLARES AND CORONAL MASS EJECTIONS

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Geometrical and physical properties of sunspots may vary during eruptive events (a filament eruption, a flare, a CME). Sunspot penumbra time variations have been studied most scrupulously by now. At the same time, there is scarce information on the sunspot umbra property variations accompanying eruptive events. Knowing regularities of such variations before the eruptive event onset may be used to predict eruptive events. We studied variations in the sunspot umbra magnetic field characteristics of active regions (ARs), where there were eruptive events of 2011 August 2, 2012, March 9, 2013, April 4, 2014, January 7, and June 18, 2015. We analyzed the behavior of the magnetic strength modulus maximum B_{max}, the magnetic field line minimal inclination angle to the radial direction from the Sun center αmin (i.e., the magnetic tube inclination angle from the sunspot umbra), and also the mean (within the umbra) values <B> and <α>. It is shown a change in the above magnetic field parameter behavior is shown to occur after the flare onset as compared with those observed before the flare onset (e.g.,

increase/decrease in the parameter before the flare onset gives way to its decrease/increase or a weak variation after the flare onset). But the variation view is different in different spots of ARs. In some cases, B_{max} and $<B>$ vary in correlation after the flare onset; in other cases, they vary in antiphase. One may arrive at a similar conclusion relative to the time variations in αmin and $<\alpha>$. We revealed that an essential variation in the umbra magnetic properties was observed in the sunspot located near one of the magnetic loop feet, whose motion leads to forming a CME frontal structure. We discovered that, within ≈3 hours before the flare onset, a decrease in the αmin was observed, with ≈ 10° to ≈ 4°, with its subsequent (after the flare onset), rapid decrease to small values (≤1°) over ≈30 min. Simultaneously, the angle $<\alpha>$ varied (decreased) significantly more weakly. This means that, after the flare onset, the magnetic tube from the umbra of such sunspots diverges from its initial position almost as a whole, i.e., without essential transformation of the magnetic field line distribution inside the tube. As to the magnetic field magnitude, B_{max} and $<B>$ increase by about 200 G within 2 hours after the flare onset.

COMPARISON BETWEEN MAGNETIC PROPERTIES AND UMBRA AREA OF WESTERN AND EASTERN SUNSPOTS WITH DIFFERENT ASYMMETRY OF THE CONNECTING MAGNETIC FIELD

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We compared magnetic properties (maximum B_{max} and mean value $<B>$ of the magnetic strength, the inclination angle of the magnetic tube to the radial direction from the Sun center αmin, and the mean inclination angle of the field lines $<\alpha>$), and also these characteristics and the umbra area S separately for the umbra of western and eastern sunspots with asymmetry of the magnetic field tying connecting them. The asymmetry character is determined by the ratio between the magnetic tube inclination angles in two types of sunspots (western/eastern). For the selected group of the magnetically-connected sunspots (i.e., the sunspots connected by field lines calculated in potential approximation) recorded over 2010–2014, the inclination angle of the magnetic tube from the western sunspot umbra is shown to be smaller than the analogous angle from the eastern sunspot umbra in 70 % of the addressed sunspot pairs. We revealed that such dependences, like $\alpha_{min}(S)$ and $B_{max}(S)$, feature equal trends, and are quantitatively close for sunspot groups with different asymmetry of the magnetic field tying connecting them. At the same time, the connection $<\alpha>$ with S and with $<B>$ in the sunspot umbra appeared different for two sunspot groups. We studied the position of the polarity inversion line of the photospheric magnetic field radial component relative to the magnetically-connected western and eastern sunspots. We draw a conclusion that, in ≈ 54–74 % of cases (depending on the character of averaging the field radial component distribution), the field polarity inversion line is closer to the western sunspot. Also, in most of these cases, the inclination angle of the magnetic tube from the western sunspot umbra is less, than the analogous angle from the eastern sunspot umbra. These results allow us to doubt the earlier conclusion that all the magnetically-connected sunspots are formed due to the emergence of a magnetic loop from the convection zone depth. Indeed, from

calculations of such tube emergence, due to the Coriolis force effect, the inclination angle of the tube from the eastern sunspot umbra should be less than the inclination from the western sunspot umbra, which does not agree with observations for a large group of the magnetically-connected western/eastern sunspots.

ON THE REDUCED GEOEFFECTIVENESS OF SOLAR CYCLE 24: A MODERATE STORM PERSPECTIVE

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The moderate and intense geomagnetic storms are identified for the first 77 months of solar cycle 23 and 24. The solar sources responsible for the moderate geomagnetic storms are indentified during the same epoch for both the cycles. Solar cycle 24 has shown nearly 80 % reduction in the occurrence of intense storms where as it is only 40 % in case of moderate storms when compared to previous cycle. The solar and interplanetary characteristics of the moderate storms driven by CME are compared for solar cycle 23 and 24 in order to see reduction in geoeffectiveness has anything to do with the occurrence of moderate storm. Though there is reduction in the occurrence of moderate storms, the *Dst* distribution does not show much difference. Similarly the solar source parameters like CME speed, mass and width did not show any significant variation in the average values as well as the distribution. The correlation between $V B_z$ and *Dst* is determined and it is found to be moderate with value of 0.68 for cycle 23 and 0.61 for cycle 24. These results are significantly different when total geomagnetic storms are taken in to consideration for both the solar cycles.

CME-RELATED SHOCK GENERATION WITHIN THE LASCO C3 CORONAGRAPH FIELD-OF-VIEW

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CME-related shocks play an important role in space weather, and, in many cases, determine characteristics of geomagnetic disturbances when shocks impact the Earth magnetosphere. The shock properties in the Earth orbit largely depend on peculiarities of their generation on the Sun. There are two viewpoints concerning the nature of CME-related shocks observed within the LASCO C2, C3 coronagraph fields. According to one viewpoint, all such shocks are piston, with a CME body as a piston, but there was no information on where such shocks originated for the bulk of the analyzed events. According to the other viewpoint, at least, a part of such shocks are generated in the lower corona by an eruptive filament rapidly accelerated to relatively high velocities, or by a flux rope disturbing the ambient corona. Right after its origin, this wave propagates as an explosive one, and, at a sufficient distance from its origin, it may start to behave as piston. We are the first to investigate the CME-related shock

generation within the LASCO C3 coronagraph field-of-view, i.e., at relatively large distances. Addressed was CME recorded, for the first time, within the LASCO C2 field on 2012 July 17 (13:48 UT). Peculiarities of the addressed CME are its forming at a relatively significant height, and the CME body slow acceleration with distance. The shock originated at a distance surpassing 12 solar radii, when the CMA body velocity exceeded the total velocity V_a+V_{sw}, where V_a is the Alfvenic velocity, V_{sw} is the solar wind velocity on the CME body axis. Based on this, there came a conclusion that the formed shock is a bow shock, and it was generated, when the ambient plasma flowed around the CME body at a super-Alfvenic speed. The generated shock appears collisionless, because its front width is many fold less than the coronal plasma charged particle free path. We came to a conclusion that the oft-used distance dependence V_a from (Mann et al., 1999) is incorrect, and provides the underrated values. Therefore, we found an Alfvenic velocity distance dependence by using representative values of the magnetic field radial component, the proton concentration in the Earth orbit, and the known regularities of the distance variation in those solar wind characteristics separately in the fast and slow solar wind. Because the CME body axis appeared, by estimates, in the slow wind domain, we used the slow solar wind velocity from Sheeley N.R.,Jr. et al. (1997) as V_{sw} velocity. For several instants, we found a brightness jump at the front of the generated shock and the Alfvenic Mach number. Compared were the variations in the shock velocity and in the CME body velocity.

KINEMATICS OF CMEs AND RELATED SHOCKS FROM LASCO DATA: COMPARATIVE ANALYSIS

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For two groups of fast CMEs related to a shock within the LASCO field, we determined time dependences for the boundary positions of the CME body and of the shock, as well as the velocities of these structures. Separately, we analyzed limb CMEs, whose sources were located within 30^o relative to the limb, and a halo CME (HCME) with sources within 30^o relative to the solar disk center. In the former case, the kinematics of the CME and the shock within the LASCO C2 and C3 field reflects the result of the joint effect of the CME translational motion CME and its expansion. In the latter case, the peculiarities of the CME and shock motions are determined, preferentially, by the expansion of these structures. These results were compared to the time dependences of the CME and shock kinematic parameters in 3D. The kinematic parameters were determined by using the «Ice cream cone model» for a mass ejection. On average, the shock velocity was shown to be higher than that of the CME body in all the cases practically to the boundary of the LASCO C3 field. But the character of the variation in the CME body velocity and in the shock velocity differs both for each CME group, and in comparison between different CME groups. On average, both the CME velocity and the shock velocity decreases with time (distance) for the limb and halo CMEs from observations within the LASCO C2 and C3 field. And for both CME groups, the shock velocity decreases with time faster, than the CME body velocity. As a result, the difference in the CME body and shock velocities for both CME groups decreases with time, on average, whereas the distance between these structures increases. From the calculations in 3D, the shock and the CME body velocities also vary at

different tempo depending on the time (distance). For five HCMEs, there is good agreement between the $\Delta R/R_b$ (standoff distance) radial distribution obtained within the LASCO C3 field from calculating the characteristics of CME and the related shock in 3D and the $\Delta R/R_b$ obtained by using the formulas from [Russell and Mulligan, 2002] valid for piston shocks. Here, ΔR is the distance between the CME body and the shock on the CME axis, R_b is the CME body radius CME on its axis, R is the distance from Sun center.

TWO TYPES OF RESPONSE OF THE MAGNETOSPHERE TO THE INTERACTION WITH INTERPLANETARY SHOCKS IN THE GEOMAGNETIC PULSATIONS

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Results of the study of interaction of 30 events of interplanetary shocks with the magnetosphere for the period 2011–2015 are presented. We found two types of the geomagnetic response. During 20 sudden storm commencement (SSC) cases occurred under solar wind with velocity <500 km/s, the shocks were accompanied by geomagnetic pulsations Psc 1-5. In 10 SSC cases, initiated of the interplanetary shocks propagating at speeds $V > 500$ km/s, a kind of precursor was revealed, which is a short duration (3–20 s) burst of geomagnetic pulsations in the frequency range of 0.2–7 Hz. On the ground, the burst of geomagnetic pulsations was observed globally, that is, in different local times and different latitudes. On spectrograms obtained at different locations, the burst often exhibits a similar resonant structure (intermittent increases and decreases of the spectral power at almost multiple frequencies) with some differences in resonant frequencies at different stations. The resonant structure of the pulsation spectrum is, possibly, associated with the interaction of the incident MHD pulse and the ionospheric Alfven resonator. It is shown that the bursts are observed just before the sharp increase in H component of the magnetic field; this is why it can be considered as the precursor of the sudden storm commencement. The possible reasons of different geomagnetic response to interplanetary shocks propagating with different speeds are discussed.

POSSIBLE CAUSES OF SHOCK WAVES GENERATION IN THE SOLAR CORONA IN THE ABSENCE OF CORONAL MASS EJECTIONS

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We present results of analysis of two solar events SOL2012-10-23T03:13 and SOL2014-03-06T09:23 associated with solar flares and type II radio bursts but without coronal mass ejections (CMEs) during shock wave generation. We used the method of constructing the

difference brightness profiles in the UV and EUV channels of AIA/SDO in space and time, together with an analysis of the type II radio bursts. It is shown that in the SOL2012-10-23T03:13 event there was formation and propagation of a compression region, ahead of which a collision shock wave is registered at the distances $R<1.3R_s$ (R_s is the radius of the Sun) from the center of the Sun. Based on the data analysis we conclude that a possible cause of the compression region and the shock wave in this event is a short (pulsed) action of a high-temperature eruptive flux-rope to a surrounding plasma medium. The shock wave can be considered initially as a piston-driven shock, but as a freely-propagating blast shock at a later stage. Initial instability and eruption of the flux-rope may be initiated by emerging magnetic flux, while its heating may be caused by the magnetic reconnection. We also found the formation and propagation of a compression region in the SOL2014-03-06T09:23 event, in front of which a collisional shock wave was registered at the distances $R<1.3R_s$ from the center of the Sun. However, this event has two main differences from the SOL2012-10-23T03:13 event: (1) The first appearance of the moving compression region was registered in a close vicinity to the flare site, at the distances $DR < 0.01R_s$ from it, and near a time of a flare peak, around 12 seconds after its start. The further movement of the compression front was smooth and with decreasing speed; (2) No plasmoid (jet) ejection was seen in the direction of the compression region and shock wave movement before and during their formation stage. All this allows us to suggest that a possible cause of the moving compression region and shock wave generation in front of it was the solar flare, namely a sudden (pulsed) increase of the total pressure associated with the flare energy release. In this case the shock wave can be considered as a purely freely-propagating blast shock.

ENHANCED PLASMA UPFLOWS DURING THE EMERGENCE OF SMALL ACTIVE REGIONS IN THE SOLAR PHOTOSPHERE

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We study the plasma flows in the solar photosphere during the emergence of two small active regions NOAA 9021 and 10768 by using SOHO/MDI data. The strong plasma upflows at the initial stage of active region formation are detected. Enhancement of the upflow velocity begins before the magnetic flux emergence; the maximum negative Doppler velocities reach −1650 and −1320 m/s. The velocity structures have size ~8 Mm in diameter and they exist for 1−2 hours. The observed flows are similar to that of the large active region NOAA 10488. The structures of enhanced plasma upflows are distinguished from the regular granules and supergranules in the quiet Sun on the size scale, the velocity values, and the lifetime. Thus, the similar parameters of enhanced upflows in the earliest phase of the appearance of small and large active regions may point to the possibility of the emergence of elementary magnetic fluxes with the similar initial properties. We used the ideal MHD simulations of the magnetic flux emergence into the solar atmosphere for investigation of the causes of the enhanced plasma flows at the initial stage of active region formation. Comparison between the observations and the simulation shows a striking consistency. We found that there exist two distinct driving forces for the plasma upflows depending on the evolution stage. Just before the magnetic flux reaches the photosphere, the enhanced upflows are caused by the gas pressure gradient, while after the magnetic flux appears in the photosphere, the magnetic pressure gradient plays a key role.

DETECTING THE SOLAR NEW MAGNETIC FLUX REGIONS ON THE BASE OF VECTOR MAGNETOGRAMS

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The advanced method of mapping emerging magnetic flux regions through the multifractal segmentation of vector photospheric magnetograms is created. It is free from influence of effects of projection. Maps of the longitudinal component of the field H_z and of the two transversal components H_x, H_y are processed separately and the computed segmented images are summarized. As a result, for the first time the detailed picture of distribution of new magnetic fluxes at the current time, is obtained. The SOT Hinode magnetograms for 2006-2015 were used. Observations of the flare-productive active regions NOAA 11158, 11263, 11520 and 11589 were processed. During the periods of rapid development, sites of new magnetic flux are built in cellular structures. Hills of a new field in case of their birth have the considerable elongation which is possibly related to their rope-like geometry. In the centers of flare activity, in the vicinity of polarity inversion lines, exits of new magnetic flux alternate with processes of magnetic cancellation.

COMPARISON OF THE MAIN OSCILLATION CHARACTERISTICS IN THE SOLAR CHROMOSPHERE, SOLAR WIND, AND MAGNETOSPHERE

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The aim of this work is to consider the probable Suns chromosphere source of the oscillations in the solar wind, and to estimate the influence of these oscillations on the pulsations registered in the magnetosphere. We compare the spectra of the oscillations in the coronal holes chromosphere with those in the solar wind. The oscillations observed in the chromosphere indicate the probable torsional Alfven wave presence — this mode can propagate long distances without dissipating in the interplanetary space. Alfven wave signatures are also found in the solar wind based on the ACE satellite data in the L1 point. We analyze the characteristics of the obtained spectra and estimate the possibility of the wave mode transformation in the process of propagating through the Sun — solar wind system.

INFLUENCE OF CME–CME AND CME–HSS INTERACTIONS ON THE PARAMETERS OF ICME AT 1AU

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Identification of solar sources of the interplanetary coronal mass ejections (ICMEs) for the growing phase of cycle 24 (2010–2012) based on the Richardson and Cane ICME list has shown that in ~30 % cases the observed ICME may be associated with two or more CMEs. Such CMEs propagating to the Earth can interact in the corona or in the heliosphere. In some other cases, CMEs can propagate along and interact with high speed streams (HSSs) of solar wind from coronal holes. As a result, this interaction can lead to specific changes in the parameters of the associated ICMEs at 1 AU, such as velocity, magnetic field and ion composition. In the report, we consider the forming of the ion charge state of the ICME plasma for a typical CME and the scenarios how interaction of a CME with other solar wind streams (CME, HSS) can influence on the ICME parameters observed at 1 AU. We demonstrate these effects on a number of cases of cycle 24.

ON GEOEFFECTIVENESS OF CMES DURING SC24

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Coronal mass ejections (CMEs) are parts of the puzzle that drives space weather. Numerous methods (theoretical or numerical) are being used to predict whether the CME will be geoeffective or not. By extending a study proposed by Srivastava (2005), we developed a logistic regression model to predict the probability of geomagnetic storms occurrence $Dst_{min}<-30$ nT. We applied it for events during the ascending phase of solar cycle 24. The results obtained are compared with similar ones obtained for the ascending phase of solar cycle 23. A summary describing the observations and methods limitations is also given.

INFLUENCE OF HSS-CME INTERACTIONS ON THE PARAMETERS OF HSS AT 1 AU

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The HSS-CME interactions can lead to the large errors in the forecasts of the arrival time HSS and the amplitude of the HSS speed, as well as to the absence of the expected CIR. We investigated the cases of possible HSS-CME interactions in the 24th solar cycle. The changes in the HSS parameters at 1 AU, such as kinematics, magnetic field and ion composition, were

examined. In the cases of HSS-CME interactions we determined the degree of discrepancy between the observed at 1 AU and forecasted parameters. We used WSA-ENLIL model and the empirical solar wind forecast model based on areas and magnetic fields of coronal holes. We investigated how the detected discrepancy depends on the relative location, magnetic configuration of the solar sources of HSS and CME.

RELATIONSHIP BETWEEN SOLAR WIND DIFFERENT TYPES AND LATITUDINAL PROPAGATION OF SUBSTORMS

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Based on the data of the catalog of large-scale solar wind types (ftp://ftp.iki.rssi.ru/omni/), OMNI database by the solar wind and IMAGE magnetometers network we made a comparative analysis of the conditions of the appearance of substorms at different latitudes. All considered substorms were divided into different types according to their location in relation to the auroral oval dynamics. The first type — the substorms which propagate from the auroral geomagnetic latitudes to the polar ones (called "expanded" substorms, according to an expanded oval dynamics); the second type — the substorms which are observed only at the geomagnetic latitudes above ~70 degrees in the absence of simultaneous magnetic disturbances below 70 degrees (called "polar" substorms, according to a contracted oval dynamics). Substorms observed close to the minimum and maxima the 23th and 24th solar cycles on the meridional chain (Tartu — Ny Ålesund) of IMAGE stations were considered (namely, periods 1995–1996, 2008–2009, 1999–2000 and 2012–2013). We have analyzed the space weather conditions before the onset of these two types of substorms. It is shown that in different conditions of space weather, determined by solar wind large-scale structure, the different types of magnetic substorms occur. Expanded, i.e. moving to north, substorms occur, mainly, during high-speed streams from coronal holes, and polar substorms occur during the slow flows and the heliospheric current sheet, as well as some of the displays of interplanetary coronal mass ejections (ICME).

AN ANALYSIS OF SOLAR ERUPTIVE PROCESSES USING COMBINED EUV AND RADIO MEASUREMENTS

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The strongest space weather disturbances are linked with Coronal Mass Ejections (CMEs) and associated shock waves. We performed a multi-wavelength study of selected CME/flare events using combined extreme ultraviolet (EUV) and radio observations. The unique large field-of-view EUV observations by Project for Onboard Autonomy 2/Sun Watcher with Active Pixels

and Image Processing (PROBA2/SWAP) allow us to investigate properties of coronal magnetic structures over a wide range of time scales, sizes and temperatures. Here, we focus on coronal loops and their magnetic topology, which produce fast electrons responsible for solar radio bursts. We compare radio source locations observed by Nancay Radioheliograph with PROBA2/SWAP images to study CME-driven shock wave kinematics.

NEW PROTON EVENT CATALOGS AND STATISTICAL RESULTS

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In this report we summarize the data analysis, contents and statistical results from three newly compiled catalogs (1996–2016) of solar energetic protons. Proton data from Wind/EPACT, SOHO/ERNE and GOES instruments are analyzed. We applied the same procedure for the proton intensity enhancement identification and analysis. Namely, we completed: visual scanning of the data; data smoothing of about 5–10 min; onset time identification of 3-sigma above background; removal of energetic storm particle contaminations from the identifications of the proton peaks; onset-to-peak fluence calculation. Solar origin (flares and coronal mass ejections) of the proton events are proposed. Here, we summarize the different trends obtained for the protons and their origin, e.g., with respect to proton energy and intensity, solar origin position and intensity, solar cycle. Finally, we discuss the proton occurrence probabilities for various ranges of the solar origin parameters.

SOLAR WIND CHARACTERISTICS IN POLAR REGIONS OF THE SUN CORONA BY STEREO DATA DURING 2009–2014

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On white-light coronagraphs images inside solar wind flows observed jets — streams of matter, driven radially outward the Sun. We analyzed white-light images producing by coronagraph COR2/STEREO (field-of-view 3.5–16 solar radii) during 2009–2014 years and determined jets characteristics in polar regions of solar corona. There were determined sizes and velocities of jets, their number during researched period. Comparison between all jets characteristics in south and northern solar hemispheres was done.

FLARE ENERGY RELEASE: INTERNAL CONFLICT, CONTRADICTION WITH HIGH RESOLUTION OBSERVATIONS, AND POSSIBLE SOLUTIONS

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All accepted paradigms of solar and stellar flares energy release are based on two whales: Source of energy is free energy of non-potential force free magnetic field in atmosphere above active region. Process of ultrafast dissipation of magnetic fields is reconnection in thin turbulent current sheet (RTTCS). Progress in observational technics in last years provided ultra-high spatial resolution and in physics of turbulent plasma showed that real situation is much more complicated and standard approach is in contradiction both with observations and with problem of RTTCS stability. We present critical analysis of classic models of pre-flare energy accumulation and its dissipation during flare energy release from pioneer works Giovanely [1939, 1947] up to topological reconnection. We show that all accepted description of global force-free fields as source of future flare cannot be agreed with discovered in last time fine and ultra-fine current-magnetic structure included numerous arcs-threads with diameters up to 100 km with constant sequence from photosphere to corona. This magnetic skeleton of thin current magnetic threads with strong interaction between them is main source of reserved magnetic energy in solar atmosphere. Its dynamics will be controlled by percolation of magnetic stresses through network of current-magnetic threads with transition to flare state caused by critical value of global current. We show that thin turbulent current sheet is absolutely unstable configuration both caused by splitting to numerous linear currents by dissipative modes like to tearing, and as sequence of suppress of plasma turbulence caused by anomalous heating of turbulent plasma. In result of these factors primary RTTCS will be disrupted in numerous turbulent and normal plasma domains like to resistors network. Current propagation through this network will have percolation character with all accompanied properties of percolated systems: self-organization with formation power spectrum of distribution of flares and micro-flares, and possibility of phase transition to flare energy release with huge increasing of energy release.

THE SHOCK WAVE DEVELOPMENT IN A MAJOR SOLAR ERUPTIVE EVENT RESPONSIBLE FOR GLE63

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The 26 December 2001 solar eruptive event produced a strong particle flux and ground-level enhancement of cosmic-ray intensity (GLE63). This solar event associated with a moderate flare and fast coronal mass ejection (CME) was not comprehensively studied because of insufficient observations. We analyze the shock-wave excitation in this event and its posterior evolution. We found that two blast-wave-like shocks appeared during the flare impulsive phase. The first strong wavelike disturbance was impulsively excited by the main eruption close to the CME onset time. The second one was produced by a jet-like eruption five minutes later. Each

wave rapidly steepened into a shock due to a steep falloff of the fast-mode speed away from the eruption region. Signatures of type II radio bursts indicate two different shock fronts following each other. The two shock waves eventually merged around the radial direction into a single shock. It was traced up to 25 solar radii as a spherical halo ahead of the expanding CME body, and a calculated trajectory of the type II emission matches its total evolution from 80 MHz to 150 kHz. Properties found for the shock wave indicate its intermediate regime between the blast wave and bow shock in the LASCO field of view. This shock-wave history updates a widely accepted view on a CME-driven shock: the shock wave actually appears earlier, being able to accelerate particles to high energies during the flare rise.

ELEMENTARY ACTS OF ENERGY RELEASE IN THE INITIAL STAGE OF THE 4 AUGUST 2011 FLARE

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Observations with the high temporal resolution in microwave and X-ray ranges allowed us to find groups of sub-second pulses (SSP) in the interval lasting 5 min (uniquely long) before the impulsive phase of the 4 August 2011 (M9.3) flare. The sources of all SSP are located near the top of a flare loop, however spectral characteristics of pulses differed in the individual groups. In the first two groups pulses were observed synchronously in the wide range of microwave and HXR radiation. The third group was narrow-band. In the second group which was observed during sub-burst intensity of broadband impulses was large enough to measure a spectrum. Temporal profiles of sub-burst were modulated by broadband multiperiodic pulsations in the microwave radiation (2–17 GHz, NORP data) and X-ray radiation (HXR) (4–100 keV, FERMI data) with the periods of several seconds. The spectral behavior of the microwave and X-ray emissions during quasi-periodic pulsations are analyzed. Probable mechanisms of SSPs and relationship with plasma parameters obtained from microwave and HXR spectra during SSPs are discussed.

SXR SOLAR FLARES DURING MINIMUM OF SOLAR ACTIVITY

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Sphinx was the Polish X-ray spectrophotometer designed to measure X-ray emission from the Sun in the energy range between 1.2 and 15 keV. The instrument was placed onboard Russian CORONAS-Photon satellite which was launched on January 30, 2009. SphinX mission operated from February to November 2009 and provided large database of flare observations. These data are used for the analysis of flares' light curves as seen in soft X-ray. We will present analysis results for selected events.

STEADY ANISOTROPIC OUTFLOWS: THE 16-MOMENTUM MHD APPROXIMATION

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Observations and measurements of space plasma in the regions, such as the ionosphere, the Earths magnetosphere, and the solar wind show the presence of the temperature anisotropy of the plasma relative to the direction of the magnetic field. This property has a collisionless plasma in a magnetic field. Such conditions are realized in the plasma of the upper solar corona, where there are enough sources to create and maintain the plasma temperature anisotropy. For that environments, the particle distribution function (especially ions) is non-Maxwellian and at small collisions, isotropic MHD equations are not applicable. For the MHD description of such a plasma is widely used equations of Chew-Goldberger-Low (CGL) model. However, these equations do not take into account the heat fluxes that occur naturally along the magnetic field in a collisionless plasma and contain artificially introduced two adiabatic invariants. Consequently, these equations cannot describe such important compressible instability as a mirror and a second firehose instabilities. To study the effects associated with heat flux along the magnetic field, it is possible to use the most common MHD transport equation for the anisotropic plasma, which was obtained by many authors as equations for the 16-momentum of the distribution function of particles. In this paper, we used the full set of the 16-momentum MHD equations that take into account the heat fluxes along the magnetic field in an anisotropic plasma of the solar wind. 16-momentum MHD equations have been used by many authors in theoretical studies, especially for the modeling of the solar wind and studying the wave instabilities of an anisotropic plasma. Parker developed the supersonic model for the expansion of the solar wind, but this model describes the solar wind only in general. In this paper, we summarized Parkers problem, taking into account the anisotropy of the solar wind plasma. We found particular analytical solutions of the obtained equations in both 16-momentum MHD and CGL-MHD models. We obtain a quasi-linear Parker-type differential equation for the outflow speed whose solution topology is numerically found with an evolution law of the temperatures such that $T_{\|}= T_{\|0}(r/r_0)^{-\beta_{\|}}$ and $T_{\perp}= = T_{\perp 0}(r/r_0)^{-\beta_{\perp}}$. We describe possible critical points both physical and unphysical in these models. Different cases are discussed by the set of constant parameters $\beta_{\|}$ and $\beta_{\perp}$ and of the anisotropy at the base r_0 of the corona. In particular, we discuss the isothermal case.

KELVIN—HELMHOLTZ INSTABILITY BETWEEN SOLAR WINDS COMPONENTS IN 16-MOMENTUM MHD FORMALIS

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We analyze wave instabilities in a magnetized, anisotropic, and collisionless plasma in the fluid approximation using the 16-momentum MHD formalism. In this work, we present simple configuration of tangential discontinuity with a possibility to choose some special cases when to parameters of plasmas such as the pressure, density, initial heat fluxes, plasma-beta, and anisotropy are given physical mean values. We discuss the cases when interfaces between solar winds components are Kelvin—Helmholtz unstable, by including dimensionless parameter h as the ratio of flow speeds, which values provide enough condition for velocity shear across the interfaces. As a first step, we eliminate the heat flux, and select the same physical parameters in both flows, and solve the dispersion equation. The task parameters for supersonic flows were chosen so that to filter out classic firehose and mirror (during quasi-transverse propagation) plasma instabilities. It turned out that KHI increment, unlike the usual hydrodynamic case, has maximum, and the instability has two thresholds in the anisotropic case. In other words, KHI occurs within $h_1<h<h_2$, where $h=V_{01}/V_{02}$ characterizes the ratio between the flow velocities.

MULTI-INSTRUMENT ANALYSIS OF SOLAR ERUPTIVE EVENTS OBSERVED BY THE SIBERIAN RADIOHELIOGRAPH AND COMPARISON WITH TRADITIONAL HYPOTHESES: DEVELOPMENT OF A SHOCK WAVE AND CME

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The first 48-antenna stage of the Siberian Radioheliograph (SRH) constructed on the base of the SSRT started observing the Sun in 2016 initially in a single-frequency mode and since August at five frequencies in the 4-8 GHz range. We firstly present an unprecedented series of negative bursts observed within one day on 9 August, which were caused by screening a compact microwave source by repetitive surges visible in extreme ultraviolet. Then we focus on an eruptive C2.2 flare on 16 March 2016 around 06:40, one of the first flares observed by SRH. We analyze this event using imaging and non-imaging radio, extreme-ultraviolet, hard X-ray, and white-light data, endeavoring to reveal its scenario and compare the observational results with expectations from traditional hypotheses and our recent conclusions. An eruptive prominence actively expanded, twisted, writhed, and brightened. This behavior rules out a passive role of the prominence, indicating development of its violent instability. A flux rope appears to have been formed from the prominence and developed into a large CME. The

prominence eruption caused a weak impulsive flare with a conspicuous hard X-ray burst at > 70 keV and a weak microwave burst of 15 sfu. The burst clearly lagged behind the prominence lift-off, as we observed in different events. The impulsive prominence eruption excited a shock wave, which appeared during the impulsive burst and was manifested in an "EUV wave" and Type II radio burst. The observations indicate a multi-component structure of non-thermal microwave and hard X-ray sources and demonstrate that an impulsive flare is not necessarily confined.

STUDY OF MAGNETIC STRUCTURE AND TRIGGER MECHANISM FOR SOLAR FLARE

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As the largest eruption in the solar system, solar flare can release large amount of energy that may disrupt satellite and spacecraft operations and may impact social aspects in the modern life. It is essential to enhance the capacity of flare prediction in order to get the better prediction result. Therefore, we studied magnetic structure of active regions, which produced large solar flares, with regard to understand the flare trigger mechanism. Nonlinear Force Free Field (NLFFF) extrapolation method was used to model the coronal magnetic field of the active regions NOAA 10930 and 11158 based on the photospheric magnetogram data from Hinode and SDO satellites. We found that the magnetic fields of the flare-productive active regions were highly sheared near the Polarity Inversion Line (PIL) before the large flares happened. We used the coronal model as an initial condition for performing MHD simulation to study the trigger mechanism. By imposing bi-pole structure with various orientations, we found that there are two type of structure that can effective to trigger the flare. They are opposite polarity (OP) and reverse shear (RS) type structure which emerge onto the highly sheared magnetic fields. This result is consistent with the previous study done by Kusano et al. (2002) who studied the trigger mechanism for the Linear Force Free Field magnetic structure. Moreover, by comparing the synthetic flare ribbons from the simulation with the observation, we could determine which possible type of trigger structure responsible for triggering the flare. We also calculated a new parameter that can show the averaged twist of magnetic field lines normalized by the total magnetic flux within AR from the NLFFF model. We found that this parameter is varied during the evolution of the active region and dramatically decreased after the onset of the flare. Finally, we discuss that this parameter may be informative for flare prediction.

THE ORIGIN OF SOLAR FLARES AND CMES: ADVANCES AND CHALLENGES

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The main drivers connecting the Sun with the interplanetary space and the terrestrial atmosphere during the extremal transient events are the solar flares and the coronal mass ejections (CMEs). Undoubtedly, understanding of the reasons and scenarios of these phenomena onset is the key initial condition for analysis and interpretation of various geoeffective disturbances. Nowadays we know a lot about the reasons and mechanisms driving to origin both

the flare and CME but some details of puzzle are still unknown. In current contribution we will present the observational facts and theoretical models explaining both qualitatively and quantitatively these phenomena. Our attention will be focused on analysis of what we have known and what we doubt or need to investigate.

ANALYSIS OF THE DIFFERENTIAL EMISSION MEASURE EVOLUTION FOR SOLAR FLARES OBSERVED BY RESIK

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The X-ray spectrometer RESIK observed the spectra in four wavelength bands from 3.3 to 6.1 Å. This spectral range contains many emission lines of H- and He-like ions for Si, S, Ar and K. These lines are formed in the plasma of coronal temperatures ($T > 3$ MK). The analysis of observed lines' intensities allows to study the differential emission measure distributions (DEM) in the temperature range between 3 and 30 MK. In this contribution, we analyze the time changes of the DEM distributions for successive flares observed with the RESIK instrument. The model of the elementary flare profile (EFP) has been used in order to separate the individual flares based on their observed light curves.

DIAGNOSTIC OF THE TEMPERATURE DISTRIBUTION IN CORONAL STRUCTURES ABOVE SUNSPOTS, USING 3-MIN OSCILLATIONS

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In this research we investigate the possibility of applying slow MHD waves for the diagnostic of the transverse temperature distribution in coronal structures above sunspots. Since the coronal EUV emission is optically thin, any EUV imaging instrument (like SDO/AIA) emission along the line of sight from the entire of an active region. Therefore, the interpretation of EUV observations is a challenging task. To determine the influence of the transverse temperature distributions in coronal structures to the observation of the slow MHD wave propagation, we apply the forward modeling approach. We apply the FoMo code, which uses the volume distribution of plasma parameters (temperature, density and plasma velocity) as an input. We performed three numerical MHD simulations of the slow wave propagation in coronal structures with uniform, hot, and cold interiors, and made synthetic EUV images for different wavelengths. The images were investigated in detail and compared with real SDO/AIA observations of slow MHD waves in coronal structures above sunspots. Specific features that allow us to distinguish between different temperature distributions were revealed and discussed.

LINK BETWEEN SLOW-MODE MHD WAVES AND QPPS IN SOLAR FLARES: MODE TRANSMISSION MECHANISM

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Recent observations of magnetohydrodynamic oscillations and waves in solar active regions revealed their close link to quasi-periodic pulsations in flaring light curves. The nature of that link has not yet been understood in detail. In our analytical modelling we investigate propagation of slow magnetoacoustic waves in a solar active region, taking into account wave refraction and transmission of the slow magnetoacoustic mode into the fast one. The wave propagation is analysed in the geometrical acoustics approximation. Special attention is paid to the penetration of waves in the vicinity of a magnetic null point. The modelling has shown that the interaction of slow magnetoacoustic waves with the magnetic reconnection site is possible due to the mode transmission at the equipartition level where the sound speed is equal to the Alfvén speed. The efficiency of the transmission is also calculated.

FLUENCE SPECTRA OF SMALL SEP EVENTS WITH METRIC TYPE II RADIO BURSTS

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Gopalswamy et al. (2016, Astrophysical Journal, 833, 216) showed that the spectral index of the 10–100 MeV proton fluence spectra organizes the major solar energetic particle (SEP) events. Ground level enhancement (GLE) events and SEP events associated with filament eruptions outside active regions (FE SEP events) have respectively hard (gamma ~2.68) and soft (gamma ~4.89) fluence spectra. Between these two distinct groups fall the regular SEP events (gamma ~3.83). Here we report on a study of proton fluence spectra of small SEP events, i.e. events with the GOES 10 MeV peak flux below 10 pfu, that have an associated metric type II radio burst during solar cycle 24. We utilize the low-background measurements by the Energetic and Relativistic Nuclei and Electron (ERNE) instrument on the Solar and Heliospheric Observatory (SOHO). Preliminary results show that the distribution and the average value of spectral index of small SEP events resemble those of the regular SEP events.

THE ORIGIN AND PROPAGATION OF SOLAR ENERGETIC PARTICLES AND THEIR IMPACT ON EARTH

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Solar eruptive events generate Solar Energetic Particles (SEPs) which, by propagating through the interplanetary medium, may reach near-Earth space. SEPs are an important component of Space Weather and produce a variety of effects, including posing a significant radiation risk to humans in space and satellite hardware. This talk will review our understanding of the origin and propagation of SEPs, based on a large body of data gathered by spacecraft and ground-based detectors and on theoretical models. It will describe processes by which particle acceleration takes place near the Sun and within the interplanetary medium. Particle transport through the interplanetary medium will be discussed, including the role of the large scale magnetic field configuration and of the superimposed turbulence, which produces scattering and field line meandering. Impacts of SEPs on the near-Earth environment will be reviewed.

THE MULTIWAVE SIBERIAN RADIOHELIOGRAPH: IMAGING SOFTWARE AND CALIBRATION

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In the year 2016 multiwave observation of the Sun with the Siberian Radioheliograph (SRH-48) in the frequency range 4–8 GHz started. It gives new possibilities for investigation of plasma and magnetic fields in solar corona, accelerated particles, coronal mass ejection, eruption phenomena and other manifestations of solar activity. The methods of processing and calibration of the raw data are presented. The examples of synthesized radio maps of the Sun at several frequencies were compared with solar images obtained at other instruments such as NoRH and AIA/SDO.

PC INDEX AS A PROXY OF THE SOLAR WIND ENERGY THAT ENTERED INTO THE MAGNETOSPHERE IN CASE OF MAGNETIC STORMS

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Magnetic storms with intensity $Dst < -30$ nT observed in epoch of 1998–2015 (N=431) have been analyzed. The 1-min *SymH* index smoothed with use of the running window of 30 min width was examined as a storm characteristic. The 30-min smoothed PC index was derived in a similar manner. The storms were classified into 3 categories according to features of the PC index behavior in course of storm, as follows: (1) storms with the well-defined regular PC index

increase above the threshold level ~1.5 mV/m, (2) storms with the periodically oscillating PC index, and (3) storms with imposition of the PC index oscillations on the PC index enlargement (composition of two first categories). The analyzed magnetic storms were compared with catalogues of the (Interplanetary) coronal mass ejections (ICMEs/CMEs) and stream (corotating) interaction regions (SIR/CIRs), which are known as the solar wind drivers of magnetic storms. It is shown that storms of the 1st category are commonly related to CME/ICME events, the storms of the 2nd category are related exclusively to SIR (CIR) events, whereas the composite storms are associated with both solar wind drivers. Relationships between the 30-min smoothed PC and *SymH* indices were examined for all categories of storms at interval $\Delta T=T_{max}\pm48$ hours, where T_{max} is a moment of maximum storm intensity (i.e. moment of maximal depression of geomagnetic field). Results of the statistical analysis demonstrate that depression of geomagnetic field (*Dst* variation) starts to develop as soon as PC index steadily excess the threshold level of ~1.5 mV/m, like to case of magnetic substorms. *SymH* index in course of magnetic storm generally follows the time evolution of the smoothed PC index with typical delay time of ~ (1±0.5) hour. The storm intensity (Dst_{min}) is linearly related to maximal value of the hourly mean PCMAX value observed about 1 hour before the moment of maximal depression. The conclusion is made that the PC index can be successfully used for now casting the magnetic storm development.

DIAGNOSTICS OF SOLAR CORONAL PLASMAS WITH RAPIDLY-PROPAGATING QUASI-PERIODIC WAVE TRAINS

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Rapidly-propagating quasi-periodic wave trains of the EUV emission intensity variations recently discovered in coronal active regions, and associated quasi-periodic radio bursts, provide us with a tool for the diagnostics of the magnetic connectivity in the solar atmosphere. In particular, a wave train observed during the impulsive phase of an M1.9 flare on 7 May 2012 with SDO/AIA in 171 and 193 Å passbands, had a period of about 140 s, and apparent instant phase speed of 660–1400 km/s. Simultaneously, quasi-periodic variations of the time derivative of the GOES soft X-ray flux were found to have a 70-s period. Similar periodicities were detected in the metric/decimetric (245/610 MHz) radio bursts at several ground-based stations of RSTN. Wave trains are shown to occur as a response of coronal magnetoacoustic waveguides or anti-waveguides to an impulsive energy deposition, e.g. bursty magnetic reconnection. The observed properties of the wave trains, such as wavelet spectra, are determined by the dispersive properties of the waveguides, prescribed by the plasma and magnetic field non-uniformities. Full-MHD numerical simulations of the evolution of broadband fast magnetoacoustic pulses show good agreement with the observed properties of fast wave trains. Thus, the frequency and amplitude modulations in the fast wave trains, determined, in particular, with the use of the characteristic tadpole wavelet signatures, and their evolution with time and along the wave path give us information about the plasma structuring. The direction of the wave train propagation, together with the estimation of the local plasma density by the frequency in the radio band, reveals the communication channel. However it is important to distinguish between the guided and leaky parts of the fast magnetoacoustic perturbation. In addition, it is found out that the observational manifestation of fast wave trains is strongly affected by the line-of-sight integration effect that has to be taken into account in the interpretation of observations.

MHD-SEISMOLOGY OF THE CORONAL MAGNETIC FIELD BY DECAY-LESS KINK OSCILLATIONS

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The magnetic field controls almost all processes in the corona, including the accumulation of energy and its release during flares and coronal mass ejections. Hence its knowledge is the key ingredient of solar activity and space weather forecasting. However, the practical application of the existing methods for the estimation of the magnetic field in the corona (radiomagnetography, extrapolation of the photospheric field and MHD seismology) is limited by some complex difficulties. As a result, there are still no regular and reliable measurements of the coronal magnetic field. MHD seismology provides a possibility for the measurement of the coronal magnetic field by using MHD waves in the coronal plasma as natural probes. Standing kink oscillations of coronal loops are the most promising tools for measuring the coronal magnetic field, because the magnetic field can be easily calculated from the observed parameters such as the oscillation period, the length of the loop, density contrast, and plasma density inside the loop. Up to the present time, observations of decaying kink oscillations of coronal loops have been relatively rare. These events are mainly associated with solar flares and CMEs, and hence occur occasionally. Therefore, they are not suitable for the routine seismological diagnostics of all solar active regions. In this work, we focus on the recently discovered decay-less regime of kink oscillations that is a ubiquitous phenomenon and can be observed in almost any active region. Hence, it can be used as a seismological tool for routine diagnostic of the coronal magnetic field. Decay-less kink oscillations are difficult to detect and to analyse due to their low amplitude (~0.2 Mm). Hence, we apply the motion magnification method to the observational data. This technique acts as a microscope, artificially magnifying low amplitude motions in an image series. It makes low amplitude oscillations easily visible in animations and time-distance plots, allowing for reliable measurements of their periods. Plasma density inside the loop and the density contrast are then estimated using the differential emission measure analysis. In combination with the knowledge of the loop length estimated in the assumption of a semi-circular shape of the loop, these parameters allow us to calculate the magnetic field. We applied this approach to measure the magnetic field in the corona of several active regions, showing the practical possibility of regular of the coronal magnetic field diagnostics by analysing decay-less kink oscillations.

SYMPATHETIC FLARE ERUPTION USING HIGH RESOLUTION OBSERVATIONS

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We report sympathetic flare events observed in region NOAA AR 12268. Our observation includes the multi-wavelength study using space instrument like SDO as well as ground based H-alpha data of ARIES, Nainital. We have not found any signature of filament associated with these events. Precursor phase study has been done for the triggering and energy generation mechanism of the flare. Very poor CMEs has been observed along with respective events with the speed of 222 and 321 km/s. Our investigation reveals the magnetic field emergence and shear in the active region during its span.

MINGANTU SPECTRAL RADIOHELIOGRAPH FOR SOLAR TERRESTRIAL CONNECTIONS

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To address fundamental processes in the solar eruptive phenomena and their geo-effects, it is important to have imaging-spectroscopy over wide frequency range from the Sun to the interplanetary space. The Chinese Spectral Radioheliograph (CSRH) is a solar-dedicated interferometric array with a frequency range from 400 MHz to 15 GHz. There are two arrays of 40 4.5-m antennas covering 400 MHz – 2 GHz, and 60 2-m antennas covering 2–15 GHz including antennas, receivers, and correlators which have already been established recently in Mingantu Town, Inner Mongolia of China. CSRH is renamed as Mingantu Spectral Radioheliograph (MUSER) after its completion. We introduce the perspectives of MUSER with high spatial resolution, high time resolution, and high frequency resolution for solar flare studies. Some initial results will be presented. The plan to extend MUSER to ~40–400 MHz frequency regime will also be described so that geo-effective solar radio bursts can be better addressed.

2.5D SIMULATION OF MAGNETOHYDRODYNAMIC WAVE PROPAGATION AND ITS INTERACTION WITH A CORONAL HOLE

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We developed a new numerical code that is able to perform 2.5D simulations of a magnetohydrodynamic (MHD) wave propagation in the corona and its interaction with a low density region like a coronal hole (CH). We show that the impact of the wave to the CH leads to effects like e.g. reflection and transmission of the incoming wave or stationary features at the CH boundary. We present a comprehensive analysis of the morphology and kinematics of the secondary waves and their primary counterparts, i.e. we describe in detail the temporal evolution of density, magnetic field, plasma flow velocity, phase speed and position of the amplitude. Effects like reflection, refraction and transmission of the wave strongly support the theory that large scale disturbances in the corona are fast MHD waves and build the major distinction to the competing pseudo wave theory. Our simulation code is based on the so called Total Variation Diminishing Lax-Friedrichs (TVDLF) scheme, which is a fully explicit method and is proved to behave well near discontinuities.

ULF BURSTS ACCOMPANYING SOLAR WIND SUDDEN IMPULSES

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In this paper we analyzed the ULF bursts observed on April 23, 2002 immediately after a sudden magnetic impulse, caused by impact of the solar wind pressure jump on the Earth's magnetosphere. Polar measurements of plasma parameters and the magnetic and electric fields and simultaneous induction magnetometer data from the Sayan and Borok mid-latitude observatories were used. Polar satellite and the Sayan observatory were located at the moment of registering the burst near the midday meridian. Comparison of temporal variation and dynamic spectra of oscillations on the Earth and in space with variations in particle fluxes and their anisotropy made it possible to assume that as a result of the action of a sudden impulse, an excitation of a burst of ion cyclotron waves occurred. A packet of these waves ran along the magnetic field line to the conjugate point in the ionosphere, and then propagated in the ionospheric waveguide. These results are compared with another June 28, 1999 event, also associated with a sudden impulse. In this case, the pattern of the dynamic spectrum of the burst is characteristic not of ion cyclotron, but fast magnetosonic waves. Possible mechanisms for the excitation of bursts of either type are discussed.

MULTI-WAVELENGTH IMAGING OBSERVATIONS OF SOLAR BURSTS FROM A PECULIAR RING FLARING REGION ON 2014 DECEMBER 17

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The multi-wavelength imaging observations of the solar eruptions such as solar flares provide a method to diagnose the thermal and non-thermal radiation from the sun to the interplanetary space. Especially, the radio observations allow us to better understand the evolution of the flare eruption and its associated hypothesized electron acceleration sites, from eruption initiation to propagation into the corona. In this work, we present multi-wavelength imaging observations to analyse a M8.7 flare in a peculiar ring active region on 2014 December 17, such as the complicated loop systems and the associated eruptions in this particular ring active region in EUV wavelength (AIA/SDO), the imaging of microwave (NORH), X-ray (RHESSI) and radio source(MUSER), the fine structure of the radio dynamic spectrum and the related CME, and also show the discussions of the possible physical mechanisms and the connectivity of the multiple loop systems in/around the ring flaring region.

SOLAR K-CORONA POLARIMETRY OBSERVATIONS WITH METIS SOLAR ORBITER

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The study of the origin and the evolution of the dynamical phenomena taking place in the solar corona is the starting point for understanding their effects on the space weather of the Solar system. The solar wind and the coronal mass ejections (CMEs) propagate from the inner atmosphere of the Sun throughout the edges of the outer solar system, affecting the Earth environment and varying the conditions of the heliosphere. In order to characterize and model the coronal phenomena it is necessary to investigate the most relevant physical parameters of the corona, such as electron and ion densities, temperatures, and outflow velocities, as well as the magnetic field. The coronal electron density can be measured by observing the polarized broad-band visible-light emission of the K-corona. The polarized brightness (pB) of the K-corona provides a measurement of the electron density integrated along the line of sight. The radial speed of the neutral hydrogen in the solar wind could be derived by observing the HI Lymanα line-emission. The Metis coronagraph of the ESA/NASA mission Solar Orbiter, will observe the Sun closer than ever (up to 0.28 AU).

From this vantage point, Metis will observe for the first time simultaneously the full solar corona in the linearly polarized, broad-band visible light (580–640 nm) and in the narrow-band ultraviolet HI Lyman-α (121.6 nm). The scientific objective of the VL channel is the measurement of the coronal electron density. This quantity is the cornerstone measurements for deriving all the other physical parameters of the corona such as the solar wind speed from UV observations of the HI Lyman-α. This presentation describes the Metis polarimeter and the expected performances in measuring the K-corona pB to derive the coronal electron density. The observation of the K-corona's pB has the advantage over that of its sole brightness of reducing the coronal background and foreground along the line-of-sight, improving in this way the contrast of the coronal images. This presentation will illustrate this advantageand the implications for future space-weather instrumentation.

CONNECTION BETWEEN MAGNETIC FIELD TOPOLOGY AND CHEMICAL ANOMALIES IN STELLAR CORONAS

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We show that abundance of the chemical elements with the low first ionization potential (FIP) in corona of the late-type stars can be connected with the topological characteristics of the large-scale magnetic field. In particular, the solar-type stars shows the increase abundance of the low FIP elements relative to elements with the high FIP with the field). The branch of the fully convective stars demonstrates the different type of the large-scale magnetic activity. Those stars reveal the opposite phenomenon. Namely, they show the decreased abundance of the low FIP elements relative to the elements with the high FIP. Also, in the fully convective stars this effect seems to be saturated and it is independent on magnitude of the large-scale magnetic field.

COMPARISON OF CORONAL AND PHOTOSPHERIC ACTIVITY OF A VERY QUIET SUN

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We compare coronal and photospheric observations during very low solar activity in the period from February until November 2009. For investigations of the activity in the photosphere, we use Debrecen Photoheliographic Data. For studies of coronal activity, we review light curves from The Solar Photometer in X-Rays (SphinX) and Synoptic Composite Image Archive of X-Ray Telescope (XRT) on Hinode spacecraft. Results of data analysis show, once again, the importance of short wavelength solar observations in space weather nowcasting and forecasting.

THE LAMBDA EFFECT AND DOUBLE-CELL MERIDIONAL CIRCULATION STRUCTURE ON THE SUN

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Recent advances in the mean-field models of the solar differential rotation show a possibility for the double-cell meridional circulation pattern which could operates in each hemisphere of the solar convection zone. This finding is also suggested by the direct numerical simulations and by some results from helioseismology. In particular, Bekki & Yokoyama (2017) showed that the double-cell circulation pattern can results from inversion of sign of the non-diffusive part of the radial angular momentum transport in the lower part of the solar convection zone. Here, we argue that this inversion of sign of the Λ effect results from the radial gradients of the Coriolis force acting on the convective flows. Employing the standard solar interior model as input, we construct a model of solar differential rotation which shows the double-cell meridional circulation pattern. Developing this model further, we show results for a dynamically self-consistent nonlinear dynamo model which take into account the magnetic feedback effect on the differential and the meridional circulation.

Session 2: LONG-TERM VARIATION OF THE SUN, GEOMAGNETIC ACTIVITY, AND CLIMATE

SUNSPOT NUMBER SERIES REVISITED: WHERE ARE WE?

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Until recently, the sunspot number (SN) series known as Wolf (WSN) or International (ISN) one, was the gold standard for generations of scientists to represent solar variability. Later, a group sunspot number (GSN) series was produced by Hoyt and Schatten (1998). However, as became clear lately, both earlier SN series need revision. Revisions were made in different directions leading to diverse SN reconstructions which differ essentially between each other. At present, seven different SN/GSN series circulate around, with a lack of a consensus one. Various SN series differ in the following issues: Datasets: while WSN/ISN series are not fully reproducible, since the raw information is not available, GSN series are based on a raw data database, which has been recently updated; Methodology: Two different methods are used to compile a composite SN series: daisy-chain linkage and direct active-day fraction method; Calibration: While most of the old series were based on the linear k-factor (ordinary least square regression forced through the origin) calibration of different observers, modern conversion matrix method has been developed; Verification: Many series do not provide a realistic estimate of uncertainties, some other do. Accordingly, the output of various series may differ significantly between each other. The present level of knowledge of the long-term sunspot variability is quite uncertain, and collective efforts are needed to reach a community consensus. The current status of the SN reconstructions for the last century is presented here with an outline of advantages and disadvantages of different approaches.

CURRENT STATUS OF SCOSTEP/VARSITI — VARIABILITY OF THE SUN AND ITS TERRESTRIAL IMPACT (2014–2018)

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The Scientific Committee On Solar-TErrestrial Physics (SCOSTEP) operates the unique scientific program "Variability of the Sun and Its Terrestrial Impact" (VarSITI) in 2014–2018 to focus on the recent and expected future solar activity and its consequences for Earth, for various time scales from the order of thousands years to milliseconds, and for various locations and their connections from the solar interior to the Earth's atmosphere. Four scientific projects are carried out under the VarSITI program: (1) Solar Evolution and Extrema (SEE), (2) International Study of Earth-Affecting Solar Transients (ISEST/MiniMax24), (3) Specification and Prediction of the Coupled Inner-Magnetospheric Environment (SPeCIMEN), and (4) Role Of the Sun and the Middle atmosphere/thermosphere/ionosphere In Climate (ROSMIC). In order to elucidate various Sun-Earth connections, VarSITI has encouraged close communications between solar scientists (solar interior, atmosphere, and heliosphere) and geospace scientists (magnetosphere, ionosphere, and atmosphere). We have carried out observation/data analysis campaigns for

particular intervals, such as ISEST/Minimax24 campaign (http://solar.gmu.edu/heliophysics/index.php/The_ISEST_Event_List) for Earth-affecting solar transients, ICSOM campaign (http://pansy.eps.s.u-tokyo.ac.jp/icsom/) for interhemispheric coupling during stratospheric sudden warming, and ERG-ground campaign for the dynamics of inner magnetosphere. We have supported more than ten VarSITI-related meetings and several campaign and database constructions every year using the SCOSTEP/VarSITI grants. VarSITI mailing list, which contains ~900 mail addresses from ~70 countries, was constructed for communications among scientists on various fields. VarSITI newsletters have been published every three months to introduce new scientific results, young scientists newly joined into the VarSITI science, and meeting reports. About 130 databases are registered for VarSITI-related research activities. All this information is available at the VarSITI web pages at http://www.varsiti.org/. After the first three years of the VarSITI program, various outstanding results has been obtained, such as solar dynamo simulations, imaging measurements of earth-affecting solar transients, high-energy particle precipitation on the Earth's atmosphere and its consequence on the ozone and other constituents in the upper and middle atmosphere, and effects of lower atmosphere to the thermosphere and ionosphere through the middle atmosphere. In the presentation we will review these various recent results obtained during the VarSITI period.

VARIABILITY OF THE X-RAY SUN FROM THE SOLAR ATMOSPHERE

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I have analyzed the time series of full disk integrated soft and hard X-ray emission from the solar corona during 2004 January 1 to 2009 December 31, covering the descending phase of solar cycle 23 from global point of view. I employed the daily X-ray index (DXI) derived from X-ray observations from the "Solar X-ray Spectrometer" (SOXS) mission in three different energy bands: 4–5.5 keV (soft X-rays) and 15–20; 20–25 keV (hard X-rays). The application of Lomb–Scargle periodogram technique to the DXI time series observed by the Si detector in the energy bands reveals several short- and intermediate-periodicities of the X-ray corona. The DXI explicitly show the periods of ~13.6 days, ~26.7 days, ~128.5 days, ~151 days, ~180 days, ~220 days, ~270 days, ~1.24 year and ~1.54 year periods in soft X-ray as well as in hard X-ray energy bands. Although all periods are above 70 % confidence level in all energy bands, they show strong power in hard X-ray emission in comparison to soft X-ray emission in accordance to Chowdhury et al. These periods are explicitly clear in all energy bands. The flare activity Rieger periods of ~150 and 180 and near Rieger period of ~220 days are very strong in hard X-ray emission, which is very much expected. On the other hand, our current study reveals strong 270-day periodicity in soft X-ray emission, which may be connected with tachocline, similar to fundamental rotation period of the Sun. The 1.24-year and 1.54-year periodicity observed from my research work is well observed in both soft as well as in hard X-ray channels. These long-term periodicities must also have connection with tachocline and should be regarded as a consequence of variation in rotational modulation over long time scales. I gratefully acknowledge support by the Indian Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP, the Centre is affiliated to the United Nations), Physical Research Laboratory (PRL) at Ahmedabad, India. This work has done under the supervision of Prof. Rajmal Jain and paper consist materials of pilot project and research part of the M. Tech program which was made during Space and Atmospheric Science Course.

CONTRIBUTION OF TSI, SOLAR UV AND ENERGETIC PARTICLES TO EARLY 20TH CENTURY CLIMATE AND OZONE LAYER EVOLUTION

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The early 20th century warming is visible in several observation data sets but the mechanisms causing this phenomenon remain unclear. During this period the climate system behavior was controlled by the increase of greenhouse gases, recovery after preceding volcanically active period, steady increase of solar magnetic activity. The former presumably leads to increase of solar irradiance and geomagnetic activity followed by more intensive energetic electron precipitation and decrease of ionization by galactic cosmic rays. To elucidate the role of different anthropogenic and natural forcing we performed several atmosphere-ocean chemistry-climate model (AOCCM) SOCOL-MPIOM runs driven by different combinations of forcing. In this talk we will compare the contributions of energetic particles and solar irradiance. The ionization rates and influx of NOx from the thermosphere were taken from the dataset prepared for IPCC CMIP-6. The solar irradiance time series was reconstructed from the solar modulation potential and sunspots time series. The obtained model results allow estimating the main drivers of climate and ozone changes in the first half of the 20th century. Preliminary results showed that the contribution of energetic particles is more important for the surface climate over the northern landmasses than solar UV, but over the oceans the contribution from the visible and infrared solar irradiances dominates. We show that the treatment of energetic particles leads to better agreement of the simulated surface air temperature trends over Europe and Eastern US with observations. The comparison of the simulated and observed total ozone evolution will be also discussed.

MODERN DALTON MINIMUM AND DISASTER RISK ON CLIMATE CHANGE

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The global warming caused by the green-house gases effect will be equal or less than the global cooling as a result of the current era of weak solar activity. In this respect, we refer to the Modern Dalton Minimum (MDM), according to which the earth's surface temperature will become cooler than nowadays, starting from the year 2005 until the year 2050. However, the degree of cooling, previously mentioned in old Dalton Minimum (c. 210 y ago), will be minimized by building-up of green-house gases effect during the MDM period. Regarding to the periodicities of solar activities, it is clear that now we have a new solar cycle of around 210 years. This paper analyses solar-X activity data given by GOES satellite to predict the incoming effects of the MDM on the climate change, global precipitation and the change of dryland areas all over the Earth surface.

TIME AND SPATIAL PATTERNS OF SOLAR VARIABILITY INFLUENCE ON THE EARTH'S CLIMATE

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One of the potential contributors to the climate change is solar activity variability associated with the low-to-high solar irradiance input to the Earth. We discuss the time and spatial patterns formed in the Earth's climate system under the solar variability forcing on time scales from 11-year solar cycle to the centennial solar variability such as the Centennial Gleissberg Cycle (CGC), a 90–100 year variation of the amplitude of the 11-year sunspot cycle observed on the Sun, solar wind, and at the Earth using the Total and Spectral Solar Irradiances reconstructed for over three centuries. The Earth's climate response to the prolonged low solar irradiance involves heat transfer to the deep ocean with a time lag longer than a decade. We identify the timing and spatial pattern of the Earth's climate response that allows distinguishing the solar forcing from other climate forcing and discuss the spatial and time correlation of the patterns induced by solar forcing with the naturally formed climate patterns such as NAM, PNA and PDO.

PROGRESS IN LONG-TERM TRENDS IN THE MLT REGION

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The increasing atmospheric concentration of greenhouse gases results in long-term changes not only in the troposphere; it affects also the mesosphere and lower thermosphere (MLT) and the embedded part of the ionosphere. Progress in investigating long-term trends in the MLT region will briefly be reviewed. There are also secondary trend drivers like ozone, geomagnetic and solar activity, atmospheric waves coming from below, and water vapor. Their unstable behavior makes the investigation of trends more difficult and trends themselves less stable. Among important areas of progress we may include the first satellite observations of carbon dioxide trends in the MLT region, better understanding and simulation of the observed impact of ozone on trends, substantially better agreement of most recent model simulations of trends with observations, better knowledge and simulation of trends in polar mesospheric clouds, and some other results to be presented in the talk.

FORMATION OF POLAR CORONAL HOLES IN CYCLE 24

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Asynchronous reversal of the Sun's polar fields in the current cycle and asymmetry in the formation of polar coronal holes are studied. A stable coronal hole was first formed at the South Pole, despite the later polar-field reversal there. On the basis of a synoptic map analysis, we study causal relationships between decay of activity complexes, evolution of large-scale magnetic fields, and formation of coronal holes. Ensembles of coronal holes are usually associated with decaying activity complexes. After the polar-field reversals, the Sun's open magnetic flux rearranges globally. During this period, ensembles of coronal holes interact with activity complexes, forming trans-equatorial corridors through which the open magnetic flux redistributes between the hemispheres. High-latitude ensembles merge with polar coronal holes, increasing their areas until the end of a cycle. Analysis of cause-and-effect relationships showed that the south polar coronal hole was formed from coronal holes originated after the decay of multiple activity complexes observed during 2014. High-latitude unipolar magnetic regions of opposite polarities resulted in a complicated magnetic configuration in the northern polar zone. This delayed formation of the polar coronal hole for 1.5 year. During the declining phase of the current cycle, the stable polar coronal holes formed extensions that reached opposite hemispheres. Despite low sunspot activity in the current cycle, these huge coronal holes produced solar wind streams, which led to recurrent geomagnetic storms.

THE SUN'S POLAR-FIELD REVERSAL IN THE CURRENT CYCLE: THE EFFECTS OF NORTH-SOUTH ASYMMETRY OF SUNSPOT ACTIVITY

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In order to study the Sun's polar-field reversal, we analyzed synoptic data from the Vector Stokes Magnetograph (VSM) of Synoptic Optical Long-term Investigations of the Sun (SOLIS) and the NASA SDO/HMI facility. Development of solar activity in the current cycle made it evident that the North–South asymmetry of sunspot activity resulted in an asynchronous reversal of the Sun's polar field. The decay of activity complexes in late 2011 and 2014 were of crucial importance for the polar-field reversals at the northern and southern poles. After decay of multiple activity complexes, the surges of trailing polarities reached the Sun's poles and led to the polar field reversals. Then two leading-polarity surges reached the northern polar zone and led to mixing of magnetic polarities there. The leading-polarity surges originated due to low-latitude magnetic bipoles, which are characterized by negative tilt angles contrary to Joy's law. The north-south asymmetry also appears in the polar-flux imbalance. Unlike the southern polar zone, the flux imbalance near the North Pole shows no cyclic changes and varies about zero. Such polar-flux imbalance reveals one more peculiarity of the current cycle. Amplitude of cumulative flux imbalance at the North Pole is less by factor of five as compared to that at the South Pole. The unusual behavior of the imbalance is caused by low sunspot activity and the violations of Joy's law, which resulted in weak polar field of mixed polarities near the North Pole.

LONG-TERM RELATIONSHIP BETWEEN DOMINANT IMF SECTOR STRUCTURE AND IONOSPHERE VARIABILITY

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IMF B_z component serves as a crucial factor to understand the IMF sector related solar-terrestrial phenomena since the solar wind energy transfer into the magnetosphere is favored by the negative IMF B_z component (towards the Earth) and resisted by the positive B_z component (towards the Sun). In this study, the perturbations of the ionospheric critical frequency, f_oF2, at Moscow are analyzed regarding the IMF Sector Structure (IMF-SS), specified by the Leif Svalgaard's list of sector boundaries (http://www.leif.org/research/sblist.txt) and the half-day dominant sign of B_z retrieved from the polar geomagnetic observations (http://www.izmiran.ru/stp/polar/SSIMF/). The half-day IMF-SS is estimated from the magnetometer measurements at Churchill and Vostok observatories where the polar diurnal geomagnetic variations serve as a proxy of sign of B_z for the IMF sector surrounding the Earth (Mansurov and Mansurova, 1970; Svalgaard, 1976). The long-term IMF-SS characteristics for 1958–2017 show dominant positive $B_z > 0$ (towards the Sun) half-day periods as compared to $B_z < 0$ with this trend growing from the 19th to 24th solar cycles. Relevant Catalogue of f_oF2 disturbances at Moscow (http://www.izmiran.ru/ionosphere/weather/dat5/dist_mos.txt) is analyzed for the positive and negative IMF B_z during the 23rd-24th solar cycles demonstrating association of the mid-latitude ionosphere variability with the IMF-SS sector structure.

IMPACT OF EPP AND GCRs ON ATMOSPHERIC ELECTRIC CIRCUIT AND CLIMATE

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The summary and progress on the topic "Direct and Indirect Impact of energetic particle precipitation (EPP), galactic cosmic rays (GCRs) and Electric Circuit on Climate" will be presented here. The overview of the main advances will cover subjects defined as:

- Observations of energetic particles in the Earth atmosphere;
- Atmospheric ionization by energetic particle precipitation;
- Impact of EPP and GCRs on the Global Electric Circuit;
- Definition of energetic particles inputs for climate modeling;
- Impact of energetic particles on climate.

Finally open questions and summary coming out will be presented as a conclusion.

INTENSE GEOMAGNETIC STORM EFFECTS ON THE NORTH ATLANTIC OSCILLATION

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Considering the solar activity level, the association between short-term variability in the North Atlantic Oscillation (NAO) and intense geomagnetic storms is analyzed using daily data records. The NAO, being the dominant pattern of variation in atmospheric circulation in the North Atlantic basin, results in a large-scale modulation of the normal patterns of heat and moisture transport especially in winter. It determines changes in temperature and precipitation in a great area from eastern North America to Central Europe. A positive correlation between long-term variations in several studies the NAO and geomagnetic activity has already been shown in several studies. However, at daily timescales, from the study of more than 200 geomagnetic storms we observe a decrease in the NAO index coincident with the maximum intensity of the geomagnetic storm. An explanation of our results is given through the upper atmosphere processes induced by geomagnetic storms followed by coupling mechanisms among the different atmosphere regions, reaching finally the troposphere, in the context of an overall increasing trend which may be due to anthropogenic activity. A possible explanation would be that the NAO decrease due to geomagnetic storms is highly localized in time at daily scales and the high positive correlation between geomagnetic activity indices and NAO, especially after 1970, is due merely to a coincidence of increasing trends in both parameters.

NORTH ATLANTIC OSCILLATION VARIABILITY LINKED TO THE AURORAL ELECTROJET INDEX, AE

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The possible association between the North Atlantic Oscillation (NAO) variability and the auroral electrojet index, AE, is analyzed. The NAO is the dominant pattern of variation in atmospheric circulation in the North Atlantic basin. This oscillation results in a large-scale modulation of the normal patterns of heat and moisture transport, especially in winter, which determines changes in temperature and precipitation in a great area from eastern North America to Central Europe. A positive correlation between long-term variations in the NAO and geomagnetic activity has already been shown in several studies, using the aa index. In the present work, the AE index is used instead, which monitors the auroral electrojets in the Northern hemisphere (a measure of global electrojet activity in the auroral zone). An explanation of our result is given through the upper atmosphere processes induced by geomagnetic storms followed by coupling mechanisms among the different atmosphere regions, reaching finally the troposphere, in the context of an overall increasing trend which may be due to anthropogenic activity.

SUNSPOT NUMBER: THE ONGOING MODERNIZATION OF A LONG-TERM REFERENCE

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Since July 2015, a new entirely recalibrated version of the sunspot number series (Version 2.0) has replaced the original static record of past solar activity (http://sidc.be/silso). The simpler but longer group number series was also updated, leading to two main multi-century reconstructions. This also marked a fundamental transition towards a continuous research-driven upgrading process, equivalent to other modern astronomical standards like the total solar irradiance. After presenting the changes introduced to the original series, we discuss the remaining inconsistencies between the sunspot and group number series published over recent months. Although the main inhomogeneities are now established and corrected (drifts and jumps around 1885 and 1947 and after 1981), several inconsistencies and uncertainties remain. In particular, the early part of the series before 1826 suffers from larger uncertainties and also from the scarcity of data over a few critical time intervals. New more advanced statistical methods, like non-linear regression or re-normalization, are also introduced to replace the past classical mean k ratios for normalizing the data from individual observers. In order to continue this work, a coordinated effort was initiated in 2017 and will be articulated around several thematic working groups and a cycle of dedicated workshops. We conclude on the current early progresses of these expert groups and we outline the key advances to be expected in the upcoming new update of the sunspot record (Version 3.0) and the possible implications for solar and solar-terrestrial research.

EXTREME SOLAR EVENTS: DEBATE ON VALIDITY, ORIGIN AND PROPERTIES

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Modern concept of Extreme Solar Event (ESE) is critically analyzed based on available direct and proxy data on solar cosmic rays (SCR), or solar energetic particles (SEP). Special attention is paid to recent debate on validity, origin and properties of the events AD775 and AD1859 (Carrington event). We demonstrate that, in spite of existing uncertainties in proton fluences above 30 MeV, all of them are fitted well by a unique distribution function, at least, with present level of solar activity. Extremely large SEP fluxes are shown to obey a probabilistic distribution with a sharp break in the range of large fluences (or low probabilities). The studies of this kind may be extended for the periods with different levels of solar activity in the past and/or in the future. Considering the recent confirmation of super-flares on solar-type stars, this issue merits attention.

SOLAR VARIABILITY MANIFESTATIONS IN WEATHER AND CLIMATIC CHARACTERISTICS

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Studies of solar activity influence on weather and climate has got a long history. Nevertheless, the question of whether solar activity contributes significantly to weather and climate change is still debatable. We discussed the main physical processes responsible for climate changes in the 20th century, and the issues that are of primary importance for understanding the nature of these changes. Most papers dealing with study of SA possible contribution to changes in climatic characteristics, consider the solar constant (SC) as the solar activity (SA) index in. However, SC changes (0.1 %) cannot contribute much to the observed global temperature variations. The ISTP proposed another mechanism of the SA influence on the climate and developed a physical model. The model key concept is the SA influence on the Earth's climate system parameters controlling the outgoing long-wave radiation in high-latitude regions. According to measurements of the atmospheric electricity parameters during geomagnetic disturbances, as well as during invasion of large fluxes of solar cosmic rays in polar latitudes, there is a significant increase in the tropospheric electric field and the ionosphere—Earth current. Changes in the electric field exert influence on vertical distribution of charged aerosols, which are the condensation nuclei and, hence, may affect the conditions of cloud formation and radiation balance in high-latitude regions. Hereby, there are changes in the thermobaric field of the troposphere, and in meridional temperature gradient, determining the meridional heat transport. As a result, the Earth's climate system heat content and the global climate are changing. We present and discuss the results of analysis of regularities and features of the troposphere and sea surface temperature reactions both to some heliogeophysical disturbances, and to long-term changes in solar and geomagnetic activity. New proofs of solar activity influence on climate processes in the ocean and troposphere are found. We revealed a reliable response to the SA influence in the main climatic characteristics: surface temperature, sea surface temperature, and precipitation. It has been determined that the climatic response to the solar and geomagnetic activity is characterized by significant space-time irregularity; the response is regional and depends on the general circulation of atmosphere. We showed that SA contributed significantly to the global climate change basically during the first warming period in the 20th century (1910–1943). This period is characterized by a significant positive trend in the level of geomagnetic activity; the activity was the highest over the entire period considered (1868–2015), which matched the increased meridional heat transport in the North Atlantics.

SPACE CLIMATE IN THE HELIOSPHERE-MAGNETOSPHERE ENVIRONMENT. CONSEQUENCES IN SOLAR CYCLE 24

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Space climate characterizes long-term variability in the heliosphere-magnetosphere environment. Our previous studies showed that the parameters describing this environment evolved at timescales related to the magnetic (Hale) solar cycle and to Gleissberg solar cycle. In this study we use the Hodrick-Prescott (HP) and Butterworth filtering to get the long-term variations, at inter-decadal (22 years) and sub-centennial (80-90 years) timescales, in several heliospheric (heliospheric magnetic field intensity, solar wind speed), and magnetospheric (geomagnetic indices which describe electric current systems in the magnetosphere or ionosphere and the variable geomagnetic field with external sources given by COV-OBS.x1 geomagnetic model) parameters. We show that the actual trend in space climate is given by the superposition of the inter-decadal and sub-centennial variations on the long-term inter-centennial trend.

INVESTIGATION OF SEASONAL TREND ANOMALIES IN MIDLATITUDE IONOSPHERE USING DROT

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Solar radiation is the most dominant contributor of ionospheric trend in diurnal, seasonal, annual and 11-year cycles. Seasonal variability can deviate from expected trends with disturbances named as anomalies. Total Electron Content (TEC) is one of the most commonly used observables of ionospheric variability. TEC can be estimated from worldwide dual frequency Global Positioning System (GPS) receivers which allow a dense representation of trend anomalies in midlatitude regions. Differential Rate Of TEC (DROT) is a promising method in detection of disturbances. DROT method is based on the ratio of smoothed detrended derivative of TEC to low-pass filtered Rate Of TEC (ROT). Typically, for 40 % < DROT <55 %, minor and singular disturbances can be present. For 55 % < DROT <75%, moderate disturbances can be observed. DROT values that are larger than 75 % are indicators of severe disturbances and extreme deviations from typical diurnal trend of TEC. In this study, DROT is applied to a number of GPS stations located in mid-latitude regions of Northern and Southern hemispheres during 23rd and 24th solar cycles. It is observed that the value of TEC increases during solar active years, and the amplitude of deviation becomes less significant. During solar minimum years, the variability in TEC due to activities other than solar variability becomes dominant. Thus, the typical annual average value is around 55 % to 60% (moderate) for a solar maximum year, whereas the same value rises to 75 % for a solar minimum year. The highest values are observed during winter (summer) months for Northern (Southern) Hemisphere. DROT values start to decrease after Spring (Autumn) Equinox for Northern (Southern) Hemisphere and reach to a local minimum during April and May (October and November) for Northern (Southern)

Hemisphere. An increasing (decreasing) trend is observed after November where a maximum (minimum) is reached with December for Northern (Southern) Hemisphere. Deviations from the expected diurnal behavior of TEC such as winter night time anomalies or bite-out phenomena increase the value of DROT to moderate and severe disturbance levels that can last for a number of consecutive days. Therefore, it can be concluded that DROT can serve as an indicator of deviation from the diurnal trend due to seasonal variability and it can also help to classify the single event upset type disturbances such as geomagnetic storms and seismic activities.

ON THE POSSIBILITY TO PREDICT THE FUTURE SUNSPOT MAXIMUM

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The influence of solar activity on the Earth's magnetic field has been studied for many years. It was found that there are two main factors causing geomagnetic storms: coronal mass ejections whose probability is proportional to the number of sunspots, and high speed solar wind streams. As the times of the sunspot maximum and the high speed solar wind streams maximum do not coincide, there are two geomagnetic activity maxima in each 11-year solar cycle. In the present work we regard the Earth as a probe immersed in the solar wind, and based on the data for the time interval between the sunspot maximum and the geomagnetic activity maximum in the declining phase of the sunspot cycle n, and the value of the minimum geomagnetic activity in the beginning of sunspot cycle n+1, we forecast the maximum of cycle n+1.

LONG TERM VARIATIONS IN THE RATIO BETWEEN THE NUMBER OF SUNSPOTS AND THE NUMBER OF SUNSPOT GROUPS

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The sunspots are the most obvious manifestation of solar activity, and the one with the longest instrumental data record. Until very recently, two indices were used to quantify the sunspot activity: the Zurich International sunspot number introduced by Wolf, based on the number of the observed individual sunspots and the number of sunspot groups, and the Group sunspot number, based solely on the number of the observed sunspot groups. The long-term variations of these two indices diverge, which can be either a manifestation of variations in the operation of the solar dynamo, leading to variations in the average number of sunspots per sunspot group, or an artifact of changes in observers, pilot observatories, instruments, observational routines, calculation schemes, etc. We use data from three observatories with continuous and homogeneous data to study this problem.

VARIATIONS OF THE SOLAR SPECTRUM IRRADIANCE IN THE VISIBLE AS OBSERVED WITH SOLAR/SOLSPEC DURING CYCLE 24

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The solar spectral irradiance (SSI) and its temporal variations are of prime importance to apprehend the physics of the Sun and to understand its effects on Earth climate through changes of atmospheric properties. Ground based measurements of SSI are indeed affected by the Earth atmosphere; space observations are therefore required to perform adequate observations. Only a few long series of SSI space measurements were obtained these last decades. The SOLSPEC instrument of the SOLAR payload on the International Space Station (ISS) has recorded one of them from April 2008 to February 2017 (last measurements the 15th) covering almost the whole solar cycle 24. The instrument is a spectro-radiometer recording data of the Sun from 166 to 3088 nm. Operated from the ISS in a harsh environment, it needed appropriate processing methods to extract significant scientific results from noise and instrumental effects. We present the original methods used to process the data to evidence visible SSI variations during cycle 24. We then discuss the results obtained showing SSI variations in phase with solar activity.

PROPERTIES OF FILAMENTS IN SOLAR ACTIVITY CYCLES N 15–24

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The series of solar filaments characteristics is represented. This series is obtained by processing of daily observations in the H-alpha line according to the Kodaikanal observatory in Kodaikanal (India, 1912–2002). The series is complemented by database of filaments properties according to Kislovodsk for the period 1959–2016, Sacramento Peak (USA, 1962–2002) and Meudon (France, 1982–2015). These data are unique because they trace the polarity inversion line which helps to identify the large-scale organization of the solar magnetic field. To select solar filaments boundaries, we have developed methods based on automatic allocation procedures of low-contrast objects on the solar disk, and methods of editing the selected structures in semi-automatic mode. More than 24 thousand photographic plates were processed in total for Kodaikanal with more than 326 thousand filaments being allocated. Comparative analysis of solar filaments characteristics in 15–24 cycles of activity was carried out. The connection of solar filaments indices and long-term parameters of space weather is considered.

RADIO EMISSION OF ACTIVITY COMPLEXES ON THE SUN IN mm- AND cm- WAVES

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Activity complexes (CA) and complexes of active regions (CAR) on the Sun are among the largest scales in the manifestation of solar activity. Here are the most powerful manifestations of solar activity as a result of the interaction of various cores of activity inside the complex. Currently they are defined according to the data of cosmic orbiting solar observatories SOHO and SDO by UV and x-ray radiation in the corona. Radio maps of the Sun on millimeter and centimeter wavelengths allow the identification of CAO and CA and at lower levels in the chromosphere and the corona. This allows to connect a manifestation of activity from under photosphere levels convection zone to magnetosphere complexes in the solar chromosphere and Corona. In this paper, the technique of identifying complexes is presented and the dynamics of their activity in radio emission according to observation data of stations of the international Sun radio service KRIM: RT-22, RT-2, RT-3, PT-m (since 1957) in the Department of radio astronomy and Geodynamics of the Crimean Astrophysical Observatory, Metsahovi Radio Astronomy Observatory on RT-14 (37 GHz), Radioheliographs Nobeyama(17 and 34 GHz) and SSRT (Irkutsk, 5.1 GHz). A feature of these data is that they allow to explore the dynamics of development of activity complexes from the 20th activity cycle when space observatories have not worked yet.

HURRICANES OVER ATLANTIC REGION DURING 1851–2010 AND SOLAR INFLUENCE ON IT

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The analysis of hurricane frequency during 1851–2010 reveals (1) It increases monotonically from 1851 up to 1910, then it begins to decrease slowly (2) Monthly variation also exists namely, the frequency is much more during august to October, September being the month of maximum Hurricane. The reverse is the situation during December to June. The 30 years variation study shows that in 1941–1970 and 1971–2000 total hurricane were maximum. The analyse of the rates of change of frequency shows that the rate monotonically increases since 1851 the max. Being during 1971–2000 (1.22 per yr. approx.). But after that it began to decrease. Another very interesting aspect is that the frequency of hurricane is found to decrease .When Solar activities are increased i.e. when Sun's Spot Number increases calculate the decadal frequency study shows that from it was less than 10 before 1991 but more than 10 after 1991 and during 2001–2010 it was 13.3. A very striking feature is that the average frequency over the time of solar maxima is 8.3 which is less than the normal average (8.8) but average over solar minima years is (9.53). Evidently, these suggest adverse effect of solar activities on hurricane formation. This is similar to the resistance found in cyclone formation. Possibly the solar hot material produces this resistance to the formation of hurricane/cyclone.

SCIENTIFIC HIGHLIGHTS FROM ROMIC

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The German Federal Ministry of Education and Research (Bundesministerium fur Bildung und Forschung, BMBF) has launched a research initiative in 2013/2014 called ROMIC (Role of the Middle Atmosphere in Climate). The aim of ROMIC is to improve our understanding of long term variations in the stratosphere, mesosphere, and lower thermosphere and to investigate their potential role for climate changes in the troposphere. This includes to study coupling mechanisms between various layers and the relative importance of anthropogenic and natural forcing, e.g., by the Sun. Scientists at a total of 15 research institutes in Germany are involved and cover a large range of experimental and theoretical topics relevant for ROMIC. Some scientific highlights from the research projects within ROMIC will be presented.

ANALYSIS OF VARIATIONS OF EARTH'S MAGNETIC FIELD PRODUCED BY EQUATORIAL ELECTROJETS IN SUDAMERICA

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Observations of the magnetic field in Huancayo in 1922 demonstrated the existence of the Equatorial electro jets, which is a narrow band of electrons traveling east to west 180 km above the Earth's surface by a belt along dip equator. Wind-driven currents, through the dynamo mechanism, produce an accumulation of positive charges at sunrise and negative at sunset, which translates into considerable variations in the geomagnetic field. In this study, we have used the Earth magnetic field (MG) data provided by Jerusalem station located in Ecuador, above the geographic equatorial line, in order to study its secular variation founding an strong correlation with sunspots number which indicates the influence of solar activity on the Earth's ionosphere. We also have used the magnetic field data from others 5 magnetic stations in order to study for first time the latitudinal dependence of the EEJ current and its morphological features in SudAmerica. We have found that the average electrojet current is symmetrically distributed along 25 degrees around the position of the peak of intensity, so that the jet extends from -10 To 15 degrees in magnetic latitude and the maximum intensity measured experimentally was in the station of Huancayo by its proximity with the dip equator.

THE LARGE SYMMETRIC SUNSPOT GROUPS AS POSTDICTORS OF ACTIVE LONGITUDES AT THE SUN DISC

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This paper considers a longitude distribution of sunspot groups over 1982–2015, using data from the National Geophysical Data Center (Boulder, USA). The space-time distribution of sunspot groups is analyzed in coordinate sectors calculated from heliographic longitudes of the groups. A longitude extent of a coordinate sector is compared to the average size of one active region (30–40°). Then, in each coordinate sector, evolutionary activity of sunspot groups is summarized according to classification values after Malde (CV) throughout the observation period. The longitude distribution of large sunspot groups plotted in such a way does not reveal anticorrelation between Northern and Southern hemispheres in sunspot cycle 23. More than five thousand large symmetric sunspot groups of the Boulder classifications CHO, DHO, EHO, FHO and HHX have been detected under the NGDC program. The average CV (43.72±4.44), the average number of sunspots in a group (6.54±7.10), and the average total area of groups (278±207 millionths of a solar hemisphere) suggest that the first of the listed indices allows us to consider simple groups with a large symmetric sunspot as postdictors of the intense process of sunspot formation in previous solar rotations. Consequently, we can analyze the statistics on longitude-time distribution of groups of large sunspots, using average CV for such a sunspot class.

SOLAR CYCLE PREDICTIONS AND PREDICTABILITY

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How strong will the next solar cycle be? The one after that? How certain are we in our answers?In this talk I will review some previous work aimed at answering these questions and why the problem is difficult. Infernces based on high-resolution observations of today, sunspot drawings up to 400 years old, isotope records going back about 10000 years and stellar observations will be combined in an attempt to come to a conclusion.

THE EXPECTED FLUXES OBSERVED BY STIX DURING DEEP MINIMUM OF SOLAR ACTIVITY

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The Spectrometer Telescope for Imaging X-rays (STIX) installed onboard Solar Orbiter mission will be launched in the autumn 2018. The instrument is designed for imaging and spectroscopy of solar X-ray sources in the energy range 4-150 keV. After three years of cruise phase it will start to gather scientific data from the orbit with perihelion distance about 0.3 AU. The first scientific phase of the mission will last three years and after which extended phase of the mission is expected. It means that STIX will operate also during the next solar minimum. For maximizing scientific output of the instrument we have to define observing modes for every expected scenario. Therefore we decided to estimate fluxes measured by the instrument during periods of extremely low solar activity. For this purpose we used real measurements which were conducted by the Solar Photometer in X-rays (SphinX), instrument designed to observe soft X-ray solar emission in the energy range between 1.2 keV and 15 keV with the resolution better than 0.5 keV. The SphinX operated from February until November 2009 aboard CORONAS-Photon satellite, during the phase of exceptionally low minimum of solar activity. Despite a very low activity about 1600 small X-ray events have been recognized by semi-automatic inspection of SphinX light curves. Many of them were registered above 4 keV STIX threshold. With a use of SphinX data we were able to estimate fluxes that will be observed by STIX during a period of low solar activity and define the observational modes which will allow us to gather valuable spectra and effective image reconstruction.

SOLAR/SOLSPEC 9 YEARS OF SOLAR SPECTRAL IRRADIANCE FROM SPACE: NEW REFERENCE SPECTRA IN UV AND IR, AND VARIABILITY RESULTS

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Since April 5, 2008 and until February 15, 2017, the SOLSPEC (SOLar SPECtrometer) spectro-radiometer of the SOLAR facility on the International Space Station performed accurate measurements of Solar Spectral Irradiance (SSI) from the far ultraviolet to the infrared (165–3088 nm). These measurements are of primary importance for a better understanding of solar physics and of the impact of solar variability on climate (via Earth's atmospheric photochemistry), noticeably through the top-down mechanism amplifying ultraviolet (UV) solar forcing effects on the climate (UV affects stratospheric dynamics and temperatures, altering interplanetary waves and weather patterns both poleward and downward to the lower stratosphere and tropopause regions). SOLAR/SOLSPEC with almost 9 years of observations covered most of the unusual solar cycle 24 from minimum in 2008 to maximum, establishing

new reference solar spectra in UV (165–400 nm) and in infrared (656–3088 nm), thanks to revised engineering corrections, improved calibrations and advanced procedures to account for thermal, aging and pointing corrections. In addition, the quality and high sensitivity of SOLSPEC data, allow to follow temporal variability in UV (165–400 nm) in several wavelengths bands, in infrared and, even, in visible. Uncertainties on these measurements are evaluated and results are compared with other instruments and models.

THE FUTURE OF SOLAR SPECTRAL IRRADIANCE MEASUREMENTS IN THE ULTRAVIOLET WITH THE SOLSIM DOUBLE-MONOCHROMATOR

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Solar Spectral Irradiance (SSI) measurements in the ultraviolet (UV), and their variability, are of prime importance to quantify the solar forcing on climate through radiation and their interactions with the local stratosphere, noticeably through the top-down mechanism amplifying UV solar forcing effects on the climate (UV affects stratospheric dynamics and temperatures, altering interplanetary waves and weather patterns both poleward and downward to the lower stratosphere and tropopause regions). SOLSIM (SOLar Spectral Irradiance Monitor) is a newly designed double-monochromator instrument covering the 170–340 nm ultraviolet spectral range. It is an enhanced and optimized version of the previously flown SOLSPEC (SOLar SPECtrometer) instrument externally mounted on the Columbus module of the International Space Station from 2008 to early 2017. While SOLSPEC had 3 double-monochromators to cover the UV to the infrared, the SOLSIM spectrometer is covering only the UV from 170–340 nm but with an almost constant and higher spectral resolution (0.5 nm or better), and in within reduced dimensions and a smaller mass (8 kg). To avoid thermal issues with the instrument, a sun-synchronous polar orbit 18h-6h at 700–750 km (for almost constant observing) is preferred to the Space Station (SOLSIM is part of the model payload of several missions to be proposed to CNES, ESA and NASA on small platforms). Characteristics, performances and calibrations foreseen for this new generation SSI instrument will be presented.

LONG-TERM TRENDS IN THE MIDDLE ATMOSPHERE OBSERVED USING GROUND BASED AND COMBINED SATELLITE MEASUREMENTS

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In recent years, the middle atmosphere (10–100 km) has evoked great scientific interest as long-term changes due to global warming can be clearly captured due to the large perturbation amplitudes at these altitudes. We have investigated the long-term trends and variability of the stratospheric ozone, water vapor and temperature over the Indian monsoon region (IMR) using

the long data constructed from multi satellite (Upper Atmosphere Research Satellite (UARS MLS and HALOE, 1992–2005), Aura Microwave Limb Sounder (MLS, 2004–2015), Sounding of the Atmosphere using Broadband Emission Radiometry (SABER, 2002–2015) on board TIMED (Thermosphere Ionosphere Mesosphere Energetics Dynamics)) observations covering the period 1993–2015. We found a very clear regional dependence in the trends of ozone but not in the water vapor and temperature. Ozone shows an increasing trend in the lower stratosphere and decreasing above 30 km. The decreasing trend is attributed to the close association of ozone with NOx chemistry. Temperature in the lower stratosphere shows an increasing trend, and in the middle and upper stratosphere it shows decreasing trend. Interestingly, the altitudes of the decreasing trend in ozone match well with the cooling trend observed in the temperature. These results on temperature trends match well with the long-term (1998–2015) observations of Rayleigh lidar over Gadanki between 30 and 70 km. Water vapor shows an increasing trend in the lower and middle stratosphere. This study reveals existence of strong regional dependence on the trends. Long term zonal wind observations between 70 and 80 km over the Indian region provided by rocketsonde (1977–1991), HRDI/UARS (1991–1999), and MST radar (1995–2015) are used to construct a long-term data set from 1977 to 2015. Using this unprecedented data set, a decreasing trend of 2 m/s/yr is found, changing from strong eastward winds during the 1970s to weak westward winds in recent years. On the other hand, between 80 and 98 km using medium frequency radar observations during 1993–2009, no perceptible trend is found. Simulations of NCAR TIME-GCM also showed a similar change in the circulation when CO2 in the atmosphere is doubled, suggesting role of anthropogenic changes in the dynamics of the mesosphere.

LONG TERM VARIATIONS OF THE SOLAR MAGNETIC FIELDS

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The Suns variable magnetic field was documented by the mid-1800s.? Fluctuations on the solar cycle timescale are easily seen in sunspot number, polar field strength, the butterfly diagram, and other measures. Additional periods exist; short-term variability such as the quasi-biennial variations and double-peaked maximum, and long-term variability like the ~88 year Gleissberg Cycle and grand minima. Dynamo models have achieved some success, albeit incomplete, in reproducing the observed behavior. However, dilemmas still exist. Is the solar dynamo made up of three components: a near-surface one that produces small-scale magnetic fields, a distributed one acting throughout the bulk of the convection zone, and a deep-seated one producing strong fields in the tachocline that serve as the source for sunspots? What percentage of the flux in the interior is seen at the surface? How strongly are the hemispheres coupled and how is that achieved? I will present a broad overview of the Suns inconstant magnetic field and the processes considered responsible. Note that the focus will be on observations and models of the photosphere and the solar interior.

NONLINEAR DYNAMO MODELS OF PRESENT AND YOUNG SOLAR ANALOGS

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We show results of a comparative study of the magnetic activity for the present and young solar analogs, which are rotating with periods of 25 and 11 days, respectively. The change of the stellar interior structure are obtained from the stellar evolution code (MESA). The model take into account the double-cell meridional circulation structure, the solar dynamo feedback on the global flows and effects of the non-axisymmetric magnetic field. Our results suggests that on the young Sun the surface latitudinal shear could be twice lesser than on the current Sun. The magnitude of the meridional circulation at the bottom and at the top of the convection zone remains the same for the modern and the young Sun. However, on the young solar analog the meridional circulation in the middle of the convection zone is suppressed, showing a weak triple-cell pattern near the stellar equator. The young solar analog demonstrates instability for the non-axisymmetric perturbations which can be produced by the surface magnetic activity. The magnetic feedback on the global flows results to the long-term modulation of the magnetic activity. On the young Sun this modulation shows the possibility for the active and inactive branches of activity and the long cycles when the star undergoes the high activity period. We compare our finding with results of stellar observational studies of young solar analogs.

Session 3: COUPLING BETWEEN THE EARTH'S ATMOSPHERE AND SPACE AND ITS RELATION TO QUIET AND ACTIVE SUN

INFLUENCE OF METEOROLOGICAL PROCESSES ON IONOSPHERE IN EASTERN EUROPE

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We present observations of atmospheric and ionospheric parameters during strong meteorological disturbances (storms) in the Eastern Europe. The critical frequency of the F2 layer (f_oF2) and the total electron content (TEC) were observed at the several stations in Eastern Europe. The analysis of ionospheric observations has shown that during meteorological storms the amplitude of diurnal variations in TEC decreases to 50 %; and in f_oF2, to 15 % as compared to quiet days. The revealed changes in ionospheric conditions during meteorological storms are regularly registered and represent a characteristic feature of the meteorological effect on the ionosphere. Numerical experiment was made to test the hypothesis using global self-consistent model of the thermosphere, ionosphere and protonosphere (GSM TIP). As thermospheric source of disturbance was defined spatially localized moving heat source, simulating the effect of AGW dissipation, extending the field of meteorological storm. The calculation results demonstrate the dynamics of perturbations of the upper atmosphere and ionosphere parameters caused by the source model. The physical processes that determine the resulting ionospheric disturbances are discussed. The characteristics of variations of the total electron content (TEC) in the atmosphere are determined from data collected by GPS navigation satellites. An analysis of the observational data showed that the spectrum of variations of the atmospheric and ionospheric parameters is indicative of acoustic-gravity waves (AGW) propagating from the lower atmosphere. The observed manifestations of TEC disturbances caused by AGW propagating from the lower atmosphere can be explained by the diurnal variation of the altitude of the ionosphere and the waveguide propagation of infrasonic waves.

NUMERICAL MODELING OF NONLINEAR ACOUSTIC-GRAVITY WAVE PROPAGATION INTO THE UPPER ATMOSPHERE AT DIFFERENT LEVELS OF SOLAR ACTIVITY

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According to present views, acoustic-gravity waves (AGWs) existing in the upper atmosphere may be generated near the Earth's surface due to different sources and propagate upwards. An algorithm for three-dimensional numerical simulation of vertical propagation of nonlinear AGWs from the Earth's surface to the upper atmosphere was developed recently. The algorithm of the solution of fluid dynamic equations uses finite-difference analogues of basic conservation laws. This approach allows us to select physically correct generalized wave solutions of the nonlinear equations. Horizontally moving horizontal sinusoidal structures of

vertical velocity on the Earth's surface serve as AGW sources in the model. Numerical simulation was made in a region of the Earth atmosphere with dimensions up to several thousand kilometers horizontally and 500 km vertically. Vertical profiles of the mean temperature, density, molecular viscosity and thermal conductivity are specified from standard models of the atmosphere. Simulations are made for different amplitudes, horizontal wavelengths and speeds of wave sources at the lower boundary of the model. It is shown that after "switch on" tropospheric source atmospheric waves very quickly (for several minutes) may propagate to high altitudes (up to 100 km). When AGW amplitudes increase with height, waves may break down in the middle and upper atmosphere. Instability and dissipation of wave energy may lead to formations of wave accelerations of the mean winds and to creations of wave-induced jet flows in the middle and upper atmosphere. Nonlinear interactions may lead to instabilities of the initial wave and to the creation of smaller-scale structures. These smaller inhomogeneities may increase temperature and wind gradients and enhance the wave energy dissipation. Simulations with background wind and temperature profiles corresponding to small and high levels of solar activity show that AGWs characteristics in the middle and upper atmosphere may change with changes in solar activity. This may alter heating and acceleration of the different layers of the atmosphere and change conditions of dynamical coupling between the lower and upper atmosphere.

QUASI-BIENNIAL VARIATIONS IN IONOSPHERIC TIDAL/SPW AMPLITUDES: OBSERVATIONS AND MODELING

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In this study, we examine the coherent spatial and temporal modes dominating the variation of selected ionospheric tidal and stationary planetary wave signatures from 2007–2013 FORMOSAT-3/COSMIC total electron content observations using Multi-dimensional Ensemble Empirical Mode Decomposition (MEEMD) from the Hilbert-Huang Transform. We examine the DW1, SW2, DE3, and SPW4 components, which are driven by a variety of in-situ and vertical coupling sources. The intrinsic mode functions (IMFs) resolved by MEEMD analysis allows for the isolation of the dominant modes of variability for prominent ionospheric tidal / SPW signatures in a manner not previously used, allowing the effects of specific drivers to be examined individually. The time scales of the individual IMFs isolated for all tidal/SPW signatures correspond to a semiannual variation at EIA latitudes maximizing at the equinoxes, as well as annual oscillations at the EIA crests and troughs. All tidal / SPW signatures show one IMF isolating an ionospheric quasi-biennial oscillation (QBO) in the equatorial latitudes maximizing around January of odd numbered years. This TEC QBO variation is in phase with a similar QBO variation isolated in both the GUVI zonal mean column O/N2 density ratio as well as the *F*10.7 solar radio flux index around solar maximum, while showing temporal variation more similar to that of GUVI O/N2 during the time around the 2008/2009 extended solar minimum. These results point to both quasi-biennial variations in solar irradiance as well as thermosphere / ionosphere composition as a generation mechanism for the ionospheric QBO. We also present results from numerical experiments using the Thermosphere Ionosphere Electrodynamics General Circulation Model (TIE-GCM) to quantify the sensitivity of the thermosphere and ionosphere to quasi-biennial oscillations in modulated atmospheric tides as well as that present in *F*10.7. Our results are some of the first numerical experiments examining the generation mechanisms behind the ionospheric QBO from both above and below.

ESTIMATING EQUATORIAL DAYTIME VERTICAL E×B DRIFT VELOCITIES FROM MAGNETIC FIELD VARIATIONS

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Accurate measurement and prediction of the vertical plasma drift is important for the study of many physical processes in the low-latitude ionosphere. Equatorial **E**×**B** drift velocities are significant input parameters that go into many ionospheric models, because they help describe vertical plasma motions near the magnetic equator. A previous work done by Anderson et al. (2004) has demonstrated the ability to derive Peruvian longitude sector, daytime vertical **E**×**B** drifts from ground-based magnetometer data and have derived the Δ*H* versus **E**×**B** relationships. The present research extends the same method to the West African longitude sector. We use magnetic field data of Conakry, Guinea (–0.46°, 60.37°) and Abidjan, Cote d'Ivoire (–6°, 65.82°) from the African Meridian B-field Education and Research (AMBER) network. On the basis of data availability, 9 magnetically quiet days have been analyzed and showed that the Peruvian Δ*H* versus **E**×**B** relationships is applicable to the West African longitude sector.

A MATHEMATICAL MODEL OF QUASI-STATIONARY ELECTRIC FIELD PENETRATION FROM GROUND TO THE IONOSPHERE

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A quasi-stationary model of electric fields and currents in the conductor that includes the Earth's atmosphere and ionosphere is created. We use an empirical model of scalar conductivity in the main part of the atmosphere up to the height of 50 km and a model of tensor conductivity, based on the empirical models IRI, MSISE, IGRF above 90 km with smooth interpolation between these layers. The steady state electro-conductivity problem is numerically solved. We set the input parameters which look typical for moderate earthquakes like a vertical electric field of about 100 V/m near ground with typical horizontal scale of a few hundred km. The result electric field in the ionosphere in such a case does not exceed 0.001 mV/m in frame of our model. This means that the penetration of a large scale electric field from ground into the ionosphere cannot be a physical process which creates ionospheric precursors of earthquakes which are observed in range of a few mV/m. This conclusion has been previously published, but it contradicts to the mathematical models by other authors. Here we analyze these models and show that their authors used inappropriate assumptions or simplifications which significantly distort the results. At the same time one of the new models confirms our conclusion.

SINGULAR VALUE DECOMPOSITION BASED ANALYSIS SOLAR ACTIVITY IN THE IONOSPHERE USING TOTAL ELECTRON CONTENT MAPS

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Singular value decomposition (SVD) is a well-established technique in linear algebra, and it is widely used to analyse signals in various fields of signal processing. Total electron content (TEC) is one of the most important observables of ionosphere and the TEC variability is directly related to the structural changes in the ionosphere. Solar activity is the driving force of ionosphere whose spatio-temporal trend is aligned with 11-year, annual, seasonal, monthly and diurnal cycles. One of the most commonly methods to estimate TEC is the use of dual-frequency GPS receivers. For spatial sparsity, GPS-TEC values obtained from various receivers in a certain area are interpolated to obtain a spatial distribution of TEC which is called as a TEC map. In this study, SVD method is applied to TEC maps for analysis of solar activity in the ionosphere. More specifically, we investigate the behavior of singular values of the TEC map for different ionospheric conditions. If the TEC map of a certain region is discretised in space and organized as a matrix, SVD can be applied to provide singular values and corresponding singular vectors representing the energy content of the TEC map. The first singular value contains most of the energy present in the image, and it provides information about large scale — low frequency (trend-like) variations in the TEC map. The second and third singular values are generally two orders of magnitude smaller compared to the first one, and these singular values represent the secondary spatio-temporal variabilities that are related to the factors other than solar activity such as gravitational, geomagnetic or seismic in nature. The TEC map can be reconstructed using the first three or four singular vectors as an image. In this study, singular values of regional TEC maps from Central Europe are investigated for quiet, positively disturbed and negatively disturbed ionospheric conditions. It has been observed that the first singular value represent the strong trend structure of ionosphere related directly to the solar activity. The first singular mode is enough to reconstruct the TEC map with an error less than 1 %. The second, third and fourth singular values are more related to geomagnetic and seismic disturbances and the values of these lower order modes increase related to the intensity of the disturbances in the ionosphere.

SQ CHANGES RELATED TO EARTH'S MAGNETIC FIELD SECULAR VARIATIONS AND SOLAR ACTIVITY EFFECTS

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Variations in the solar quiet geomagnetic field (Sq) are mainly caused by the ionospheric current systems which flow in the E-region driven by electric fields generated by the atmospheric dynamo. The main variables in Sq are ionospheric conductivities, the dynamo electric field, the solar diurnal tide and the E-region electron concentration. In turn, solar EUV irradiance and Earth's magnetic field are among the variables involved in ionospheric conductivity. Both present changes, and so does their contribution to ionospheric conductivity and so, to Sq. Considering the theoretical equations of Hall and Pedersen conductivity, the effect of solar activity and Earth magnetic field variations are analyzed comparatively. An experimental analysis is also carried out using Sq variation of the horizontal intensity, *H*, of magnetic observatories at low and mid-latitudes.

IONOSPHERIC CONDUCTING LAYER HEIGHT CHANGES DUE TO GEOMAGNETIC SECULAR VARIATIONS AND SOLAR ACTIVITY LEVEL

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Ionospheric conductivity, a critical element in magnetosphere-ionosphere-thermosphere coupling and ionospheric electrodynamics in general, responds to several forcings. Among them, the Earth's magnetic field, which determines not only the conductivity magnitude but also the height of the conducting layer. This field that varies greatly in geological timescales, can be approximated by a magnetic dipole that accounts for ~80 % of the magnetic field of the Earth's surface, plus multipolar components making up the remaining ~20 %. We analyze in this work the effects over the conducting layer height of the secular variations of the Earth's magnetic field considering that during a polarity transition the field magnitude diminishes to about 10 % of its normal value at the expense of decreasing the dipolar component and becoming mostly multipolar in nature. In general, a field decrease lifts the ionospheric conducting layer to regions where the electron density is higher, eventually reaching the F layer. Height changes are compared to variations induced by solar activity level through its effect on the scale height and neutral density.

IONOSPHERIC DISTURBANCES AFTER THE MAIN PHASE OF GEOMAGNETIC STORM

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We present an overview of the ionospheric effects of geomagnetic storms occurred on September 26–30, 2011 and March 17–23, 2015 during recovery storm phases. The results were obtained from both the satellite and ground-based observations, and from the computer simulation using the Global Self-consistent Model of the Thermosphere, Ionosphere, and Protonosphere (GSM TIP). The simultaneous formation of positive disturbances in f_oF2 and negative disturbances in TEC at low latitudes during the storm's recovery phase are explained by the plasma tube diffusional depletion, which is the main formation mechanism of the negative perturbations in TEC at this storm period. We have found that in general, the GSM TIP model gave a reasonable prediction of both positive and negative ionospheric storms. We are facing the greatest difficulties for the St. Patrick's Day storms. Namely, a strong positive storm at low latitudes above the Pacific and SAA region on the recovery phase could not be predicted by the model. Though the positive storm could be explained by the ionization effect of energetic electron precipitation enhancements. During the storm recovery phase in the low, middle and subauroral latitudes the model results show an increase in the n(O)/n(N2) ratio and a decrease in the n(N2) that results in the daytime positive effects in the N_mF2. We checked how this conclusion can be generalized to other geomagnetic storms. For testing we used the 2003–2016 Irkutsk ionosonde (52.3° N, 104.3° E) data set.

SEASONAL ANOMALIES AND VARIATIONS IN EQUINOX AND SOLSTICE PERIODS IN IONOSPHERE OVER TURKEY

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A region of the upper atmosphere of the Earth is called as the ionosphere that extends from 50 km to 1000 km. Ionospheric electron density is the major point to investigate the spatial and temporal variations in the ionosphere. Total Electron Content (TEC) is the integral of the electron density along the ray-path between the transmitting satellite and the receiver. Global Positioning System (GPS) is tool for monitoring the electron distribution within the ionosphere. One of the most used solar indices is the Sun Spot Number defined to measure the number of sun spots and groups of sun spots on the surface of the sun that appear visibly as dark spots compared to surrounding regions. SSN decreases and increases over a period of approximately 11 years. This study is focused on the analysis of the variations of ionosphere over Turkey during equinox and solstice periods using IONOLAB-TEC estimates obtained by GPS. Bite-out phenomenon is examined for discovering its possible effects. It is observed that bite-out predominantly occurs in winter for minimum Sun Spots Numbers (SSN) in the middle zones of Turkey. The middle zones of Turkey are also significantly affected from the winter anomaly. TEC values and ionospheric variations at solstice periods are greater than those at equinox periods. This study is supported by TUBITAK EEEAG grant 114E541 and joint TUBITAK EEEAG 114E092 and AS CR 14/001.

COMPARISON OF NMF2 SOLAR ACTIVITY DEPENDENCE OVER KALININGRAD AND IRKUTSK — EMPIRICAL MODEL'S RESULTS

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In this report we have analyzed the solar activity dependence of the N_mF2 diurnal variations for different seasons over two mid-latitude stations Irkutsk and Kaliningrad. In order to estimate the solar activity dependence of N_mF2 diurnal variation we used the empirical models based on the statistical analysis of ground based ionosonde data, satellite and radio occultation measurements. For the local empirical model development, we used the database of N_mF2 observation data from the Irkutsk and Kaliningrad ionosondes. These data were obtained from the manually scaled ionograms using interactive ionogram scaling software, SAO Explorer in the case of the Irkutsk ionosonde and PARUS software in the case of the Kaliningrad ionosonde. The geographic latitudes of both stations are very similar. We obtained the 27-daily median of N_mF2 values for diurnal variations over two these stations for different months. We analyzed and compared the coefficients and mean squared errors of linear and dual linear regression for both stations. Also, we used the radio occultation N_mF2 values, IRI and MIT modeling in order to compare local empirical model results with global empirical models of different kinds.

UNUSUAL EVOLUTION OF PLASMA BUBBLES INTO NON-CONJUGATE FEATURES DURING 17 MARCH 2015 STORM

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We study the equatorial plasma bubbles occurred over the Indian region during the 17 March 2015 geomagnetic storm using OI 630 nm airglow imaging from two locations Kolhapur (16.7° N, 74.3° E, 11.5° N dip latitude) and Tirunelveli (8.7° N, 77.8° E, 1.6° N dip latitude). Since airglow imaging technique covers large area, we could observe the region between 5° S and 18° N dip latitudes. Though several works have already been reported about the effects of the 17 March 2015 storm, we present results that are unique and not identified earlier. The plasma bubble zonal drifts on this night changed from east to west. Interestingly, the portions of the bubbles mapped to higher latitudes were seen to reverse their zonal drift before the portions closer to the dip equator reversed. Simultaneously the westward tilt of the bubbles increased considerably. Subsequently, the plasma bubbles were seen to evolve into non-conjugate features between the hemispheres within 4° of the dip equator. To our knowledge no earlier report has identified non-conjugate plasma bubbles. Also significant differences are noticed in the drifts between the adjacent bubbles for a short duration. These results are discussed in the light of current understanding of the low latitude electrodynamics.

THE EARTH'S ATMOSPHERE IONIZATION RATE CALCULATION WITH THE RUSCOSMICS SOFTWARE PACKAGE

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To solve some problems, e.g. the equivalent dose evaluation at altitudes of 10 km, it is needed to know the ionization rate of the Earth's atmosphere matter by cosmic rays (CR) in the absence of disturbances and during the solar flares (The SCR events).In this work the passage of cosmic-ray protons through the Earth's atmosphere by numerical Monte Carlo methods are calculated. The main characteristics of the CR secondary fluxes and the ionization profiles depending on a primary particle energy and a geomagnetic cutoff rigidity are presented. The results allow to quantify the equivalent dose for the different heights of the Earth's atmosphere.

SOLAR SIGNATURES WITHIN ATMOSPHERIC AND IONOSPHERIC PARAMETERS

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We have analyzed time series of solar data together with the atmospheric and ionospheric measurements for last four solar cycles according to their availability. Within data of 1-day sampling rate, we have searched for common spectral domains. As a convenient mathematical tool we used Continuous Wavelet Transform (CWT) that is favorable for detection of wave-like oscillations with limited duration and variable period. Then we looked for common oscillation domains in the datasets using Wavelet Transform Coherence (WTC), which is a measure of the intensity of the covariance of the two series in time-period space with stable phase difference. Despite wide oscillation ranges detected by mean of CWT we found only limited domains by mean of WTC, particularly significant high power domains (with stable phase difference) for periods 1 month, 2 months, 6 months, 1 year and 2 years between pairs of solar data, and atmospheric or ionospheric data. The detected domains vary during particular solar cycle and from cycle to the following one. These results indicate the changing solar forcing of the atmosphere and/or its sensitivity with time.

SOLAR CYCLE IN UV AND ITS RESPONSE IN D-REGION (3D SIMULATIONS)

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3D photochemical simulations with CHARM-I (Chemical Atmospheric Research Model with Ions [Krivolutsky et al., 2015]) to study changes in D-region induced by solar UV variations during 2003–2009. This interval belongs to 23rd solar cycle with a deep minima between 2007 of global electron concentration fields between 2009 and 2003 (from minima to maxima) was calculated. The results of simulations showed that corresponding changes of electron density for day time conditions equaled about 30 % with minus above 70 km. At the same time a weak increase of [e] was found in zonal mean fields around 60 km.

INFRA-RED TEMPERATURE MAPPING STUDIES OF MESOSPHERIC GRAVITY WAVES

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The Advanced Mesospheric Temperature Mapper (AMTM) is a wide-field (120°) high-performance digital imaging system developed at Utah State University. The AMTM is capable of precision measurements of the OH(3.1) band intensity and rotational temperature (~1–2 K in < 30 s) important for quantifying the effects of a broad-spectrum of gravity waves at the ~87 km level, with periods ranging from several minutes to many hours. This presentation highlights measurement capabilities, and recent results from several focused campaigns employing coordinated lidar, radar and AMTM measurements to quantify the properties and momentum fluxes of mesospheric gravity waves, including orographic waves generated by the interaction of strong winds with prominent mountain ranges. Mountain waves are identified by their quasi-stationary appearance, and until recently, observations of their penetration into the mesosphere and characteristic signatures have been very sparse. Selected studies include gravity wave propagation, dissipation and temperature signatures in the high Arctic and over Antarctica, and mountain wave breaking at mesopause heights during the DEEPWAVE program (June–July 2014) where two AMTM's were operated from New Zealand in the vicinity of an intense gravity wave "hot spot".

EQUATORIAL IONOSPHERIC VARIATIONS CAUSED BY THE DIFFERENT LARGE SCALE SOLAR WIND STRUCTURES

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We examined equatorial ionospheric variations during geomagnetic storms associated with large scale solar wind structures. Yohkoh, SOHO and Ulysses missions proved that in general, the mass emissions from the Sun as interplanetary coronal mass ejections (ICMEs), corotating interaction regions (CIRs), and heliospheric current sheet (HCS) are responsible for generation of different types of geomagnetic storms. Intensive ionospheric currents during these geomagnetic storms change the quiet ionosphere and short-term variations of the ionospheric characteristics are observed. Under these conditions the critical frequency f_oF2, virtual height h'F, drift velocities and others ionospheric characteristics are mainly defined by the the state of the solar wind flowing around the Earths magnetosphere. We show that these variations are defined to a significant degree by the direction of the B_z component of the interplanetary magnetic field but duration and intensity of these variations determined by the origin of the solar wind streams (CMIs, CIRs or HCS). The ionospheric heights and f_oF2 variations at the equator during the northward IMF B_z and the southward IMF B_z (the main phase of the magnetic storm) are very

distinguished. Distinction between quiet and disturbance periods in the heights can reach up to100 km and more. The critical frequency f_oF2 is markedly lower during the southward IMF B_z. We show also that intensity of the equatorial ionospheric variations is different for the same solar wind conditions and depends on solar activity phases.

LONG TERM METEOR RADAR OBSERVATIONS OF GRAVITY WAVE ACTIVITY IN THE MESOSPHERIC LOWER THERMOSPHERIC REGION OVER A LOW LATITUDE STATION

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Gravity waves play a profound role in the vertical coupling of the different regions of the Earth's atmosphere. Divergence/convergence of the energy and momentum fluxes carried by the gravity waves accelerate/ decelerate the mean flow which in turn partly responsible for the maintenance of QBO and SAO in the stratospheric and mesospheric region, which are the characteristic features of the equatorial middle atmosphere. To quantify the role of short period gravity waves in controlling the dynamics of the MLT region, more than ten years of continuous meteor radar observations during June 2004 – Dec 2013 are extensively used. The gravity wave activity in the Mesosphere Lower Thermosphere (MLT) region is estimated over Trivandrum (8.5° N, 78° E), a low-latitude station in India during aforementioned period. The seasonal, inter annual variation and solar cycle variability of the wave activity is also examined. The results will be discussed in detail in the conference.

SOLAR AND METEOROLOGICAL CONTROL OF THE HIGH-FRIEQUENCY TOTAL ELECTRON CONTENT VARIABILITY

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We study seasonal and helio-geomagnetic activity pattern of total electron content (TEC) variability over Siberia region during the 2002–2015 period. The considered years cover interval between the 23th and the 24th solar activity cycle peaks. For the analysis of TEC behavior we have used data from phase dual frequency GPS/GLONASS receivers located in mid-latitude (Irkutsk, 52° N, 104° E; 42° N Glat, 177° E Glon), subauroral (Yakutsk, 62° N, 130° E; 52° N Glat, 196° E Glon) and high-latitude (Norilsk, 69° N, 88° E; 60° N Glat, 166° E Glon; Tixi, 72° N, 129° E; 66° N Glat, 198° E Glon) regions and have calculated an index of intensity of TEC variation (vrTEC) with periods of up to 4 hours. The index is a relative standard TEC deviation from the daily average values in daytime. Obtained vrTEC coefficient reflects ionospheric variability associated with internal gravity waves (IGWs) propagation. It is revealed that TEC variability level depends on the solar activity during winter seasons. Maximum winter vrTEC values reduce of up to 40 % at the solar activity descending stage. The effect is more pronounced at high latitudes. Surprisingly, the TEC variability level does not change with solar activity in summer months. It has been shown for all the stations considered that there are significant changes in the

TEC variation coefficient with seasons. The largest values is observed in winter and the smallest ones in summer. The summer-winter vrTEC difference is more noticeable for high-latitude stations (Norilsk and Tiksi) and reaches up to 6 times. Such seasonal vrTEC variations are regularly observed from year to year. The winter enhancement of the high-frequency part of the TEC variability is assumed to be induced by medium-scale wave-like motions in the stratosphere and mesosphere. The sources of these motions are instabilities in the spatially non-uniform, high-velocity jet stream on the boundary of circumpolar vortex (CPV) forming in winter hemisphere. Traveling upward, the medium-scale waves cause changes in the lower thermosphere and ionosphere structure and dynamics and manifest themselves as traveling ionospheric disturbances.
This study is supported by RF President Grant of Public Support for RF Leading Scientific Schools (НШ-2942.2014.5) and by the RFBR projects No. 16-35-60018 and 15-05-05227.

SOURCES OF THE IONOSPHERIC VARIABILITY OVER EUROPE IN WINTER TIME FROM THE IONOSONDE AND GPS/GLONASS DATA

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The latitudinal dependence of ionospheric variability on the configuration and parameters of high-speed jet streams associated with the winter circumpolar vortex at the stratosphere/lower mesosphere heights are studied. We conducted a joint analysis of the variations of the ionospheric F2-layer electron density peak and total electron content (TEC) of the ionosphere over the mid- and high-latitude regions of Europe in the winter months (November to February) over 2008–2010 under low solar and geomagnetic activity conditions. The ionosphere parameters were obtained from measurements made at the meridional chain of European vertical sounding ionosondes Rome (41.9° N, 12.5° E), Pruhonice (50.0° N, 14.6° E), Juliusruh (54.6° N, 13.4° E), Sodankylä (67.3° N, 26.6° E). The measurements on a network of the phase dual-frequency GPS/GLONASS receivers located in the range of 40–70° N and 10–30° E were used to obtain TEC. The calculation of the vertical total electron content from the initial series was based on the developed absolute TEC model taking into account differential code biases. To study the dynamics of the winter circumpolar vortex in the Northern Hemisphere, we use the data from the ECMWF ERA-Interim Reanalysis. The analysis showed the significant increase in wave-like activity in the stratosphere/lower mesosphere during winter seasons for all analyzed years. Variations of ionospheric parameters observed at different latitudes depend on the station positions relative to the jet stream circulation zone.

THE CHELYABINSK METEORITE EFFECTS IN IONOSPHERE ACCORDING TO THE GPS NETWORK DATA

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We present the results of studying characteristics of ionospheric effects of the Chelyabinsk meteorite. The results are based on the unique data from several GPS networks located in the vicinity of the final part of the meteorite fall trajectory. GPS receivers detected two kinds of traveling ionospheric disturbances (TIDs) in total electron content (TEC) variations triggered by the meteorite fall and explosion. 6–14 min after the meteorite explosion, a TID with a cone-shaped wavefront was observed at the 80–100 km distance from the airburst location. The averaged TID propagation velocity was 661 m/s. We associated this TID with shock-acoustic waves (SAW). 14 min after the meteorite explosion, behavior of the TEC disturbances complied with the annular wavefront propagating with the averaged velocity of 337 m/s from the center which was located approximately 37 km northwestward of the airburst. The annular front was formed approximately 200 km away from the meteorite explosion location. The annular TID velocity damping with time and distance from the airburst was estimated using the GPS interferometric technique. This TID was interpreted as gravitational mode of internal atmospheric waves.

The data from the global GPS network were provided by Scripps Orbit and Permanent Array Centre (SOPAC, http://sopac.ucsd.edu). The data from the Russian GPS network operated by the NAVGEOKOM company were available at http://www.navgeocom.ru. Raw TEC data and auxiliary information from GPS stations in the Chelyabinsk region were kindly provided by LLC GEOSalyut (Moscow) and LLC Poleos (Chelyabinsk, contact with shestakov.nv@dvfu.ru). Raw TEC data and supporting information from GPS stations in the Chelyabinsk region were provided by LLC GEOSalyut (Moscow) and LLC Poleos (Chelyabinsk, contact with shestakov.nv@dvfu.ru). Raw TEC data and supporting information from the Kazan GPS network were provided by Federal Kazan University (KFU) and RPC Geopoligon KFU (Kazan, contact with shestakov.nv@dvfu.r). We are deeply indebted to all companies and agencies and personally to S. Parshin provided us with access to GPS data. This work was supported by the Presidium of the Russian Academy of Sciences (program No. 15, project No. 0344-2015-0019 Study of the Lithosphere–Atmosphere–Ionosphere System under Extreme Conditions), RF President Grant of Public Support for RF Leading Scientific Schools (НШ-6894.2016.5), and RFBR grant No. 17-55-53110 GFEN_a.

EXPERIMENTAL STUDY OF IGW-WIND INTERACTION USING THE COMBINED IRKUTSK INCOHERENT SCATTER RADAR AND IONOSONDE DATA

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This paper studies the interaction of internal gravity waves (IGW) with neutral wind using the statistics of traveling ionospheric disturbances (TID) from the Radio Physical Complex of the Institute of Solar-Terrestrial Physics. The simultaneous measurements of Irkutsk incoherent radar and ionosonde DSP-4 allows us to obtain representative statistic of TIDs parameters, including full velocity vector. Measurement of TID full velocity vector allow us to separate IGW

induced TIDs from TIDs of other nature. Selecting of IGWs induced TIDs by estimating of neutral wind velocity projection on TID propagation direction, show that ~60 % TID induced by IGW. TIDs distribution on time and IGWs distribution on time have significant difference. Number of nighttime TIDs, especially in winter season, is much bigger then daytime TIDs, but for IGW induced TIDs distributions are more evenly. Assuming fulfillment of Hines dispersion equation, average diurnal variation of meridional and zonal wind for winter, spring and summer seasons were obtained. There are very few direct measurements of meridional and especially zonal neutral winds at ionospheric heights. Therefore, indirect estimations of neutral winds based on measurements of TID three-dimensional velocity vector, can be very useful to neutral wind model improvement. Shown that the main cause of the observed anisotropy of TIDs characteristics associated with filtration IGWs by neutral wind. IGWs, propagating against the neutral wind at observations heights, increase amplitudes, and azimuths, co-directional with a strong neutral wind (over 50 m/s) on any of the heights through which IGWs passed before reaching observation height, were prohibited. Most of TIDs (83 %) have a downward phase velocity (negative elevation angle), which corresponds to IGW propagating from the source located under the region considered. Positive elevation angles, can be divided into two ranges: 0–45° (reflected TIDs ~9 %) and 45–90° (TIDs from sources above observation area ~8 %). Peculiarities of TIDs azimuths distributions for this three IGW types were also well explained by the neutral wind. The present work was done under support of the Russian fund of basic research (grant No. 15-05-02313).

IMPACT OF STRATOSPHERIC WARMINGS ON THE MLT COMPOSITION AND TEMPERATURE FROM SPECTROMETRIC OBSERVATIONS OF OH (6-2) AIRGLOW AT MID LATITUDES

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We present the results of studying the atmospheric composition and temperature disturbances at the mesosphere and low thermosphere (MLT) associated with sudden stratospheric warmings (SSWs) in 2010–2017. Several events related to different types of stratospheric warming (major, minor, final) were selected for the analysis. We analyzed the data on the OH emission intensity and rotational temperature derived from spectrometric measurements of the hydroxyl emission (834.0 nm, band (6-2)) at the Geophysical Observatory of the Institute of Solar-Terrestrial Physics (51.8° N, 103.1° E) and at the Zvenigorod station of the Obukhov Institute of Atmospheric Physics (55.7° N, 36.8° E). The OH emission maximum is at the mesopause region height (~87 km). The OH molecule rotational temperature is determined with a 1–2 K accuracy and corresponds to the atmosphere temperature at the radiation height. The emission intensity provides information on the dynamics of photochemical processes and recombination of atomic oxygen at the emission layer heights. The data on OH (6-2) rotational temperature and intensity were used to calculate variations in the atomic oxygen density in the MLT during the analyzed stratospheric warmings. In the calculations, we used the photochemical model of OH emission and the NRLMSISE-00 atmospheric model. It is shown, that significant SSW events can cause an increase in the intensity of OH emission (6-2) and in the atomic oxygen density at the height of the OH layer by more than 2.5 times. The revealed effect can be caused by the SSW-related increase in vertical transfer of the atmospheric components. This study was done with a support from the Russian Foundation for Basic Research, Grant No. 17-05-00192-a, and RF President Grant of Public Support for RF Leading Scientific Schools (НШ-6894.2016.5). Experimental data recorded by the Angara Multiaccess Center facilities of ISTP SB RAS were used.

STATISTICS OF IONOSPHERIC DISTURBANCES DURING SUDDEN STRATOSPHERIC WARMINGS OVER EASTERN SIBERIA

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We study statistics of ionospheric disturbances during sudden stratospheric warmings (SSWs)) over Eastern Siberia. The statistics is based on the 2003–2016 dataset of F2 peak electron density (N_mF2) from Irkutsk DPS-4 Digisonde (52.3° N, 104.3° E). Atmospheric temperature and dynamics during SSWs were analyzed from Aura MLS v3.3 satellite data and MERRA reanalysis. As onsets of SSW events we chose the days of reversal in longitudinally averaged zonal wind at 60° N and 10 hPa (in cases of major SSWs) or days of the largest temperature at 10 hPa (in cases of minor SSWs). Further we analyze day-to-day behaviors of N_mF2 disturbances over the 20-day intervals after the SSW onsets. The N_mF2 disturbances are the percentage differences between the observed N_mF2 ($N_m F2_{obs}$) and the 27-day sliding median value ($N_m F2_{med}$): $dN_m F2(\%)=(N_m F2_{obs}-N_m F2_{med})/N_m F2$ med 100 %. In order to reveal positive and negative ionospheric effects of the SSW events we consider the day-to-day variations in the daytime and nighttime averaged N_mF2 disturbances. For studying intensification of wave activity during the SSW events we analyze the intensity of the N_mF2 disturbances in different period ranges: the internal gravity wave period range (periods $T<8$ hrs) and the tidal range (8 hrs $\leq T \leq$ 24 hrs). The intensities of the N_mF2 disturbances are the root mean square values of disturbances calculated for the given day. The comparison of the obtained disturbance intensities with the background level of the ionospheric variability allows us to make conclusion about the SSW effects on the intensification of ionospheric wave activity. The 2003–2016 dataset of N_mF2 allows us to analyze the ionospheric responses to the 7 minor and 7 major SSW events. The work was supported by RF President Grant of Public Support for RF Leading Scientific Schools (НШ-6894.2016.5) and the Russian Foundation for Basic Research, Grant No. 17-05-00192-a. Experimental data recorded by the Angara Multiaccess Center facilities of ISTP SB RAS were used.

COMPARISON OF THE LEVEL OF IONOSPHERE DISTURBANCE AT SEVERAL GNSS STATIONS

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Using special WTEC index, we compared the level of ionosphere disturbance at three GNSS stations: BADG (mid latitudes), TIXI and NRIL (high latitudes) in 2013. WTEC is calculated from the total electron content (TEC) obtained by GNSS receiver. WTEC represents continuous multi-day series of average TEC variation intensity for the selected range of periods. We studied the TEC disturbances with periods of 10 min (middle-scale ionospheric disturbances) and 40 min (large-scale ionospheric disturbances). At the BADG station, the WTEC minimum level is higher in summer than in winter. The WTEC daily variations are pronounced throughout a year and have some features: from April to October, depression in manifestation of the WTEC diurnal variations is observed for medium-scale disturbances, from June to September the same is fair for large-scale disturbances; large amplitude of diurnal variations are typical for WTEC variations from October to December. The WTEC behavior agrees well with the *Dst* and K_p

variations only during strong magnetic storms. At TIXI and NRIL stations, the WTEC minimum level does not depend on the season. The WTEC diurnal variations are weakly pronounced and more evident for medium-scale disturbances than for large-scale ones. The WTEC index behavior accords well with the AE geomagnetic index variations; it is less consistent with *Dst* and K_p indices behavior; only in severe planetary magnetic storms, the WTEC behavior agrees with the *Dst* behavior. This work was supported by the Grant of the Russian Scientific Foundation (Project No. 14-37-00027).

BEHAVIOR OF IONOSPHERIC TOTAL ELECTRON CONTENT IN THE HIGH LATITUDES ON 4–6 MAY 2013

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We present the results of a study of the total electron content (TEC) spatial-temporal distribution in the high-latitude ionosphere on 4–6 May, 2013. We used the data from high-latitude GPS stations being a part of the International GNSS Service (IGS) network: LOVJ (Murmansk), NRIL (Norilsk), TIXI (Tiksi), BILB (Bilibino). For analysis we used only those satellites that were in the radio visibility zone of NRIL, LOVJ, TIXI, BILB within the 04:00–10:00 UT time period. The analysis revealed that on May 5, 2013, on some GPS receiver-satellite lines of sight, there were dramatic TEC deviations from the behavior typical for control days on May 4 and 6. This indicates that there was an ionization trough (a low electron density region) in the ionosphere at these latitudes. To determine the trough position, we plotted the trajectories of the ionospheric points, where the TEC deviations were recorded. The ionization trough was located within the 72–84 N latitudes and 0–200 E longitudes. We compared the experimental results with the numerical simulation data. Using the ionosphere-plasma interaction theoretical model, developed in ISTP SB RAS, global distributions of the thermal plasma characteristics for 05:00 UT and 07:00 UT on May 5, 2013 were calculated. This model showed that at high latitudes on the day side in the same range of latitudes and longitudes, a region of reduced TEC values can form, which can be identified as a high latitude trough. This work was supported by the Grant of the Russian Scientific Foundation (Project No. 14-37-00027).

BURSTS OF MAGNETOSPHERE CHARGED PARTICLE FLUXES AND VARIOUS TYPES OF GEOMSGNETIC PULSATIONS AND ATMOSPHERE GLOWS DURING THE SUPERSTORM AT MIDDLE LATITUDES NEAR IRKUTSK

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We study variations of broadband geomagnetic pulsations and charged particle fluxes in the magnetosphere during the atmosphere glows at midlatitudes during the two superstorms. Geomagnetic and optical data of the ground-based observatories of the ISTP SB RAS are used,

as well as satellite data of the series LANL. One observes a difference in the behavior of the bursts of atmosphere glows in the red and green lines. We discuss a possible relationship of bursts of these glows and broadband (T=0.3–600 s) geomagnetic pulsations in the post-midnight sector with the precipitation of charged particles.

THE RELATIVE ROLE OF IONOSPHERIC CONDUCTIVITY AND ELECTRIC FIELD IN THE DYNAMICS OF FIELD-ALIGNED CURRENTS ON THE NIGHT SIDE DURING A SUBSTORM

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During the expansion phase of the magnetospheric substorm, the intensity of the field-aligned currents (FACs) increases dramatically. There are two types of asymmetry in the distribution of FACs in the nearmidnight ionosphere: dawn- dusk and north-south. To explain these asymmetries, the principal scheme of the global circuit of electric currents of the magnetosphere-ionosphere (MI) system of the two hemispheres is used. Based on the output data of the magnetogram inversion technique, the dynamics of FAC intensities in the pre- and post-midnight mesoscale cells of the three Iijima and Potemra zones, which are closed in the global electrical circuit by meridional ionospheric currents, are analyzed. The feedback instabilities of the MI system are considered between the FAC intensity and: 1) the conductivity of the ionosphere (type 1), and 2) the electric field (type 2). Both types of instability can operate simultaneously in different places. The relative role of conductivity and the electric field in the dynamics of FAC intensities during the expansion phase in the pre- and post-midnight mesoscale cells of the summer and winter hemispheres is also investigated.

MAPPING OF IONOSPHERIC CONVECTION POTENTIAL ON POTENTIAL GRADIENT FROM MULTI-STATIONS MEASUREMENTS OVER ANTARCTICA: A CASE STUDY

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Simultaneous observation of Potential Gradient (PG) from longitudinally (magnetic) aligned stations, Vostok (78°27 S, 106°52 E), Dome C (75°06 S, 123°20 E) and Maitri (70°45 S, 11°44 E) is presented in this work. Influence of solar wind-magnetospheric interaction on PG for the selected geomagnetic disturbed days in the year 2010–2011is also demonstrated. Observation shows that change in Potential Gradient (ΔPG) is associated with magnetic latitude during geomagnetic disturbance. The analysis shows that small-scale changes of ionospheric electrostatic potential (Weimer_05 model) substantially maps down at polar latitudes. For lower magnetic latitude (Maitri), the link is evident only on severe disturbances. The linear relation (R) between PG and ionospheric potential is highly pronounced (R>~0.90) during noon-evening

sector (06:00–18:00 UT) followed by the morning sector (00:00–06:00 UT). Nonlinear response of PG (R<~0.3) is also accounted during midnight hours (18:00–24:00 UT) on 05–06 August 2011. The paper is also pointed out the importance of estimating PG fair-weather pattern on monthly basis to account the ambient PG variation for every spatial station over high latitude.

GLOBAL ELECTRON CONTENT IN THE 23rd and 24th SOLAR CYCLES

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Based on the data of total electron content (TEC) Global Ionospheric Maps we analyze behavior of the ionospheric Global electron content (GEC) in the 23rd and 24th solar cycles. We study GEC dynamics during the 1998–2016 period as well as its annual, semiannual and 27-day variations. We also carry out comparison of the variations parameters in GEC and regional electron content (REC), which is the total number of electrons in the ionosphere over a certain area, for the Baikal rift zone, European and Japan regions. The maximal amplitude of considered REC variations is observed in Japan. Semiannual REC variations for all analyzed regions are in phase with GEC semiannual variations, while annual REC variations and GEC ones are opposite in phase. It is shown that general dynamics of REC, GEC and their variations repeat well the behaviour of the $F10.7$ solar radio emission. GEC and RECs reflect deep minimum in 2009 as well as excess of the 23rd over the 24th one. Dependence of diurnal REC variations amplitude on the $F10.7$ index is revealed to be close to linear, unlike the analogous Global electron content dependence. The study is supported by RF President Grant of Public Support for RF Leading Scientific Schools (НШ-6894.2016.5) and by the RFBR project No. 16-35-60018.

COMPARISON OF THE MEDIUM-SCALE WAVE ACTIVITY IN THE IONOSPHERE OBSERVED BY THE KAZAN IONOSONDE "CYCLONE", DENSE GPS/GLONASS RECEIVER NETWORK IN THE MIDDLE VOLGA REGION, AND EKATERINBURG HF RADAR

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We present medium-scale traveling ionospheric disturbance (MSTID) observations using three spatially-spaced facilities: (1) Kazan vertical sounding ionosonde Cyclone providing high temporal resolution measurements (~1 min); (2) dense GPS-GLONASS receiver network in the Middle Volga region (more than 200 receivers); and (3) the Ekaterinburg HF radar located near Arti village. The ionosonde MSTID observations are carried out by analysis of vertical ionogram features, by construction of amplitude and height maps (A- and H-maps). Dense GPS/GLONASS receiver network allows us calculating two-dimensional maps of total electron content (TEC) perturbation and studying dynamics of horizontal MSTID structure. The HF radar allows registering MSTIDs by analysis of time variations of ground backscatter range associated with HF skip distance. The facilities cover large spatial region of more than 20° along latitude and longitude. We compare the data of these facilities in order to find similarities and differences in

observed wave dynamics in the ionosphere and to reveal typical MSTID propagation distance and lifetime. The work is performed according to the Russian Government Program of Competitive Growth of Kazan Federal University.

STUDY OF GROUND BACKSCATTER INTENSITY REGISTERED BY THE EKATERINBURG HF RADAR

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We present the analysis of ground backscatter intensity measured by the Ekaterinburg HF radar (EKB radar; 56.42° N, 58.53° E) during the period from 2013 to 2016. The analysis includes the study of the features of ground backscatter occurrence in the radar field-of-view (FOV) in order to identify specific topographic and geographic regions with enhanced/depressed HF backscatter ability. We study diurnal and seasonal variability of ground backscatter occurrence within the radar FOV as well as its solar and geomagnetic activity dependence. To explain found dependencies we simulate ground backscatter intensity under different geophysical conditions on the basis of waveguide approach. In addition we compare the observed range profile of ground backscatter intensity with the model profile, developed in the framework of interference integral method. The advance of the model is that it determines the relation between the broadening of ground backscatter echo and the parameters of random field of medium-scale ionospheric irregularities. We discuss the possibility of the model application for automated monitoring the degree of medium-scale ionospheric irregularity by use of HF radars.

COSEISMIC VERTICAL MIDSCALE IONOSPHERIC DISTURBANCES BASED ON IRKUTSK CHIRP IONOSONDE DATA IN 2011–2016

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One of the intensive sources of wave energy to the ionosphere from below are tectonic sources. In this paper a statistical analysis is made of short-lived ionospheric effects after earthquakes which appeared in 2011–2016 years. These effects are related with surface seismic waves far from epicenter. We based our analysis on the Irkutsk fast monostatic chirp ionosonde data far from the epicenter and on GPS data in the epicenter vicinity.

The analysis has shown that far from epicenter some of these earthquakes were accompanied by vertical midscale ionospheric irregularities. To estimate the ionospheric efficiency of the seismic waves we estimated the maximal amplitude of the acoustic shock wave. This was done by taking into account the spatial distribution of seismic vibrations and additional acoustic wave intensification related with this.

Based on the analysis of experimental data we have shown that earthquake-related 5–25 s. irregularities are observed mostly at daytime at large acoustic wave amplitudes, and this correlates well with case-study results from other researchers. The observations of internal gravity waves by GPS technique in the epicenter vicinity (120–600 s irregularities) do not show such a daytime dependence. Possible mechanisms of this effect are discussed.

STUDIES ON VERTICAL COUPLINGS BY GRAVITY WAVES OVER THE ANTARCTIC WITH THE GROUND-BASED OBSERVATIONS

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The high latitude southern hemisphere is known to be a region of high activity of the atmospheric gravity waves. Vertical propagation of the gravity waves is important in vertical couplings between the troposphere, the middle atmosphere and the upper atmosphere. However, not enough observations cover the Antarctic region to reveal such vertical couplings. Japanese Antarctic Research Expedition (JARE) started a prioritized project of observing the middle and upper atmosphere observations in 2010. The extension of the observations included a large MST/IS radar (PANSY radar), a Rayleigh/Raman and resonance lidar, a millimeter radiometer, and an airglow imager. In this paper, we focus on the recent analysis results of gravity wave observations using the sodium and OH airglow imagers and a Rayleigh/Raman lidar. The former provides detailed information on horizontal structures of the gravity waves at 90 km altitude. The new spectral analyses in horizontal phase velocity domain [Matsuda et al., 2014] is quite useful in discussing the vertical propagation and the source of the internal gravity waves. The latter provides height profiles of the inertia gravity wave activity in the middle atmosphere in detail. This also helps to understand the generation and the vertical propagations of gravity waves in different aspects. These two observations have revealed the characteristics of gravity waves around Syowa station (69° S, 40° E) and clarified a distinct difference from what has been observed over Davis station (69° S, 78° E), about 1.500 km east of Syowa.

INTERACTION OF SMALL-SCALE GRAVITY WAVES WITH THE DIURNAL TIDE FROM THE MESOSPHERE TO THE UPPER THERMOSPHERE

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Effects of subgrid-scale gravity waves (GWs) on the diurnal migrating tides are investigated from the mesosphere to the upper thermosphere during September equinox, using a general circulation model coupled with the extended spectral nonlinear GW parameterization of Yiğit et al. [2008]. Simulations with GW effects cut off above the turbopause and included in the entire thermosphere have been conducted. GWs appreciably impact the mean circulation and cool the thermosphere. They significantly affect the winds modulated by the diurnal migrating tide, in particular in the low-latitude mesosphere and lower thermosphere and in the high-latitude thermosphere. These effects highly depend on the mutual correlation of the diurnal phases of the GW forcing and tides: GWs can either enhance or reduce the tidal amplitude. In the low-latitude

MLT, the correlation between the direction of the deposited GW momentum and the tidal phase is positive due to propagation of a broad spectrum of GW harmonics through the alternating winds. In the Northern Hemisphere high-latitude thermosphere, GWs act against the tide due to an anti-correlation of tidal and GW phases, while in the Southern high-latitudes they weakly enhance the tidal amplitude via a combination of a partial correlation of phases and GW-induced changes of the circulation. The variable nature of GW effects on the thermal tide can be captured in GCMs provided that a GW parameterization (1) considers a broad spectrum of harmonics, (2) properly describes their propagation, and (3) correctly accounts for the physics of wave breaking/saturation.

Session 4: UNDERSTANDING THE EARTH'S SPACE ENVIRONMENT AND ITS CONNECTION TO SPACE WEATHER

MAGNETOSPHERE AND IONOSPHERE RESPONSE TO THE INTERPLANETARY SHOCK ON 24 JANUARY 2012

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The magnetosphere and ionosphere response to the SSC event at 24 January 2012 was investigated using complex of spacecraft and ground-based instruments. The SSC produce strong increase of the energetic particles fluxes (40 keV – 2 MeV), density, temperature inside the magnetosphere as seen by the THEMIS, GOES spacecrafts. It is shown that the SSC impulse is not shock wave in the outer magnetosphere (Mf ≈ 0.4). SSC produce the substorm development on the nightside during prolonged (10 hours) positive B_z-component of IMF and generation of Pc4-5 pulsations on the morning side. We firstly show that SSC cause abrupt increase of the TEC, determined by the GPS receivers, in the morning (ΔTEC= 20–30 %) and evening (ΔTEC≤ 8–9 %) sectors of auroral zone. The increase of the TEC during SSC is not observed on the middle and low latitudes. So obviously the TEC response is caused the particle precipitation into the ionosphere. During the SSC the increase of the electron density at the altitudes 90–200 km registered by the VHF EISCAT radar in Tromso. So the main contribution to TEC increase has the lower part of the ionosphere. SSC produce strong increase of the CNA in Scandinavia and in Svalbard. The strong increase of the aurora intensity at different spectrum lines (450–700 nm) was registered by hyperspectral camera NARUSSCA II of the Polar Geophysical institute in Svalbard. The SSC produce strong increase of the GIC (geomagnetically induced currents) at electric power lines of the Kola Peninsula and Karelia (~30 A).

INVESTIGATING THE TOTAL COLUMNAL ELECTRON CONTENT RESPONSE TO GEOMAGNETIC ACTIVITY AT TORO AN EQUATORIAL STATION

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The study of geomagnetic storm as it affects distant radio wave transmission cannot be overemphasized. The response of the ionospheric total electron content to geomagnetic activity had been investigated using TEC data from a GPS system situated at Toro with geographical coordinates (10.12° N, 09.41° E) an equatorial region in Nigeria. The variability of the ionospheric TEC during geomagnetic quiet and stormy active periods were compared. The storm events for the period of July 6–9, November 11–17 and November 18–19, 2012 were studied.

The response of the *Dst* index was observed to be simultaneous with that of the Horizontal component of the interplanetary magnetic Field IMF B_z and the total electron content TEC for the July 6–9 and November 11–17 events. Both IMF B_z and *Dst* shows an irregular pattern during the 18–19 November event. However, there was a positive increase in the value of TEC. There was a nighttime TEC enhancement during both main and recovery phases of the Nov 11–17 event with percentage increase of about 23 % in the value of TEC. However, there was TEC enhancement in the two storms studied. The observed effects during these periods could be explained in terms ionospheric-magnetospheric dynamics as a result of modulation of the equatorial electric field by geomagnetic storms.

INTER-HEMISPHERIC FIELD ALIGNED CURRENT CHARACTERISATION IN THE AFRICAN SECTOR AND ITS RESPONSE TO A 2009 SUDDEN STRATOSPHERIC WARMING EVENT

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The sudden stratospheric warming (SSW) is a key linkage in the vertical coupling between the lower atmosphere and the geospace, but no studies have attempted to establish the variability of inter-hemispheric field aligned currents (IHFACs) in response to SSW. In this work, we examine ground magnetic variations from September 2008 to August 2009 at eleven stations not only to investigate IHFACs in the African chain, but also to reveal the variability of IHFACs in terms of its connection with SSW. For the first time, there is a compelling evidence from our results that much of the IHFACs variability during the period of the winter northern hemisphere arises mainly from SSW through the activities of planetary waves, rather than ionospheric wind and conductivities or the imbalance of the ionospheric horizontal Sq current. The fact that the amplitude of the IHFACs shows an unusual depletion during this period point to a relation to the offshoot of the 2009 SSW event. For instance, the manifestation of the latitudinal depletion in the amplitudes of the noon time IHFACs in month of January coincides with the unusually strong 2009 SSW event. Quite unexpected, in January, a significant depletion in the IHFACs amplitude was observed during the noon sector around the magnetic equator (Addis Ababa, AAB), compared to any other months under investigation, accompanied with a consistent significantly reduced amplitudes across the Northern hemisphere and a moderate decrease in the Southern hemisphere. Other new insights from our results are that: (1) we obtain prominent currents flowing from the Northern (summer) hemisphere to the Southern (winter) hemisphere around dusk in the equinox; (2) we obtain strong cross – equatorial currents in the equinoxes (August and February); (3) during the noon sector, the IHFACs in the Northern hemisphere penetrates the Southern hemisphere less deeply; and (4) the IHFAC pattern in the African chain show a persistent reversal in the north – south asymmetry, such that, the ionospheric horizontal Sq current imbalance is stronger in the northern hemisphere than the southern hemisphere, except during the dusk. In addition, we confirm the existence of longitudinal variations for IHFACs.

EFFECTS OF PENETRATING INTERPLANETARY ELECTRIC FIELD ON THERMOSPHERIC NIGHTGLOW EMISSION VARIATIONS: A CASE STUDY

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The present study reports nighttime response of the Equatorial Ionosphere Thermosphere System (EITS) over a dip equatorial station, Trivandrum (8.5° N, 77° E, 0.5° dip lat.) to two distinct prompt penetration electric field (PPEF) events occurred during nighttime on 05 January 2016 and 06 March 2016. The investigation carried out using the data from a Nighttime Photometer, Digital Ionosonde, and Fluxgate Magnetometer, revealed that the thermospheric airglow (atomic oxygen emissions) responds promptly to the PPEF events during nighttime. It has been observed that, during the westward PPEF event, the thermospheric O1D 630.0 nm emission intensity enhances whereas during the eastward PPEF event the intensity decreases. While the downward transition of the ionospheric layer causes spike like enhancements in the 777.4 nm oxygen line intensity. The behavior of ionospheric base height vindicates that during eastward (westward) PPEF event the ionospheric layer moves upward (downward). The downward layer movement brings more ionization to the centroid of thermospheric O1D 630.0 nm emission, which in turn enhances the emission rates. While the layer transition through the 777.4 nm emission centroid causes the spiky enhancement on the emission. The temporal variation of emission intensities reveals the nighttime thermospheric dynamics. This study discusses these aspects in detail.

EFFECTS OF SPACE WEATHER ON THE IONOSPHERE: A CASE STUDY OF THE GEOMAGNETIC STORMS DURING THE PERIOD 17–28 FEBRUARY 2014

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Geomagnetic storms represent an extreme form of Space Weather, which can have significant effects on the ionosphere. This study focused on the effects of Space Weather on the ionosphere during geomagnetic storms for the period 17–28 February 2014 over the African equatorial region. The dual frequency Global Navigation Satellite System (GNSS) data were to used retrieve Vertical Total Electron Content (VTEC). Increase and decrease in VTEC compared to monthly median VTEC represented positive and negative ionospheric storm effects, respectively. The analysis showed that positive and negative ionospheric storm effects occurred during the period of study. These storm effects were discussed in terms of the Prompt Penetration Electric Field (PPEF), storm induced wind-lifting effect, and Disturbance Dynamo (DD) electric field. Occurrence of ionospheric irregularities during the storm period was analyzed using rate of change of TEC Index (ROTI). The results obtained show that most of the storms studied triggered ionospheric irregularities. Furthermore, the effect of the irregularities on GNSS signals was analyzed by determining the number of visible satellites in 30 s intervals. A drop in the number of satellites was observed during the occurrence of ionospheric irregularities. This suggests that ionospheric irregularities cause loss of lock in GPS receivers.

EFFECT OF MAGNETIC STORMS ON THE DEVELOPMENT OF SCINTILLATION-PRODUCING IRREGULARITIES IN LOW LATITUDE IONOSPHERE

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An important component of space weather in low latitude ionosphere is the equatorial plasma bubble (EPB) formed by growth of the Rayleigh-Taylor instability on the bottom-side of the post-sunset equatorial F region. As an EPB extends to the topside of the equatorial F region, it develops structure over a wide range of scale sizes, of which the intermediate scale (~100 m – few km) irregularities give rise to fluctuations or scintillations in the amplitude and phase of VHF and higher frequency transionospheric radio signals. The EPBs involve whole flux tubes so that the irregularities at different altitudes over the magnetic equator map down along the geomagnetic field lines to different latitudes. Thus ionospheric irregularities that have the potential to degrade the performance of satellite-based communication and navigation systems may sometimes be present in the low latitude ionosphere over a large part of the globe. Hence numerous schemes have been developed to predict scintillations on L-band signals transmitted from GNSS satellites. An important aspect of the development of scintillation-producing irregularities that has not been considered in these studies is the nature of intermediate scale irregularity spectrum at different altitudes over the magnetic equator within the much larger scale EPB, which map to different latitudes along the geomagnetic field lines. The irregularity spectrum as well as the background electron density determine the strength of L band scintillations at different latitudes. Using observations of scintillations on VHF and L-band signals recorded by a network of ground stations and modelling them using different irregularity models, it has been recently shown that as an EPB develops over the magnetic equator, it becomes more structured on the topside of the F region than near the equatorial F region peak. This explains the occurrence of strong L–band scintillations near the crest of the equatorial ionization anomaly when weak or no L-band scintillations are recorded near the magnetic equator. Two important factors that control the development of structure in an EPB are the height of the equatorial F region and distribution of thermospheric density which affects the altitudinal profile of ion-neutral collision frequency. A major magnetic storm alters both through prompt penetration of a convection or over-shielding electric field into the equatorial ionosphere, and through the effect of a disturbance dynamo. Ionosonde and scintillation observations are used to show how the interplay of the two factors may influence the latitudinal distribution of L-band scintillations associated with geomagnetic activity.

THE RESPONSE OF THE IONOSPHERIC F2 LAYER PEAK PARAMETERS AROUND THE CREST OF THE EIA TO SOME SPACE WEATHER EVENTS

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The equatorial electrodynamics is known to play a vital role in the distribution of ionization at the equatorial/low latitude ionospheric region; it is responsible for the formation of the equatorial ionization anomaly (EIA). The EIA is characterized by the formation of two crests of ionization around ±200 magnetic latitude with a trough at the equator. This study investigates the response of the ionospheric F2 layer over four equatorial/low latitude stations to three (two moderate ($Dst \geq -100$ nT) and one strong ($Dst = -100$ to -150 nT)) geomagnetic storms. Two stations were chosen on either side of the geomagnetic equator, such that they fall within the same or a close range of local time. Results from the study show similarities in the response of N_mF2 from all the stations to the storm events; both positive and negative phases were recorded from the two stations. The highest percentage change in N_mF2 of about 86 % was recorded at Jeju, South Korea, while that of the main phase (about 160 %) was recorded in Townsville, Australia. Averagely, depletions in N_mF2 dominate all the phases of the geomagnetic storms, except the strong storm of 30 September – 01 October 2011. The main phase of this geomagnetic storm corresponds to the daytime period in all the stations. Results from this study further confirm the dependence of the ionospheric response during geomagnetic storms to the local time, longitude and latitude of the stations.

ITUHAB

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We have initiated a low budget project, named “ITUHAB”, that allows some high altitude experiments at stratosphere level in Antarctica and Turkey for detecting alfa, beta and gamma particles. The main target is launching payloads weigh less than 2.5 kg to stratosphere. We used temperature and humidity insulated boxes made of Styrofoam. Geiger counter air and light pollution sensors, IR cameras which are installed in our systems can easily detect air and light pollution. Thus, it will be possible to construct air and light pollution database in Turkey from stratosphere level. In this study, all devices and instruments necessary for this project are GPS modules, air and light pollution quality meters, pressure sensors, IR cameras, HD cameras and other specific sensors (i.e. temperature, humidity, radiation etc.) All tests (i.e. vacuum, very low temperature) were performed at Istanbul Technical University Space Systems Test and Design Laboratory. As a summary, this project will help to develop research related to space and atmospheric sciences in Turkey.

RECURRENT IONOSPHERIC STORMS: TEMPORAL AND SPATIAL SCALES

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Recurrent magnetic storms are produced by fast solar wind streams from coronal holes, which co-rotate with the Sun with ~27-day periodicity. The storms accompanied by various ionospheric disturbances of different temporal and spatial scales. The scales are related to the origin of disturbances. We analyzed low- and mid-latitude ionospheric storms (both positive and negative) with 2-hour resolution by using global ionospheric maps of vertical total electron content derived from the ground based GPS network in time period from 2004 to 2009. It was found that positive ionospheric storms have largest temporal and spatial scales: the duration can exceed ten hours, latitudinal and longitudinal extensions can reach up to 40 and 120 degrees, respectively. In contrast, negative ionospheric storms have ~2 time smaller scales: duration of several hours, latitudinal and longitudinal extents of ~20 and 60 degrees, respectively. Various mechanisms resulting in different temporal and spatial scales of ionospheric storms are discussed.

RESULTS FROM RADIATION ENVIRONMENT INVESTIGATIONS ON THE INTERNATIONAL SPACE STATION IN THE PERIOD 2007–2015 WITH LIULIN-5 CHARGED PARTICLE TELESCOPE

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The space radiation environment of the Earth is complex, composed of galactic cosmic rays, trapped particles of the Earth's radiation belts, solar energetic particles, albedo particles from Earth's atmosphere and secondary radiation produced in the space vehicle shielding materials. Dose characteristics in near Earth and space radiation environment also depend on many other parameters such as the orbit parameters, solar cycle phase and current helio- and geophysical conditions. Since June 2007 the Liulin-5 charged particle telescope has been observing the radiation characteristics in two different modules of the International Space Station (ISS). In the period from 2007 to 2009 measurements were conducted in the spherical tissue-equivalent phantom of MATROSHKA-R project located in the PIRS module of ISS. From 2012 to 2015 measurements were conducted in and outside the phantom located in the Small Research Module of ISS. In this paper attention is drawn to the obtained results for the dose rates, particle fluxes and dose equivalent rates in and outside the phantom from the galactic cosmic rays, trapped protons and solar energetic particle events occurred in that period. Compared are the radiation doses obtained at the deep minimum of solar activity in 23th solar cycle and close to the maximum of 24th cycle and the implications for human space flights are discussed.

MANIFESTATIONS OF THE INTENSE CONVECTION AND SUBSTORM IN THE PROTON AND ELECTRON AURORA DYNAMICS AND IN THE SAR ARC OCCURRENCE

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It is known that the 486.1 nm line (H-beta) is emitted by atomic hydrogen as a result of precipitation of protons with the energy of ~10–20 keV and their recharging at the altitudes of ionosphere E layer (proton aurora). The red line of atomic oxygen (630.0 nm) in the aurora is radiated at the ionosphere F2 region altitudes as a result of precipitation of electrons with energies up to ~1–2 keV. The velocity of magnetic drift of the charged particles in the magnetosphere is proportional to their energy. The energy of particles does not influence to the electric drift. In this work, the dynamics of electron and proton aurorae in the evening MLT sector at the Yakutsk meridian (130º E; 200° E, geom.) during the magnetic storm on January 7, 2015 using the all-sky imager (ASI) is analyzed. The angular westward motion velocity of the auroral structures in the 630.0 and 486.1 nm emissions along the magnetic latitude of 58° N at a high value of electric field of the solar wind $-V_xB_z$ = 9 mV/m (dawn-dusk) has been defined. On the basis of this parameter the value of radial component of the convection electric field and the precipitating protons energy have been estimated. Next, ASI data show an intensification of aurorae in the 630.0 and 486.1 nm emissions in the range of geomagnetic latitudes of 56–61° N and occurrence of the stable auroral red (SAR) arc at latitudes of 49–52° N in ~20 min after the onset of an intense substorm expansion. Measurements aboard the Van Allen Probes A satellite show a sharp increase of fluxes of the energetic H+, O+ ions (injection boundary) at the L~2.6–3.0 at the same time near the Yakutsk meridian. The satellite registers the overlapping of energetic ion fluxes with plasmapause in this L interval. This region is mapped by the SAR arc at lower latitudes (L~2.2–2.6) pointing to the nondipole configuration of the geomagnetic field in the inner magnetosphere at the current values of *SYM-H* ~ –120 nT and *ASY-H*~150 nT. The research is supported by RFBR grants No 15-05-02372 a and No 15-45-05090 r_vostok_a.

THE JOINT ANALYSIS OF THE DYNAMICS OF THE IONOSPHERE PARAMETERS AND COSMIC RAYS DURING PERIODS OF INCREASED SOLAR ACTIVITY

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We performed a joint analysis of the dynamics of the ionosphere parameters and cosmic rays during periods of increased solar activity (the events for the years 2010–2016 were analyzed). Used computational solutions, developed by authors, are based on the application of wavelet transform and neural networks and allows to highlight instants of occurrence of abnormal changes in the data and evaluate their energy features. Of interest are allocated abnormal enhancement in the intensity of cosmic rays that occur at the same time as an increase in the ionospheric electron density. Anomalous effects occurred a few hours before the beginning of strong magnetic storms and had a large spatial and temporal scales.

PWING GROUND NETWORK OBSERVATION OF WAVES AND PARTICLES IN THE INNER MAGNETOSPHERE DURING THE FIRST ERG-GROUND CAMPAIGN

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In order to provide global distribution and quantitative evaluation of the dynamical variation of plasmas and waves in the inner magnetosphere, we have started PWING Project (study of dynamical variation of Particles and Waves in the INner magnetosphere using Ground-based network observations, http://www.isee.nagoya-u.ac.jp/dimr/PWING/PWING_web_e.htm), which will last for 5 years from April 2016, as a Grant-in-Aid for Specially Promoted Research of the Japan Society for the Promotion of Science (JSPS). In this PWING project, we operate all-sky aurora/airglow imagers, 64-Hz sampling induction magnetometers, 40-kHz sampling ELF/VLF receivers, and 64-Hz sampling riometers at 8 stations at ~60 MLAT around the north pole, as well as two EMCCD cameras at two stations. The stations are distributed in Canada, Iceland, Finland, Russia, and Alaska. We combine these longitudinal network observations with the ERG (Arase) satellite, which was launched on December 20, 2016, and global modeling. Using these comprehensive dataset, we investigate dynamical variation of particles and waves in the inner magnetosphere, which is one of the most important research topics in recent space physics. The inner magnetosphere contains plasmas in wide energy ranges from below electron volts to Mega-electron volts. These plasmas (electrons and ions) interact with ULF/ELF/VLF waves at frequencies of 0.1 Hz to 10 kHz to cause their energization in the equatorial plane of the magnetosphere and loss into the ionosphere. The first campaign observation of PWING project with the newly-launched ERG satellite is planned in the second half of March 2017. In this presentation, we show PWING ground network observations of waves and particles in the inner magnetosphere during the first ERG-ground campaign.

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DYNAMICS AND FEATURES OF GEOMAGNETIC DISTURBANCE PROPAGATION DURING MAGNETIC STORMS (BASED ON GROUND STATION NETWORK)

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Geomagnetic data for the periods of magnetic storms in 2015 (events on January 07, March 17, June 21–22, August 15, and December 19–20) were analyzed. The data were recorded at the stations located along a meridian in the north-east of Russia (Kotelny KTN, Tixie TIX, Chokurdakh CHD, Zyryanka ZYK, Cape Shmidt CPS, Yakutsk YAK, Magadan MGD, Paratunka PET, Khabarovsk KHB) and at near equatorial Indian stations (Hyderabad HYB and Choutuppal CPL). A method developed by the authors was used to detect local increases in geomagnetic disturbance intensities and to estimate their dynamic characteristics. Small-scale short-period increases of geomagnetic activity were detected and analyzed. They occur simultaneously at all the stations under analysis several hours before the beginning of the geomagnetic storms. During the main phase of the storm, the areas of activation were detected which had large spatial scales and, evidently, associated with the processes of energy accumulation and relief in the magnetosphere. The development of the method was supported by RSF Grant No.14-11-00194. Experimental investigations were supported by RFBR Grant No. 16-55-45007.

SHORT-TIME FORECASTING OF THE MID-LATITUDE TOTAL ELECTRON CONTENT WITH A MEDIAN MODEL AND A FOURIER TRANSFORMATION APPROACH

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Predictions of the ionosphere are important information for users for either mitigation of threats due to ionospheric perturbations or for the purpose of mission planning. However, increasing uncertainties for forecasts of more than one hour can limit the usability of forecasts. Here, users may have individual thresholds. Therefore, we present an estimation of the accuracy of quiet time forecasts to allow judgement of their applicability and identification of development needs. Empirical prediction of the quiet-time ionospheric total electron content (TEC) is performed with two time-series approaches: the Median Model (MediMod) and a Fourier Transformation approach. Time-series models calculate their prediction values out of the most recent data or maps. The models are applied on real-time map values of the Space Weather Application Center Ionosphere (SWACI). The forecast accuracy is presented for 1 day, 3 days, 7 days and 27 days forecasts ahead and in a comparison between medium and high solar active during the years 2011 and 2015, respectively. A decreasing accuracy of longer forecasts and during higher solar activity is apparent as expected. We will show the definite values to demonstrate the performance of both approaches.

ACCELERATION OF THE ELECTRONS TO THE RELATIVISTIC ENERGIES AT THE OUTER RADIATION BELT DURING MAGNETIC STORMS AND WITHOUT IT

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It is considered traditionally that the appearance of relativistic electrons is one of the manifestations of the magnetic storms in the near-Earth environment. Here we present some events showing that the rate of the electron flux increase does not depend on the geomagnetic storm intensity and such increase can even occur without geomagnetic storm. Using the magnetic field and charged particle data from the GOES geostationary satellites the acceleration of the electrons with energies from 40 keV to > 2 MeV in the outer radiation belt is investigated. To characterize the magnetospheric wave activity in the Pc5 frequency range (1–7 mHz) the ULF index is used. The electron fluxes with lower energies start to grow earlier than fluxes of subrelativistic and relativistic electrons. The necessary condition of the electron acceleration to the relativistic energies is a prolong substorm activity which is accompanied by the injection of seed electrons (50–100 keV), generation of VLF waves, and the occurrence of the high speed solar wind streams promoting the Pc5 wave generation. The correlation between the periods with the high solar wind speed and growth of the relativistic electron fluxes with a 1–2 days delay confirms the idea about the important role of the drift resonance of the magnetospheric electrons with MHD waves in the Pc5 frequency range. The resonant interaction between them leads to the electron radial diffusion deep into the magnetosphere and their preliminary acceleration up to the subrelativistic energies.

CHARACTERING THE GEOMAGNETIC FIELD VARIABILITY FOR THE STUDY OF MAGNETIC STORM AND SUBSTORM IMPACT ON ELECTRIC POWER LINES

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The geomagnetically induced current (GIC) intensity is determined by variations of geomagnetic field. Predominantly geomagnetic field disturbances are oriented in the N–S direction, and produced by the E–W ionospheric currents. Thus, such disturbances seemingly will not induce any significant GIC in a latitudinally oriented system. However, during magnetic storms GIC in power systems elongated in the N–S direction were quite significant. The relative contribution of geomagnetic disturbances into GIC enhancements are examined using data from GIC-recording system deployed by Polar Geophysical Institute. We apply to the IMAGE

magnetometer data for the geomagnetic storm 17 March 2013 various techniques to characterize the geomagnetic field variability: vector mapping of time series, and a measure of time variations of vector angle cosines. This technique has shown that ionospheric currents fluctuate not just in E–W direction, but chaotically in both E–W and N–S directions. So these fluctuations cannot be described only by variations of the auroral electrojet intensity but the model of the GIC estimation must take into account small scale current systems in the ionosphere.

PROCESSES IN THE FRONT OF BOW SHOCK

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The front of the bow shock (BS) is the region where the parameters of the solar wind (SW) undergo strong changes, especially in the nose part. The particle number density and the intensity of the tangential component of the magnetic field increase approximately by a factor of 4 behind the front, the normal velocity component decreases by the same factor (according to data of well-known satellite missions: GEOTAIL, CLUSTER-II, THEMIS; interplanetary shocks in SPECTR-R). If almost all SW energy before the front is concentrated in the progressive motion, then behind the front it is concentrated in the energy of compressed gas and magnetic field. The bow shock front is the main converter of solar wind kinetic energy into electromagnetic energy (Ponomarev, Sedykh et al., 2006). When passing through the bow shock front, the intensity of the tangential component of the SW magnetic field and the plasma density increase several fold. Therefore, among other things, the BS front is a current sheet. It is possible to show that current is diverging in this layer, i.e. the front is the generator of the electric current. Since plasma with magnetic field passes through the front, electric field arises in the front reference system. Thus, the BS front is a source of electric power. There is a potential difference between the BS front and the magnetosphere, unequivocally (since the magnetic field of magnetosheath or transition layer (TL) is determined by the SW magnetic field) associated with the velocity of the transition layer plasma flow. Thus, the magnetopause potential is functionally related to SW parameters. The power consumed by the magnetosphere is spent on the compressor work and consists of active and reactive power. The active part covers losses in the ionosphere (ohmic, primarily), the reactive part returns to the magnetospheric compressor (Sedykh 2011; Sedykh and Ponomarev 2012). We shall assume the bow shock front to be a paraboloid of rotation with its axis coinciding with the X axis in the solar-magnetospheric coordinate system. In the paper we shall be limited to a simple case – I shall consider the dependence only from coordinate x. Certainly, more full decision of the general problem (when dependence not only on one coordinate is examined) has to be considered. However, it is not possible to solve at once a complex problem analytically. Therefore in this study we shall be limited to such statement of a problem. Further, the obtained solution can be generalized on more difficult cases. It is clear that the primary energy source for magnetospheric processes is the solar wind, but the process of energy transfer from the solar wind into the magnetosphere, or rather, to convecting magnetospheric plasma, appears to be rather complicated. The solar wind energy also feeds the ion acceleration process, the generation of waves in the region of bow shock, and the energy necessary to build up the foreshock.

SUBAURORAL ION OUTFLOW WITHIN POLARISATION JET

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Polarisation Jet, or SAID, is a narrow band of fast westward convection which can appear during magnetic storms in the subauroral zone approximately along the nightside plasmapause. It causes strong heating of subauroral plasma due to collisions, fast plasma outflows, and ion conic formation. It results at F-region altitudes in upward or downward plasma motions, a narrow drop in density, or trough in the trough, changes in ion composition, an electron temperature peak, weak SAR-arc, density inhomogeneities and other effects. Data on ion drifts and field-aligned ion outflows from Kosmos-184 and DE-2 satellites at ionospheric altitudes are analysed. Model calculation have shown that bi-Maxwellian ion distributions resulting from perpendicular ion heating in regions where the magnetic field is inclined to the satellite velocity vector, can produce vertically asymmetric fluxes in a driftmeters frame which mimic fast field-aligned ion flows. It is shown that in many cases the data within the Polarisation Jet are consistent with the contribution of the perpendicular ion heating as an additional cause of the observed fast convection.

MODELING THE FORMATION OF HOT RING ZONE IN THE SUBAURORAL IONOSPHERE IN WINTER

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The modeling results of electron temperature distribution in F region of the subauroral ionosphere for different helio-geomagnetic conditions considering plasmaspheric heat fluxes are presented. The study has been conducted using a three-dimensional model of high-latitude ionosphere in Euler variables in view of its thermal regime. It is shown that for quiet geomagnetic conditions during a winter period in the dawn and dusk sectors the “hot” zones with the higher electron temperature are formed, and for disturbed geomagnetic conditions an annular “hot” region in the time interval of 04–06 UT is formed as a result of heat flow from the Earth’s plasmasphere along the magnetic field lines. Analysis of data obtained with the DE-2 and CHAMP satellites shows the possibility of formation of such zone during geomagnetic disturbances.

PRECIPITATION OF RELATIVISTIC ELECTRONS UNDER CYCLOTRON RESONANT INTERACTION WITH ELECTROMAGNETIC ION-CYCLOTRON WAVES

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We study cyclotron resonant interaction of relativistic electrons in the Earths radiation belts with ion-cyclotron waves. Wave packets with varying frequency are considered, and the dipole model of geomagnetic field is used. The equations describing the interaction of test particles with a given wave packet are solved numerically. We analyze the results of numerical simulations for a large number of test particles and obtain the probability of electron trapping and the probability of significant change in electrons pitch-angle for both trapped and untrapped electrons. The energy and pitch-angle variation in the trapping and untrapped regimes are studied for relativistic electrons of outer radiation belt. Conditions, under which effective electron scattering into the loss cone is possible, are obtained and analyzed. It is shown that, depending on electron energy, the interaction with a wave-packet of a constant amplitude can be both more and less efficient than the interaction with a wave-packet having a varying (Gaussian-shaped) amplitude. We compare the results with the numerical simulations reported previously by other authors and with current experimental data.

TEC VARIATIONS OVER MEXICO OBTAINED WITH TAYABSTEC METHOD

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Total electron content (TEC) is one of the main parameters characterizing the Earth's ionosphere. The study presents the analysis of TEC variations over the territory of Mexico. At the moment there is no available ionospheric sounding data in the country. Consequently, TEC studies have a special value for estimating the ionosphere state in this region, especially during Space Weather disturbances. Developed networks of GNSS receivers in Mexico (TLALOCNet and SSN) provide the opportunity of continuous TEC monitoring in near-real time. From 2015 this monitoring is performed by the Mexican Space Weather Service (SCiESMEX). TEC values for this study were derived from data of local GNSS receiver stations with use of TayAbsTEC technique designed by Institute of Solar-Terrestrial Physics, Siberian Branch, Russian Academy of Sciences. The results were compared to global ionospheric maps. The benefits of the TayAbsTEC data processing method for Mexico region were shown. In particular, TayAbsTEC allowed us to observe the finer TEC deviations (small-scale effects). The data during different quiet and disturbed geomagnetic periods between 2011 and 2016 was studied. Regular patterns

(diurnal, seasonal, annual) of TEC behavior over Mexico were obtained which include dependence on solar activity, shift of the main diurnal maximum to the afternoon hours, night-time TEC enhancements, annual anomaly and winter anomaly presence. The results were compared to patterns of other low-latitude zones. Specific features of TEC behavior during disturbances were discussed. An important peculiarity for Mexico was revealed: the presence of strong positive TEC enhancements sometimes not related to geomagnetic disturbances is characteristic for this region. The results were confirmed by measurements at low-altitude satellites.

PREMIER INVESTIGATION OF THE OCCURRENCE FREQUENCY OF EQUATORIAL PLASMA BUBBLES OVER NIGERIA USING THE ALL-SKY OPTICAL IMAGER AND GNSS OBSERVATIONS

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The work examined the frequency of occurrences of plasma bubbles and the seasonal dependence over an African equatorial region using the All-Sky Optical Imager and GNSS observations. The All-Sky Optical Imager, situated in Abuja, has about 500 km fish-eye view covering almost the entire airspace of Nigeria (Longitude 2–15° E and latitude 4–14° N). The GNSS receiver stations used are those within the coverage of the all-sky imager. To enhance the visibility of plasma bubbles on the images, image analysis was performed on the raw images by computing 30-min running mean deviations for the images. Data for the period of June 2015 (when the imager was installed) to January 2017 was used. The images were observed on a day-to-day basis to identify whether or not plasma bubbles were recorded. Computations of differences between evening-time and day-time ROTI (Rate of change of TEC Index) were also used to decide whether or not plasma bubbles were observed on the GNSS observations. Observations from the two sets of equipment were fairly consistent. Preliminary results from the study reveal that there are more plasma bubble occurrences over the region during the months of March and April (March Equinox months) and less occurrences during the months of December and January (December Solstice months).

SUBSTORMS OBSERVED DURING GEOMAGNETIC STORMS BY THE CAMERAS SYSTEM MAIN IN APATITY

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In this work substorms generated during geomagnetic storms were examined. Observations from the Multiscale Aurora Imaging Network (MAIN) in Apatity during 2024/2015, 2015/2016 and 2016/2017 winter seasons have been used. Solar wind and interplanetary magnetic field parameters were taken from the 1-min sampled OMNI data base. Substorm onset and further development were verified by the 10-s sampled data of IMAGE magnetometers and by data of the all-sky camera at Apatity. Subject of the study were the substorm peculiarities during different storm phases. A statistical study of the substorm auroras development depending on the level of geomagnetic activity expressed by the SYM/H and AE geomagnetic indices was carried out and discussed.

STORM TIME ION COMPOSITION VARIATIONS IN THE NEAR EARTH PLASMA SHEET USING SPACE BORNE MEASUREMENTS

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Streaming solar wind particles and ionospheric O+ ions play an important role in the global dynamics of the Earth's magnetosphere. The major particle source for the plasma sheet ions is solar wind and ionosphere. The ion composition of the near-Earth plasma sheet changes with the geomagnetic conditions. The solar wind ions contributes the most to the plasma sheet population during geomagnetically quiet conditions while, ionosphere contributes exclusively during the geomagnetic storm conditions. Its ion composition change during different interplanetary conditions is compared using energetic particle flux data obtained from Geotail spacecraft and Van Allen probes. Intense and moderate geomagnetic storms from solar cycle 23 and 24 with ion composition variations in the near-Earth plasma sheet are compared. Intense geomagnetic storms shows higher O+/H+ and He+/H+ energy density ratio than the moderate ones while there is a strong geomagnetic storm dependence on singly charged heavy O+ ions. The energy density of H+, O+ and He+ ions also depends on the magnitude and duration of southward IMF B_z and solar wind dynamic pressure. The ion composition changes in plasma sheet are comparable to the ring current region, as reported in previous studies indicating transport of ionospheric ions from plasma sheet to the ring current region through mass dependent acceleration by convection electric field. Some of the results regarding the intense and moderate events for solar cycle 23 and 24 will be discussed in the meeting.

DYNAMICS OF THE PROTON AURORA AND SAR ARC ACCORDING TO THE ALL-SKY IMAGER DATA AS THE MAPPING OF PC1 WAVE EASTWARD PROPAGATION ALONG THE PLASMAPAUSE

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The stable auroral red (SAR) arcs are the consequence of interaction of the plasmapause with energetic ions of the ring current. The Pc1 waves are registered on the Earth as a consequence of generation of electromagnetic ion cyclotron (EMIC) waves in the equatorial plane of the magnetosphere. EMIC instability causes the scattering of ring current protons into the loss cone. Precipitation of energetic protons and their recharge on the heights of the ionosphere E layer can be observed as a proton aurora in the H-beta line of atomic hydrogen. In this work the dynamics of the SAR arc, proton aurora and Pc1 waves in the MLT evening sector at the Yakutsk meridian (130° E; 200° E, geom., MLT midnight is 15:50 UT) using the all-sky imager (ASI) and induction magnetometer during the growth and expansion of intense substorms on December 31, 2015 is analyzed. After the enhanced magnetospheric convection due to the southward IMF B_z turning ASI observes an equatorward motion of the diffuse aurora (DA) boundary in the 557.7 and 630.0 nm emissions and H-beta (486.1 nm) band from the northern horizon of observation station. The weak SAR arc is registered equatorward of DA since the beginning of observations. During the expansion phase with the onset at ~12:12 UT and epicenter in the midnight MLT sector the SAR arc center is located at the geomagnetic latitude of 58° N at the zenith of the station. The band in the H-beta emission is registered at the latitudes of 59–61° N. In 10 minutes after the start of substorm expansion ASI registers the SAR arc intensity growth from the western horizon toward the east with an angular velocity of ~4 deg/min. As a result, along the arc a few intensity maxima are formed. At the same time, the narrow band in the H-beta emission with a similar dynamics appears poleward of the SAR arc at a distance of ~ 0.6°. The induction magnetometer detects a sharp increase of Pc1 pulsation amplitude during the arrival of end of the band in the H-beta emission to the zenith of observation station. The Pc1 pulsations and the dynamic proton aurora are registered within ~ 30 min. The SAR arc is registered by ASI until about 1400 UT. We connect the observed phenomena in the SAR arc and proton aurora with the propagation process of EMIC waves to the east along the plasmapause. The generation of EMIC waves occurs probably at higher L shells in the boundary region of plasmaspheric plume. The research is supported by RFBR grants No 15-05-02372 a and No 15-45-05090 r_vostok_a.

EXPERIMENTAL STUDY OF THE PLASMASPHERE BOUNDARY LAYER

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The boundary of the plasmasphere – the plasmapause – is a crucial place for the interaction of energetic particles with the cold plasma. Many specific phenomena are observed in this region: development of Polarization Jet (SAID, SAPS), Subauroral red arcs, formation of Subauroral morning proton spots etc. During large magnetic storms the plasmapause approaches L~2.5 and the ring current energetic particles are observed close to the Earth at such distances, and this is essential

for the space weather safety studies. The in situ cold plasma measurements onboard MAGION 5 were carried out with very good time resolution and permitted to analyze thin boundary layer near the plasmapause. It is found that in this layer the plasma density NPBL is decreasing exponentially with L: NPBL~exp(-L/WPBL), where WPBL describes the width of the plasmasphere boundary layer. The density in the middle of the boundary layer is inversely proportional to the volume of magnetic flux tube, whereas its width is proportional to the volume of magnetic flux tube. The width of the boundary layer also depends on magnetic activity and on time elapsed since the most recent burst of magnetic activity. The talk is partially supported by the program 1.7 P of RAS.

ANALYTIC MODEL OF CHANGES IN THE MAGNETOPAUSE SHAPE AND POSITION WITH IMF AND SOLAR WIND PARAMETERS VARIATIONS

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It is generally accepted to use solar wind ram pressure and IMF B_z component for empirical description of the geomagnetopause position and shape. Specific feature of the present talk is to use not solar wind parameters but neighboring to magnetopause thermal, and magnetic field pressures for proper modeling. These pressures are deduced basing on the results of 3D MHD runs and analytic solutions for post bow shock MHD flow in Lagrangian variables. IMF B_y and B_z components influence the planetary magnetopause position and shape in two different ways: both components lead to increase close to magnetopause magnetic pressure while B_z part of IMF leads additionally to variation of this boundary shape. The magnetopause shape variation in turn changes the so called 'doubling factor' which indicates how much the internal magnetospheric field is increased due to Chapman-Ferraro currents. Doubling factor can be analytically related with magnetopause shape by Tsyganenko magnetospheric field ellipsoidal model. Incorporating all above effects in our analytical model leads to 'perfect' description of 'rapid' magnetopause approach to the Earth for southward IMF and to its 'stagnative' behavior with increase of northward IMF component. Our analytic model well describes additionally the magnetopause motion with variation of IMF cone angle. The talk is partially supported by the program 1.7 P of RAS.

CORRECTION OF THE NeQuick MODEL AT HIGH LATITUDES USING GROUND-BASED GNSS RECEIVERS - VERIFICATION BY IONOSONDE DATA AND HF RAY TRACING

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In recent years, attention to investigation and diagnostic of ionosphere significantly increases. This is largely due to the fact that the requirements for the radio systems accuracy

using ionospheric channel is increased significantly. Consequently high accuracy of ionospheric modeled prediction and/or real-time definition is required. Nowadays, global navigation satellite system (GNSS) such as GPS and GLONASS, worldwide ground-based network of satellite signal receivers provide a new possibility of real time ionospheric monitoring. GNSS Signal Processing is used for calculating absolute total electron content (TEC) along radio path between each satellite and ground-based receiver. However, integral nature of absolute TEC parameter causes difficulties for real application. Absolute slant TEC can be used for the correction of ionospheric models providing more accurate electron density distribution. In this paper, we propose modeling of HF ray tracing in the high-latitude ionosphere. To describe the electron density of the propagation medium the correction of absolute TEC data from NeQuick model is used. Correction algorithm of ionospheric model parameters is based on the control parameters according to the slant TEC. Smoothed sunspot number R12 in the NeQuick is an example of such parameter. The number of the parameters requiring for the calculation of the complex refractive index for the ordinary and extraordinary waves, were taken from empirical IRI model. In addition HF ray tracing modelling is performed by the shooting method and direct variational approach. Simulation of ray paths was provided for all seasons and time of day in 2014. These calculations were carried out by two methods: variational method, and homing-in approach. We compared the calculation results and the experimental data in order to estimate the efficiency of the algorithm for ionospheric model correction according to slant TEC data adaptation.In recent years, attention to investigation and diagnostic of ionosphere significantly increases. This is largely due to the fact that the requirements for the radio systems accuracy using ionospheric channel are increased significantly. Consequently high accuracy of ionospheric modeled prediction and/or real-time definition is required. Nowadays, global navigation satellite system (GNSS) such as GPS and GLONASS, worldwide ground-based network of satellite signal receivers provide a new possibility of real time ionospheric monitoring. GNSS Signal Processing is used for calculating absolute total electron content (TEC) along radio path between each satellite and ground-based receiver. However, integral nature of absolute TEC parameter causes difficulties for real application. Absolute slant TEC can be used for the correction of ionospheric models providing more accurate electron density distribution. In this paper, we propose modeling of HF ray tracing in the high-latitude ionosphere. To describe the electron density of the propagation medium the correction of absolute TEC data from NeQuick model is used. Correction algorithm of ionospheric model parameters is based on the control parameters according to the slant TEC. Smoothed sunspot number R12 in the NeQuick is an example of such parameter. The number of the parameters requiring for the calculation of the complex refractive index for the ordinary and extraordinary waves, were taken from empirical IRI model. In addition HF ray tracing modelling is performed by the shooting method and direct variational approach. Simulation of ray paths was provided for all seasons and time of day in 2014. These calculations were carried out by two methods: variational method, and homing-in approach. We compared the calculation results and the experimental data in order to estimate the efficiency of the algorithm for ionospheric model correction according to slant TEC data adaptation. The reported study was funded by RFBR according to the research project No. 16-35-00590 мол_а.

FORMATION OF HIGH DENSITY REGIONS IN THE PLASMASPHERE BY VERTICAL FLUXES OF COLD IONS FROM THE IONOSPHERE

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Cold plasma measurements onboard the INTERBALL spacecraft reveal the regions in the plasmasphere where the density was 3–5 times higher than in the neighbor regions. Such regions were mostly observed after the substorm activations. Ground based and satellite measurements in the ionosphere during substorms, showed that fast upstreaming plasma fluxes are formed in the polarization jet band. The vertical velocity of such fluxes achieves 1.0–1.5 km/s at the height of DMSP satellites (~850 km). The case study comparing the observed high-density structures in the plasmasphere with high speed plasma streams from the ionosphere during the polarization jet development, taking into account the time of plasma transport from the ionosphere to the plasmasphere, reveals the interconnection of these phenomena. The talk is partially supported by the program 1.7 P of RAS.

EXPERIMENTAL STUDIES OF PHYSICAL CONDITIONS FOR THE POLARIZATION JET FORMATION

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Observations of polarization jet (PJ) by the coherent backscattering radar – SuperDARN – in Tasmania showed that PJ is developing during the substorm break up. These observations confirm the conclusion made previously from the data of Yakutian chain of ionosondes. This fact is very important for the analyses of possible mechanisms of PJ formation. The SuperDARN data also evidences on the existence of large sporadic electric fields at the moment of PJ formation, and this suggests that thermoelectric mechanism of electric field creation in the mode of voltage generation is effective. The connection of PJ with the injection of ions into the inner magnetosphere is considered in details using simultaneous measurements by the ionosonde chain and onboard AMPTE/CCE. It is shown PJ is formed on the ionospheric projection of the inner injection boundary of ions with the energy of 20–30 keV. According to ground-based measurements on the longitude chain of ionospheric stations the velocity of westward motion of the source responsible for the PJ formation is 3 hours MLT per hour at L=3. This corresponds to the velocity of azimuthal drift of ions, observed by AMPTE/CCE. The mechanism of PJ generation should be effective even in the conditions of high electrical conductivity in sunlit summer ionosphere. In the region of PJ formation due to strong heating of neutrals under the action of electric field, the thermospheric circulation is completely reconstructed.

EXPOSURE TO EXTERNAL INFLUENCES EARTH AND SOLAR SYSTEM

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The study and attempts to explain the properties so-called Solar-Terrestrial Relations were in a protracted crisis. Without taking into account the roles and contributions of all external influences on the Earth still has not explained their mechanisms and cyclicity, energetics, polar asymmetry, synchronicity, and others species of manifestations. Answers to these questions are obtained by taking into account, in addition to solar activity and the flow of GCR, the endogenous activity of the Earth due to the gravitational influence from the Moon, the Sun and the other planets in the barycentric motion of the Solar system in the gravitational field of the Galaxy, as well as external influences on the Solar system whole. Taking into account all the external factors allowed explaining a pause or a temporary reduction in global warming in 1998–2013.

ON NON-UNIVERSALITY OF SOLAR-TERRESTRIAL CONNECTIONS

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Non-universality of the solar-terrestrial connection (STC) caused by complex and dynamical character of the dynamo process in the Sun from the one side and of the non-stability of the global atmospheric circulation in the Earth from the other side. These reasons lead from time to time to drastically change of the STC manifestations as whole. Partly it leads to change of the phase relations between different forms of the Earth environment responses (EER) on solar activity (SA). The dynamo mechanism, controlled SA, includes few basically elements (differential rotation, solar convection, toroidal and poloidal magnetic fields, global circulation and more). All this elements are connected one to another with direct and feedbacks causal-reason relations between them. In result solar cycle has dynamically change in amplitude, in period and in phase behavior up to phenomena of strange attractor. This non-stationarity leads to different phase pattern of main manifestations of solar activity and its non-stability (sunspots number, flares frequency (with different phase patterns for different amplitudes), coronal holes, chromosphere emission and more). When this non-stability overlaps on non-stability of the global atmospheric and oceanic circulation, it leads to complex and non-stable response of the earth weather and climate on solar activity. We discuss this non-universal character of STC and its sequences for identification of solar variability in atmospheric, agriculture response and wheat price dynamics. We propose list of necessary conditions and possible scenarios of SCT taking in account the non-universality of SCT.

RESPONSE OF HIGH FREQUENCY RADIO WAVE PROPAGATION CHARACTERISTICS TO THE X-RAY FLUX VARIATIONS

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In this work we carry out the analysis of HF radio wave propagation characteristics obtained over several paths located in the Siberian and Far Eastern regions of Russian Federation during periods of solar flares from C to X classes by X-ray fluxes data. The lowest observed frequencies (LOF) have been evaluated using program complex of automatic interpretation of oblique-incidence sounding (OIS) ionograms. We analyze OIS data obtained from 2014 till 2016 LOF values characterize signal absorption over the paths. LOF variations for studied days were compared with LOF median values for the month investigated. Sharp LOF increases during studied X-ray solar fluxes in comparison with quiet conditions were registered over all paths. In the moment of maximum of X-ray fluxes disappearance of reflections from lower layers of ionosphere has been observed, HF signals propagation has occurred by means of reflections from F2 layer. Amplitude of HF signal has been decreased also. Thereby as a result of our study of HF radio wave propagation characteristics response to the X-ray flux variations sharp increase of radio waves absorption and decrease of frequency range during solar flares has been observed. The modeling of HF radio waves propagation characteristics on the base of complex algorithm which includes modules of ionosphere and plasmasphere global model and radio waves propagation model for the several solar flares has been carried out.

TEC ENHANCEMENT IN SOUTHERN HEMISPHERE DURING MAGNETIC STORM OF AUGUST 15, 2015

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Solar flare of August 14, 2015 caused strong magnetic storm and significant increase electron density at the lighted side of the Earth. This enhancement is clearly observed at Global Ionospheric Maps (GIM) and has separated pronounced areas of high density. The most interesting is the one located in high latitudes of Southern Hemisphere. We investigate the phenomenon in details using different sounding instrument and facilities in the region and tried to explain the mechanism of its generation.

FORCING OF COSMIC RAYS ON THE EARTH'S ATMOSPHERE

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The way to understanding the mechanisms of cosmic influence on the atmosphere of the Earth has a rather long history. In the 70th of XX century on the basis of theoretical investigations it was found, that energetic particles coming from space (solar and galactic cosmic rays) create new HOx and NOx chemical compounds, which destroy ozone in catalytic cycles. After that new mechanism was used in model photochemical simulations. In XXI century it became possible to compare the results of model simulation with satellite observations (UARS, ENVISAT). The results of model simulations, which illustrate the response of chemical composition (neutral and ionized) and dynamics of the atmosphere to major solar proton events are presented. Changes in electron density induced by galactic cosmic rays are also presented.

THE DRIFT-COMPRESSION WAVES PROPAGATING IN THE EASTERN DIRECTION

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In the work in the gyrokinetic framework it was shown that in the magnetosphere the drift-compression waves can be propagating in the drift direction of energetic electrons. The plasma is assumed to be composed of core cold particles and a hot admixture of protons with a Maxwell distribution and electrons with an inverted distribution. The conditions of existence of such waves and their amplification due to resonance interaction with energetic electrons (drift instability) have been found. The obtained results can be useful for interpretation of wave observations in the magnetosphere with frequencies in the range of geomagnetic pulsations Pc5 and below.

ANALYSIS OF TECHNIQUE FOR PLASMA TEMPERATURES DETERMINATION ON THE BASIS OF RADIOPHYSICAL MODEL OF INCOHERENT SCATTER SIGNAL

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Irkutsk incoherent scatter radar (IISR) enters to the world net of ground-based instruments for ionosphere remote sensing. These instruments may be considered to be basic for ionosphere indirect measurements in the wide range of altitudes. As any incoherent scatter facility, the IISR construction is unique, what necessitates special technical approach to determination of plasma parameters under study. IISR raw data (in terms of quadrature independent realizations) are being kept on HDs. This allows to save the all information that signal may contain. Hence, if the processing technique was not very correct, we could improve it using comprehensive approaches to systematical errors counted out. The most effective approach on the basis of theory is the

direct model of backscattered signal. The following sources of systematical errors are under study: 1. Time integration of independent realizations and effects of radio noise. 2. The IISR radiates and receives signal of linear polarization. So power profiles of the received signal have dying-outs because of Faraday Effect. This leads to complication of ambiguity function that couples statistical performance of plasma fluctuations with that of the received signal. 3. Spectral distortions are treated in terms of physical phenomena they reflect. Doppler shift determines the value of neutral wind velocity along the radar beam. Complicated symmetric form of the spectra depends on ion composition. Spectral asymmetry may be explained whether by presence of electric fields unexpected in middle latitudes or by peculiarity of radar construction – frequency scanning (dependency of radar pattern direction form operating frequency). 4. Significant contribution of coherent component to backscattered signal is experimentally observed. The main assumption for nature of this component is integral contribution of plasma turbulence with its own spectra. A technique for its estimation is under development. The goal of this study is to provide regular high-quality estimations of plasma temperatures for Siberian region. Acknowledgement The study was done under RF President Grant of Public Support for RF Leading Scientific Schools (NSh-6894.2016.5). Experimental data was obtained with unique scientific equipment Irkutsk incoherent scattering radar, reg. nb. 01-28. The work was done under the basic research project II.12.2.1 Development of new methods for experimental radiophysical studies of the upper atmosphere of the Earth and near-Earth space.

SIMULTANEOUS OBSERVATION OF RADIO SIGNAL IONOSPHERIC SCINTILLATIONS IN METER AND DECAMETER BANDS IN THE DIRECTION OF THE MAGNETIC ZENITH

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Radio signal scintillations in the ionosphere occur due to scattering on irregularities, whose size is close to size of first Fresnel zone for signal frequency. In the number of papers it was shown that intensity of radio signal scintillations increases when line of sight (LOS) to the source of radio signal and geomagnetic field vector become almost collinear. This effect is usually referred to as magnetic zenith effect and believed to be caused by field-aligned irregularities of ionosphere plasma density (FAIs). Scintillations in direction of magnetic zenith were observed using facilities of ISTP SB RAS observatory of atmospheric radio probing – Irkutsk incoherent scatter radar (IISR) and Novatel GPStation-6 receiver. IISR operates in 154–162 MHz frequency band, and navigation signal receiver – at ~1.2 and ~1.6 GHz. For this study we used data obtained at IISR from June18 to July 1, 2015. During this experiment IISR operated in passive mode without transmitting any signal, as a radio telescope registering cosmic radio noise. This mode allows to measure the power of discrete radio source Cygnus-A emission with high time resolution (4.5 seconds) and to investigate fast radio signal amplitude variations using scintillation index *S4* and also to perform their spectral analysis. GPS/GLONASS receiver allows to measure both amplitude (*S4*) and phase scintillations with 1 min resolution. The analysis of dynamic spectra of Cygnus-A emission scintillations under quiet geomagnetic condition has shown substantial widening of amplitude spectrum when the source approaches magnetic zenith. This causes increase in S4. During geomagnetic storm on June 22, 2015 disturbances were observed away from the magnetic zenith and their amplitude spectrum differed from the quiet one significantly: sharp increase of scintillation intensity was observed in wide band during main storm phase. The navigation receiver data analysis shows no dependence of amplitude

scintillation intensity at ~1.2 and ~1.6 GHz on angle between LOS and geomagnetic field, but we have found the clear dependence for phase scintillations. Also we have studied correlations between amplitude and phase scintillations of the navigation signal in decameter band and amplitude scintillations of Cygnus-A emission in meter band for the same ionosphere area. Acknowledgements The study was done under RF President Grant of Public Support for RF Leading Scientific Schools (NSh-6894.2016.5) and supported by the Russian Foundation for Basic Research (project N 15-05-03946_a). Experimental data was obtained with unique scientific equipment Irkutsk incoherent scattering radar, reg. nb. 01-28. The work was done by the basic research project II.12.2.1 Development of new methods for experimental radiophysical studies of the upper atmosphere of the Earth and near-Earth space.

COMPARISON BETWEEN CALIBRATED AND ABSOLUTE POWER MEASUREMENTS AT THE IRKUTSK INCOHERENT SCATTER RADAR

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Incoherent scatter (IS) radars are most informative instruments for regular measurements of ionospheric parameters including height profiles of electron density, ion and electron temperatures, plasma drift velocity, ion mass and collision frequency. Irkutsk Incoherent Scatter Radar (IISR) is horn antenna 246 × 12.2 m with polarization filter that limits transmission and reception to a linear polarization. This limitation together with frequency range 154–162 MHz leads to fading of the received signal due to Faraday rotation in the ionospheric plasma. By following phase of the fading, one can restore height profile of electron density without considering exact power levels. This method was utilized at IISR during long-term observations. There is radar equation that links electron density of the ionosphere and power measured by the radar. This work is dedicated to comparison between absolute IS power, obtain with Faraday rotation method, and actual measured power. Inequality between the two may be referred to an additional scatter, reflection or absorption in the atmosphere. The results allow us to validate Faraday rotation method and improve our estimations of electron density, plasma temperature and drift velocity since any unaccounted coherent signal affects them. To accomplish the comparison, we have performed calibration of receiving channels using extraterrestrial sources — we convolved sky temperature map based on Global Sky Model with antenna radiation pattern and used it as source of known signal. Using regression between measured and known noise we estimated total gain and system noise for the radar. Several other peculiarities like compensation for bias and nonlinearity of antenna frequency response also should be taken into consideration. Apart from ionospheric measurements, calibration of receiving channels helps to evaluate signals from passive observations of the Sun. Acknowledgement The study was done under RF President Grant of Public Support for RF Leading Scientific Schools (NSh-6894.2016.5). Experimental data was obtained with unique scientific equipment Irkutsk incoherent scattering radar, reg. nb. 01-28. The work was done under the basic research project II.12.2.1 “Development of new methods for experimental radiophysical studies of the upper atmosphere of the Earth and near-Earth space”.

STATISTICAL CHARACTERISTICS OF FLASHES IN THE ATMOSPHERE BASED ON CCD PHOTOMETER DATA

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Fast dynamic optical processes in the upper atmosphere of the Earth can be divided into phenomena associated with atmospheric electricity, phenomena caused by magnetosphere-ionospheric interaction through particle precipitation, and phenomena associated with meteors and artificial satellites of the Earth. In addition, we can note optical flashes associated with superhigh-energy subatomic particles invading the Earth atmosphere. According to the latest information, transient light phenomena (Transient luminous Events, TLE) such as sprites, elves, halos, giant jets are connected to the region of thunderstorm activity. A global picture of the location of these geophysical events is that they predominantly occur in the equatorial zone. The first registration of fast optical flashes with a multichannel zenith photometer and an analysis of the results obtained by means of the geophysical observatory of the ISTP SB RAS were carried out in 2000. Estimations of the luminosities of optical flashes for various ranges of the optical spectrum, the distribution over durations, and the probability of recording optical flashes during the night were obtained. Comparison of the moments of registration of optical flashes and gamma-ray bursts was carried out according to the data of the BATSE catalog. The extremely low occurrence frequency of TLE over the central parts of the continents of the northern and southern hemispheres, particularly in Eurasia, in conjunction with the observed rapid optical flashes, raises the question of the nature of the flashes or the refinement of the results obtained. At the end of November in early December 2016, night sky monitoring was resumed for the searching of fast optical flashes using a photometer based on a CCD matrix. The using of modern devices based on CCD matrix with a time resolution of a few seconds makes it possible to determine the local space morphology of events which are the reason of the fast optical flashes in the Earths atmosphere, and for the selection of fast optical flashes from meteors. In this work we use a photometer based on a CCD matrix designed to observe fast processes (units of seconds). The photometer is assembled on the basis of the SONY ICX285AL CCD matrix (video camera-285 / P-USB, development of the NGO VIDEOSKAN, http://videoscan.ru/). As an input lens is used the lens Jupiter 3. Resolution (pixels) 1392×1040. Pixel size (μm) 6.45×6.45. Matrix size (inch / mm) 2/3 (8.77×6.6) Exposure time from 3.5 microseconds to 110 seconds. The frame frequency (Hz) is from 7.7 to 19.5. The working spectral range is 400-800 nm. Observations are conducted on the territory of the Geophysical Observatory Торы (51.809813° N, 103.077429° E) of ISTP SB RAS. The camera is mounted on a fixed mount at an angle of ~ 51° to the horizon and directed to the north. Exposure time of 2 seconds was chosen based on preliminary results of the photometer work. The main objective of the study is to determine the cameras capabilities for fixing fast optical flashes, artificial Earth satellites and meteor bolides. The results of observations for December 2016, January and February 2017 are revived in the paper. An automatic algorithm for selecting a frame with a flash is described. Automated algorithms for extracting frames containing satellites and meteor bolides are proposed. Based on the primary flash database, a statistical analysis of the results was carried out. The contribution of natural noise is estimated. The study was done under RF President Grant of Public Support for RF Leading Scientific Schools (NSh-6894.2016.5). The data of the CCD of a photometer included in the optical complex of the CCU «Angara» were used in the work. The work was carried out with the financial support of the project Study of dynamic processes in the system of a neutral atmosphere — the ionosphere — the Earth's magnetosphere. Unique number is 0344-2014-0006. Reg. Number Center for Information Technologies and Systems-01201281656. The internal cipher of the Institute is 200 005 100.

THE PATTERN OF IONOSPHERIC DISTURBANCES CAUSED BY COMPLEX INTERPLANETARY STRUCTURE ON 19–22 DECEMBER 2015

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On 19 December 2015 a heliospheric structure created by two interplanetary coronal mass ejections (ICMEs) triggered two-step severe geomagnetic storm. It started at 16:17 UT on 19 December, reached a first minimum of SYM-H = –77 nT at 09:20 UT and a peak intensity –170 nT at 22:52 UT on 20 December. The initial phase was associated with an upstream sheath of ICMEs; first step, with ~ –16 nT interplanetary magnetic field (IMF) B_z component and ~30÷70 cm^{-3} solar wind density(N_{sw}); second step, with IMF B_z decrease from –10 to –19 nT and solar wind rarefying from 50 to 2 cm-3. The high N_{sw} does not allow to identify the mentioned negative IMF B_z regions as magnetic clouds. The recovery phase developed during southward IMF B_z weakening on the background of N_{sw} ~2 cm^{-3}. An analysis of ionospheric disturbances was conducted using ionospheric data obtained in Northern hemisphere near meridian 120° E. During the initial phase an increase in F2 layer critical frequency (f_oF2) was detected only at the most equatorward Hainan station (19° N) nearby midnight. The f_oF2 increase was preceded by a growth of F2 layer peak height by about 100 km coincident with a sharp northward IMF B_z turning, thus with reduction of magnetospheric convection and generation of eastward over-shielding electric field. During the first storm's step the stations located northward of 25° N observed positive f_oF2 disturbance which could be associated with amplified equatorward thermospheric wind caused by high-latitude Joule heating. It was the most intensive at low-latitude Okinawa station. The second step was characterized by blanketing sporadic E_s layers at high latitudes, an absence of clearly defined disturbances at middle latitudes, and fluctuating increased f_oF2 at low latitudes. At the beginning of the recovery phase fluctuating increased f_oF2 appeared at 30–40° N. At low latitudes wave-lake fluctuation of decreased f_oF2 were observed up to the end of the phase. The fluctuations of f_oF2 were similar to those of polar cap PCN/PCS indices, but there is no one-to-one correspondence between their phases. The long-duration f_oF2 depletion which could be associated with thermospheric composition changes was observed only at high-latitude stations. This work was supported by RFBR grant N 16-05-00563.

ANALYSIS OF FINE STRUCTURE OF BACKSCATTERED SIGNALS BASED ON EKB ISTP SB RAS RADAR DATA

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Coherent decameter (8–20 MHz) radar EKB ISTP SB RAS works in monitoring mode. Its field-of-view covers an approximate segment Ekaterinburg — Norilsk — Novaya Zemlya. The basis of radar operation is transmitting sounding sequences and receiving both the signals backscattered by ionospheric irregularities (ionospheric scatter, IS) and signals backscattered by the Earth's surface irregularities (ground backscatter, GS). Analysis of the average parameters of the scattered signal — Doppler frequency shift (DFS), spectral width and scattered power, allows

such radar to investigate processes in high- and mid-latitude ionosphere. Statistical methods of the scattered signal processing are developed well enough. In this work, a preliminary analysis of the fine structure of the backscattered signal had been made. Based on the model of single scatterers, which had been initially designed for VHF Irkutsk Incoherent scatter radar, the algorithm for analyzing the scattered signal was made. The model signal is a superposition of elementary signals similar to the transmitted, with different amplitudes, DFS and the initial phase. These parameters are determined from experimental data. We used three criteria of the signal presence: the minimum of the phase root-mean-square deviation (RMSD) to the linear phase trend, the maximum of the correlation function (CF) between received and model signal, and the minimum RMSD between the quadrature components of received and model signals. The results for each method were used to construct the statistical distributions of DFS, signal/noise ratio and phase RMSD. A comparative analysis of the different scattering types was performed based on these statistical distributions. The analysis has shown that the distributions are very similar for IS and GS. The difference between the distributions of IS/GS and noise looks substantial. This makes the separation of noise from IS/GS possible even for individual samples of scattered signal.

STORM TIME OCCURRENCE OF THE IONSPHERIC TROUGH IN GPS-TEC MEASUREMENTS OVER EUROPE

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In the dynamics of the main ionospheric trough during December 20, 2015 storm in TEC (Total Electron Content) is presented. The active phase of the storm started on December 20, 2015 after midnight. Maximal value of Sum of K_p reached of 45, maximal value of *Dst* was about –155 nT near 23 UT. Recovery phase of storm took place December 21, 2015. For analyses of trough the TEC latitudinal profiles formed from TEC maps over Europe have been used. GPS observations collected by International GNSS Service (IGS) and European Permanent Network (EPN) were used to create TEC maps. More than 150 stations from Europe were included in the analysis. The dense world-wide GPS network provided TEC measurements with high spatial resolutions. The TEC maps over Europe are presented at http://data.wdizmiran.ru:8080. High-precision phase measurements were used while processing. After pre-processing an absolute TEC for all satellite-receiver paths was calculated. In order to obtain the spatial and temporal variation of TEC and to create TEC maps, the measurements were fitted to a spherical harmonic expansion in a geographic latitude and longitude. The large number of GPS stations in Europe provides good coverage for GPS data and enable high-accuracy TEC maps with a temporal resolution of 5 min to obtain. The profiles were created with resolution of 1 degree at fixed longitude of 20° E. An automatic procedure was developed to identify the trough signatures. To locate the trough mimima we used the criterion of the curvature for TEC function. A visual identification was used to control and check the automatic procedure. Usually the trough signatures on latitudinal profiles are demonstrated as the minimum values of TEC with well-defined equatorial and polar walls. During winter the trough-like structure can be recognized in evening and night hours. During the storm the sharp decrease of TEC, which was associated with the trough, was recognized in daytime after 13 UT. Location the trough minimum was evaluated near 66° N. After 13 UT a trough minimum shifted toward equator

untill 51 N. In this time it was recogized seconf trough minimum located near 68° N. The trough structure can recognize as occurrence of high latitude trough. During recovery of phase storm the behavior of TEC profiles similar one main phase of storm, but latitudinal location of trough take ones stand at higher latitudes. In whole latitudinal profiles during storm demonstrate more variability against quiet conditions. This investigation was supported by RFBR Grant N 16-05-01077, partly Program N 7 of the Presidium RAS.

FABRY—PEROT INTERFEROMETER KEO SCIENTIFIC ARINAE FOR AIRGLOW OBSERVATION IN THE EASTERN SIBERIA: FIRST RESULTS

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We present measurements technique and first results obtained with the Fabry—Perot Interferometer (FPI) which was recently installed at the Geophysical Observatory of the Institute of Solar-Terrestrial Physics (51.8° N, 103.1° E, Tory). Using FPI measurements data we can derive neutral wind and temperature at the height of emission layers. The instrument has some individual technical features which allow us to observe upper atmosphere airglow from several spectral regions and obtain data on various atmospheric emissions including OI 630 nm and OI 557.7 nm. The input window of the instrument is equipped by the electromechanical periscope with automatical operation. So, we can organize any observational program (timing and direction) during the night. Moreover, using modern bandpass filters and CMOS chamber with cooling and thermal control for all thermally sensitive parts provides the powerful tool for upper atmosphere study. In the present work we describe the modification of the method for retrieving line position and width from observed interferogramms. Using proposed method we obtained night variations of neutral wind and temperature from 630 nm (~250 km) and 557.7 nm (~97 km) emission data. The obtained results were compared with reference models of the upper atmosphere and with the results obtained from other existing observational tools installed at the ISTP Geophysical Observatory. At the moment we can conclude that temperature values derived from 630 nm oxygen line data are in agreement with existing empirical model of the airglow but lower than ones calculated using MSIS model. The neutral winds velocities obtained from 630 nm and 557.7 nm emission data are mostly in agreement with HWM-14 model for MLT and thermosphere. The work was performed with equipment of collective usage area “Angara”. The work was carried out with the financial support of the project Study of dynamic processes in the system of a neutral atmosphere — the ionosphere — the Earths magnetosphere (Unique number is 0344-2014-0006, Reg. Number CITiS-01201281656), and RF President Grant of Public Support for RF Leading Scientific Schools (NSh-6894.2016.5).

ABOUT OBSERVATIONS OF SPECTRAL RESONANCE STRUCTURES IN THE FREQUENCY BAND OF THE ALFVEN IONOSPERIC RESONATOR AT THE MAGNETIC STAION BAYGAZAN

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In November 2014, an induction magnetometer developed by the Gorno-Altaysk State University (GASU) based on the INT-1 sensor (provided by the Institute of Solar-Terrestrial Physics of the SB RAS) was installed at the magnetic station Baigazan of the GASU and monitoring of geomagnetic variations was started. The low level of magnetic noise at the station, which is located on the cordon of the Altay Reserve, and the relatively high sensitivity of the equipment allows us to confidently register the spectral resonance structures (SRS) in the frequency band of the ionospheric Alfven resonator and three Schumann resonances (8, 14, 20 Hz). A preliminary analysis of the frequency of observations of the SRS at the station for 2015–2016 was conducted. The dynamic spectra for induction magnetometer data, were calculated and, according to the characteristic patterns of the SRS, the days of their observations were revealed. SRS was observed at night. The one-year period wave for number of SRS observation per month with a minimum in the summer months (1–5 obs/month) and maximum in the November (20 obs/month) have been identified. The average percentage of SRS observation days at the station is 35 %.

HIGH-ENERGY MAGNETOSPHERIC ELECTRONS DURING LAST SOLAR CYCLES

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The daily fluence of electrons is selected as the main characteristic of the behavior of electrons with energy >2 MeV measured by GOES satellites in geostationary orbit, since this characteristic is closely related with malfunctions of satellite electronic equipment. It is shown that the increases in the flux of high-energy magnetospheric electrons are associated with considerable interplanetary and magnetospheric disturbances, but the beginning of the electron increases lags behind them by 1–3 days. A greatly increased solar wind speed is observed as 3 days before the electron flux starts to grow, with a maximum being reached by onset of growth. It is shown that the electron fluence is weakly associated with the level of geomagnetic activity on the same day, but correlates to A_p-index of geomagnetic activity observed 2–3 days earlier. The fluence of high-energy magnetospheric electrons is closely associated with the solar wind speed, especially with its value measured 2 days earlier.

INVESTIGATION OF ACTIVE AREA DYNAMICS IN AURORAL ZONE USING OBSERVATIONS OF IRREGULAR GEOMAGNETIC PULSATIONS

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The analysis of middle latitude Pi2 irregular geomagnetic pulsation during auroral substorms in various longitudinal sectors of Russian Arctic was carried out. In particular, the behavior of the main axis of polarization ellipse of irregular geomagnetic pulsation was investigated. The technique of determination substorm longitude in auroral zone using the observations of irregular pulsations in middle latitudes was offered. Data was obtained on magnetometric complex «Angara» of Institute of solar-terrestrial physics SB RAS. More than 50 magnetic disturbances were analysed. The main axis of polarization ellipse of middle latitude Pi2 irregular geomagnetic pulsation indicate dynamics of auroral active areas.

ON THE ROLE OF PLASMA SHEET STATE IN THE MAGNETOSPHERIC PLASMA ACCELERATION BY THE SOLAR WIND

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A well-known substorm-related plasma acceleration in the magnetosphere, launched by the arrival of southward IMF and dayside reconnection is considered as a primary magnetospheric acceleration process, which leads to the precipitation of the electrons into ionosphere, changing its conductivity and ionospheric currents. Less appreciated is that the state of solar wind plasma controls the background plasma sheet parameters, which themselves influence the acceleration of magnetospheric plasma. Based on 19 years long data base of EISCAT observations in Scandinavia and THEMIS database, we investigate statistically the ionospheric conductivity variations, and how they are influenced by the plasma sheet and solar wind state. We find that the main solar wind drivers for AL index, Pedersen and Hall conductances are the SW merging electric field (e.g., Kan-Lee function, Ekl) and the solar wind velocity V_{sw}, however the hierarchy of SW drivers varies. Whereas Ekl is the main driver of *AL* index, the role of V_{sw} increases for the conductances so that it outruns the Ekl as main driver for the Hall conductance. We explain this by the action of some additional, solar wind velocity dependent, acceleration mechanism, that increases the energy of the precipitated electrons. Recently the importance of solar wind control was discussed in relation to the chorus wave acceleration (which provides the population for the radiation belts), as well as to the intensity of field-aligned electrostatic acceleration (contributing to the ionospheric conductivities and ground magnetic perturbations), which both depend on plasma sheet electron parameters T_e and N_e proportionally to eTN = $(T_e)1/2/N_e$. In this talk we are trying to show how the plasma sheet state, influences the energy of electrons precipitated, due to magnetospheric plasma acceleration influenced by the solar wind.

REAL-TIME MODIFICATION OF OVATION-PRIME-PC MODEL: VALIDATION AND NOWCASTING

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OVATION-Prime model is based on spectral measurements of auroral particles (electrons and ions) onboard DMSP spacecraft and parameterized by solar wind driving. Distinguishing features of the model include the separation of aurora into categories (diffuse aurora, monoenergetic, broadband, and ion), the inclusion of seasonal variations, and separate parameter fits for each MLATxMLT bin, thus permitting each type of aurora and each location to have differing responses to season and solar wind input. To predict auroral power far better than K_p or other traditional parameters, the model uses an optimized solar wind — magnetosphere coupling function (dΦMP/dt) which is defined by parameters measured at the Lagrange point (L1). However, when using dΦMP/dt, some difficulties may arise: (1) in the case, when the solar wind, measured by ACE spacecraft in L1, is not encountered with the magnetosphere at all, (2) dependence of the precipitating particles distribution on magnetospheric conditions (under the same conditions in the solar wind the magnetospheric response may be different). These problems are automatically eliminated if we examine 1-min PC index as a current electric field EKL actually impacting the magnetosphere, and replace coupling function dΦMP/dt with PC index. The PC-index as a quantitative characteristic of the substorm activity level can essentially improve timing within substorm cycle that in turn allowed us to compare observable aurora dynamics (e.g. captured by THEMIS all-sky cameras or Polar spacecraft) with those computed by modified OVATION-Prime model. We use PC-index to (1) eliminate the need for solar wind parameters as model input and (2) applied it to develop real-time PC-based version of OVATION-Prime model.

GROUND-BASED SUPPORT OF SATELLITE MISSIONS AT KOLA PENINSULA

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Last decades a numerous satellite missions aimed to study the response of the Earths space and atmospheric environment to solar drivers have been realized and are still planning. Successful use of the international near-Earth satellite mission data depends largely upon the ground-based observations in conjugate regions. The high-latitude regions have a key role in such observations as regions where varied processes in the magnetosphere, ionosphere, and atmosphere are the most prominent. The observatories of Polar Geophysical Institute located at Kola Peninsula can give important additional eastward extension of the Scandinavian ground-based support of the satellite missions. In this report we review the available equipment and possible data of the optical, VLF/ULF and other measurements. Capabilities and potential results of the coordinated observational campaigns are discussed on the examples of conjugations with Van Allen Probes and THEMIS satellites.

FORECASTING OF GEOEFFECTIVENESS AND COSMIC RAY MODULATION INDUCED BY COROTATING INTERACTION REGIONS

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When high-speed solar wind streams originating in coronal holes (CH) interact with the preceding slow solar wind, they form regions of compressed plasma called "corotating interaction regions" (CIR). These phenomena can influence Earths space environment, cause the geomagnetic storms and modulate the cosmic rays (CR) flux at the Earth. With the aim to improve space weather predictions, we investigated the relationship between the area of CHs and different geomagnetic indices corresponding to equatorial (Dst, ring current), middle (ap) and high (AE, polar electrojet) latitude regions. The relationship between CH area and CR flux using satellite CR measurements taken from SOHO EPHIN was also studied. The minimum phase of the solar cycle 23–24 (2007–2010) was selected for analysis due to lower CME activity. Since the interplanetary near-Earth disturbances are delayed about 4 days after the changes in CH area, this gives a good opportunity to forecast a CR modulation on Earth and geoeffectiveness of CIRs.

GEOEFFECTS OF CHELYABINSK METEOROID ENTERING THE EARTH'S MAGNETOSPHERE

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On 15 February 2013, a superbolid having a diameter of about 17 m and a mass of about 17,000 t entered the Earth's atmosphere at a velocity of about 18 km/s. At 03:20:33 UT, it exploded over Chelyabinsk, at a height of 22 km. After the fall of the Tunguska meteorite on 30 June 1908, it has been the second largest cosmic body entering the Earth's atmosphere in the past 100 years. A 17,000-tonne block of stones, metal and ice passed through all layers of the Earth's upper atmosphere (magnetosphere, plasmasphere and ionosphere). If we assume that passage of this cosmic body in the Earth's magnetosphere was geoefficient, then the desired signal had to be detected after the body entered the Earth's magnetosphere, 80–60 min before the explosion in the atmosphere. According to the analysis of *AU*, *AL*, *AO* and K_p indices, the bolide passed the Earth's magnetosphere under very quiet magnetic conditions. Induction magnetometers at the ISTP SB RAS station for registering geomagnetic pulsations (the Republic of Buryatia, the Eastern Sayan, φ=51.4°, λ=100.5°) and at the IKIR FEB RAS Geomagnetic Observatory "Paratunka" (Kamchatka, φ=53.1°, λ=158.4°) showed a noise-like burst in variations of the magnetic field in the frequency range 0.2–5 Hz at 02:45–02:58 UT (i.e., 35 min before the meteoroid explosion). The anomaly registered at mid-latitude observatories under quiet geomagnetic conditions could be due to the interaction between the meteoroid and the Earth's plasmasphere. According to the review of papers dealing with occurrence of magnetic effects during the passage and explosion of the Tunguska meteorite in the Earth's magnetosphere and atmosphere on 30 June 1908, some researchers noticed anomalies in variations of the geomagnetic field 80 min prior to the explosion.

Session 5: SUN TO EARTH CAMPAIGN EVENT STUDY

CHALLENGES IN UNDERSTANDING AND PREDICTING EARTH-AFFECTING CORONAL MASS EJECTIONS

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The Working Group 4 (Campaign Events) of the VarSITI/ISEST has identified a number of Earth-affecting coronal mass ejections (CMEs) that present various challenges when we try to understand their origins on the Sun and effects at 1 AU. We discuss several examples from our growing list of events, trying to clarify what we understand and what remain uncertain after our recent investigations. Our emphasis is on the origins of CMEs that were not accompanied by obvious low coronal signatures (LCSs). These CMEs characteristically start slowly. We show that EUV images taken by the Atmospheric Imaging Assembly (AIA) on board the Solar Dynamics Observatory (SDO) can reveal coronal dimming and a post-eruption arcade (compelling LCSs for CME), if we make difference images with long enough temporal separations that are commensurate with the slow initial development of the CME. By providing the limb views of Earth-bound CMEs, data from the EUV imager and COR coronagraphs of the Sun Earth Connection Coronal and Heliospheric Investigation (SECCHI) on the Solar Terrestrial Relations Observatory (STEREO) turn out to be very useful as they help us limit the time interval in which the CME forms and undergoes initial acceleration. For other CMEs, we find similar but weaker LCSs, and only with lower confidence. It is noted that even these less clear events may result in unambiguous flux rope signatures in in situ data at 1 AU. There is a tendency that the CME source regions are located near coronal holes or open field regions. This may have implications for both the initiation of the stealthy CME in the corona and its outcome in the heliosphere.

CHANGES IN OZONOSPHERE AND LOWER IONOSPHERE INDUCED BY SOLAR PROTON EVENT OF 28 OCTOBER 2003 (3D SIMULATIONS)

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3D photochemical model CHARM-I (Chemical Atmospheric Research Model with Ions [Krivolutsky et al., 2015] was used to study the response of neutral and ionized chemical compounds after Solar Proton Event of 28 October 2003. Model describes more than 200 reactions Ionization rates induced by particles has been calculated using AIMOS module [Wissing, Kalenrode, 2009] between the ground and 90 km. Ionization in both polar regions generates additional neutral HOx and NOx and positive ions which disturbs neutral species (ogzone and others), positive and negative ions, and electron density. Calculated ozone depletion looks similar the corresponding effect obtained in HEPPA Project [Funke et al., 2011]. The result of simulations showed that electron density was strongly increased after SPE over both regions.

IONOSPHERIC OBSERVATIONAL CAMPAIGN STUDY OF GEOSPACE STORMS: A SCENAIO FOR STRONG IONOSPHERE AND THERMOSPHERE COUPLING DURING THE 2015 ST PATRICK'S DAY STORM

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A number of ionospheric observational campaigns and analyses have been conducted during the geospace storm events over the last a few years. The storm intensity spans different levels and the storms have different solar and interplanetary drivers (i.e., CME and CIR types). The most dramatic event was perhaps the 2015 St. Patricks Day that reached a minimum *Dst* at ~ -220 nT, the largest storm during the current solar cycle. We initiated the observations using a network of incoherent scatter radars over America Sector, along with other more densely distributed sensors (GPS receivers, FPIs, ionosondes, etc), to characterize ionosphere, thermosphere, and magnetosphere responses. This presentation focuses on substantial I/T perturbations caused by the presence of strong electrodynamic processes (e.g., subauroral polarization stream, SAPS). These include strong ion-neutral frictional heating accompanied by large atmospheric upwelling, with ion upwelling as a potential source of ion upflow. Penetration electric fields were also measured by the Millstone Hill incoherent scatter radar during the storm main phase and played important roles in creating the storm-enhanced density (SED) observed during the event at subauroral latitudes extending into high latitudes. We will also discuss future international observation campaign plans, in particular, along the meridian circle at

SUN-TO-EARTH PROPAGATION OF THE 2015 JUNE 21 CORONAL MASS EJECTION REVEALED BY OPTICAL, EUV, AND RADIO OBSERVATIONS

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The 2015 June 21 double M flare was associated with a halo coronal mass ejection (CME) that resulted in all the familiar space weather effects: a large solar energetic particle event, an interplanetary shock, and an intense geomagnetic storm. The geomagnetic storm was the second largest in solar cycle 24 that resulted in significant ionospheric and radiation-belt changes. In this paper, we consider the propagation of the CME-driven shock as revealed by the type II bursts at metric and longer wavelengths. The eruption consisted of two M-class flares, with the first one being marginally eruptive, with no metric or interplanetary radio bursts. However, there was intense microwave burst, indicating accelerated particles injected toward the Sun. The second flare was eruptive that resulted in a halo CME. The interplanetary type II burst was particularly intense, and was visible all the way to the vicinity of the Wind spacecraft with fundamental-harmonic structure. The CME was fast (~1700 km/s), as expected because of its association with a large SEP event (>100 pfu in the >10 MeV channel) and a metric-to-kilometric type II radio burst. The CME continued to accelerate in the coronagraph field of view, with interesting consequences to the appearance of the type II burst in the interplanetary medium. Making use of

the measured drift rate of the interplanetary type II burst, we were able to identify the heliocentric distance where the CME/shock started deceleration. We also computed the shock speed using the type II drift rates at various heliocentric distances and obtained information on the evolution of the shock. Finally, we discuss the structure of the interplanetary CME that resulted in the intense geomagnetic storm.

THE 2015 JUNE 22-23 STORM EFFECTS: FROM THE SUN TO THE EARTH

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Our research is devoted to the 2015 June 22–23 magnetic storm. It was one on of the most intense storms of the 24th solar cycle. We investigated whole chain of processes from the Sun to the Earth. There were a lot of manifestations in different geophysical fields. The storm was associated with coronal mass ejection (CME) linked with active region 2371. CME has speed of ~1366 km/s and kinetic energy of ~ $9.0 \cdot 10^{31}$ erg. When CME reached the Earth it compressed the magnetosphere and resulted in sudden storm commencement with positive H-SYM up to +88 nT. Negative B_z component of interplanetary magnetic field produced strong magnetosphere perturbation with intense variations in the Earth's magnetic field. We also recorded sharp decrease in H-SYM, increase in electrojet width and moving electrojet to lower latitudes, as well as strengthened precipitation flux, pulsations, and magnetosphere convection. We revealed strong displacement and intensification of equatorial anomaly crests, and sharp decrease in global electron content (up to 50 %). The storm resulted in strong large-scale ionosphere irregularities which originated at auroral oval boundaries and reached even opposite hemisphere. Overall increase in total electron content slips was ~5–8 times against the quiet level. Variations in solar wind parameters also influenced on observed galactic cosmic rays intensity. We also recorded increase in solar proton flux at ~20 UT on June 22, which was found to be connected with M6.5 solar flare (June 22, start time 17:39; maximum 18:23) associated with the same active region 2371. The work is a result of activity during the COSPAR Capacity Building Workshop. The study is partly supported by RF President Grant of Public Support for RF Leading Scientific Schools (NSh-6894.2016.5) and by the RFBR project No. 15-05-03946.

RADIATION BELT RESPONSE TO THE MARCH 15, 2015 EVENT

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The geomagnetic storm of March 15, 2015 was the largest one observed during the past decade. I will report on observations made by REPT (the Relativistic Electron and Proton Telescope) and MagEIS (the Magnetic Electron and Ion Sensors) on board NASA's Van Allen Probes. Detailed spectral and pitch angle measurements covering electron energies from ~10's of

keV to ~10 MeV are obtained by MAgEIS and REPT. One of the pobes was serendipitously located to observe the immediate electron response to the IP (interplanetary) shock that preceded the CME driving the geomagnetic storm. The interplanetary shock that preceded the coronal mass ejection injected ultra-relativistic electrons almost instantaneously to L~3. Subsequently, over a period of several days the radiation belts saw enhanced fluxes of very high energies of up to 8 MeV.

Session 6: ATMOSPHERIC RESPONSE TO SOLAR VARIABILITY AND MODULATION OF ITS IMPACT ON TIMESCALES FROM MINUTES TO DECADES

ATMOSPHERIC IMPACTS OF THE STRONGEST KNOWN SOLAR PARTICLE STORM OF 775 AD

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A severe solar energetic particle storm, which took place in 774–775 AD, was the greatest one over 11 millennia, 40–50 times stronger than the largest event directly recorded during the modern instrumental era. This offers a unique opportunity to test the existing models and assess a potential impact on the Earth's atmosphere for a realistic worst case scenario. Here we present a systematic analysis of this severe event using the available data and up-to-date models. First we reproduce, with the atmospheric climate chemistry model SOCOL and the ^{10}Be production model CRAC, the observed variability of cosmogenic isotope ^{10}Be in four different ice cores from Greenland and Antarctica, thus confirming the validity of the models and the input energy spectrum. Furthermore, important for determining the correct dynamical consequences, the model results suggest that the event likely occurred during boreal autumn. Next, we calculated the amount of nitrate deposited in different polar ice cores and compare those with the observations. We show that, contrary to some earlier claims, even such an extreme solar particle storm cannot produce a notable peak in nitrate concentration. Finally, we assess the possible effect of this uniquely strong event on the Earth's atmosphere and found statistically significant negative total ozone changes lasting for at least one and a half years after the event and changes of the surface weather in the northern hemisphere during the winter after the event.

PROPAGATION OF STATIONARY PLANETARY WAVES FROM THE LOWER TO THE UPPER ATMOSPHERE AT DIFFERENT LEVELS OF SOLAR ACTIVITY

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Changes of zonal circulation and amplitudes of stationary planetary waves (SPWs) in the atmosphere at different levels of solar activity (SA) are studied. General circulation model of the middle and upper atmosphere MUAM is used. To account for changes in solar activity in the model a set of different values of solar radio emission flux at wavelength of 10.7 cm is used. Ionospheric conductivities are also taken into account with their latitudinal, longitudinal and time dependencies calculated for different SA levels. The simulation includes general atmospheric circulation, amplitudes of SPWs with zonal wave numbers 1 and 2, refractive indices for SPWs and Eliassen-Palm fluxes corresponding to considered SPWs. Simulations are carried out for January-February and conditions of low, medium and high solar activity. It is shown that at high SA the zonal winds are larger at altitudes above 150 km and smaller at lower altitudes. At high SA SPW amplitudes are smaller at altitudes above 120 km and are larger at altitudes lower than 100 km, than those at low SA. These differences correspond to the calculated changes in the

SPW refractive index of the atmosphere and Eliassen-Palm flux. Changes in conditions of SPW propagation in the thermosphere at different levels of solar activity may affect changes in SPW amplitudes and atmospheric circulation at smaller heights in the middle atmosphere.

USING THE EMISSIONS OF EXCITED OXYGEN TO STUDY FAST [O3] VARIATIONS IN THE MESOSPHERE AND LOWER THERMOSPHERE

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In the framework of the model of electronic vibrational kinetics of excited products of O3 and O2 photolysis in the MLT of the Earth, YM2011, we study the possibilities of retrieval the [O3] altitude profiles using as proxies electronic-vibrationally excited levels of oxygen molecule, namely O_2(b1, v=0, 1), O_2(a1, v=0) and excited atom O(1D). Population of O2 (b1, v=2) doesn't depend on [O3]. Concerning the [O3] retrieval in the range of 50–100 km, the emission at 1.27 μm formed by transition from O_2(a1, v=0) and emission at 762 nm formed by transition from O_2(b1, v=0) are the most intensive ones among all emissions under consideration. However, considering the complexity of kinetics of the excited components: choosing O_2(a1, v=0) as a proxy for [O3] retrieval requires taking into account 25 aeronomical reactions. For other proxies the number of aeronomical reactions is as follows: O_2(b1, v=0)−18; O_2(b1, v=1)−13; O_2(1D, v=0)−5. Increasing the number of reactions that must be considered when using a proxy from O(1D) to O_2(a1, v=0) depends on the fact that, calculating the population of each of the underlying electronic-vibrationally excited state requires considering the mechanisms of the population of the upper levels. Therefore, O_2(b1, v=1) is the preferable proxy at the altitudes of 50−98 km. Commonly used [O3] retrieval proxy, O_2(a1, v=0), transition from which forms the 1.27 μm O2 IR Atmospheric band, has more than one hour photochemical lifetime in the MLT region. On the other hand, the O(1D) and O_2(b1, v=0, 1) lifetime in the altitude region of 50−120 km is less than 14 sec. So, the proposed O_2(b1, v=0, 1) and O(1D) proxies can be used for tracking fast variations of the O3 atmospheric concentrations generated by wave processes, electron precipitations, solar flux changes, and so on, when the O_2(a1, v=0) proxy becomes useless.

INFLUENCE OF SOLAR ACTIVITY ON INDIAN SUMMER MONSOON RAINFALL FOR THE LAST FIVE CENTURIES

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Previous studies investigating the relationship between solar activity and Indian Summer Monsoon Rainfall (ISMR) using instrumental records have been reported. Temporal scale of observed Sunspot numbers (since 1700) and recorded ISMR time series (starts from 1871) are a constraint to study any relation between solar cycle and ISMR in the multi-decadal variability scale. So, this present research effort investigates decadal and multi-decadal variability in the ISMR and its teleconnection with solar activity using proxy reconstructions for few centuries before present. Increased precipitation in the tropical region favors growth of tree rings. Speleotherm records can also yield similar rainfall estimates like tree rings. Both tree rings and speleotherm records is used as ISMR proxy data. Simulated Sunspot numbers are available to study its teleconnection with ISMR

for the last 500 years. Correlation between ISMR and solar cycle is not very pronounced for the considered time span but improves significantly in discontinues temporal scale. Wavelet analysis and cross-wavelet transform are also employed to study the time series of ISMR and Sunspot numbers. The recognized 11-year solar cycle are determined in the ISMR time series. The periods of 2–5 years are found to exist in the summer monsoon rainfall over India.

SOLAR EFFECTS ON THE UPPER ATMOSPHERE FROM SOLAR FLARE TO SOLAR CYCLE TIME SCALES

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Solar irradiance is the primary energy input to the thermosphere/ionosphere system. The thermosphere absorbs solar irradiance in XUV (the soft X-ray ultra-violet, 1–30 nm), EUV (extreme ultra-violet, 30–120 nm), and FUV (far ultra-violet, 120–200 nm). The solar EUV ionizes, dissociates, and excites the thermospheric constituents, creates the ionosphere, and heats the thermosphere. In this presentation, we discuss solar irradiance variations from solar flare to solar cycle time scales, and their effects on the upper atmosphere, from the perspective of modeling and data results of thermosphere neutral density due to these variations in solar irradiance. We will discuss variations in neutral density include abrupt changes with a time scale of minutes to hours due to solar flare, diurnal variation, solar-rotational variation, annual/semiannual variation, and solar-cycle variation. The neutral density data sets include neutral density observed by the accelerometers onboard the Challenging Mini-satellite Payload (CHAMP), neutral density at satellite perigees, and global-mean neutral density derived from thousands of orbiting objects. Modeling results are from the National Center for Atmospheric Research (NCAR) thermosphere-ionosphere-electrodynamics general circulation model (TIE-GCM), and from the NRLMSISE-00 empirical model.

SOLAR AND GEOMAGNETIC CONTROL OF IONOSPHERIC WINTER ANOMALY AND SUMMER EVENING ANOMALY IN NMF2 AND TEC

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We analyzed the winter anomaly (WA) and mid-latitude summer evening anomaly (MSEA) manifestation in the F2 peak electron density (N_mF2) and Total Electron Content (TEC) based on the observation data and model calculation results. For the analysis we used 1998–2015 TEC Global Ionospheric Maps (GIM), N_mF2 ground-based ionosonde observation data and COSMIC, CHAMP and GRACE radio occultation ionospheric data. We also used the Global Self-consistent Model of the Thermosphere, Ionosphere, and Protonosphere (GSM TIP) and the International Reference Ionosphere model (IRI-2012). Based on the observation data and model calculation results we constructed the maps of the WA and MSEA intensity in TEC and N_mF2 for the different levels of

solar and geomagnetic activity. According to both observation and modeling we found that the winter anomaly intensity was higher:

1) in N_mF2 than in TEC;

2) during solar maximum than in solar minimum;

3) for the greater level of geomagnetic activity.

MSEA appears earlier in TEC than in N_mF2. The MSEA intensity does not depend on the level of geomagnetic activity. We investigate in detail the formation mechanisms of longitudinal variability and interhemispheric differences in WA and MSEA. It is shown that the vertical plasma transport along geomagnetic field lines due to the thermospheric wind at heights of ionosphere F region plays an important role in the formation of longitudinal variability in WA and MSEA. The possible reasons of MSEA and WA interhemispheric asymmetry are also discussed.

NONLINEAR SPECTRAL ANALYSIS OF CARBON C^{14} FOR THE LAST 12.000 YEARS: ABRUPT CLIMATE CHANGES IN THE PAST AND FUTURE

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The important evidence within the last years has accumulated the capacity of the climate system to undergo major changes on time scales of less than a century, in some cases, less than decade. Abrupt climate fluctuations at period T~1500 yr were revealed during the last glacial period in the Greenland ice cores. Similar fluctuations during Holocene are referred to Bond events (BEs), but their connection with climate is poorly studied. Bond et al (1997) identified 8 events based on tracers of drift ice. Causes of the BEs are unknown, main focus to solar activity and atmosphere circulation. Because the BEs points to nonlinearity and resonance a non-linear spectral analysis has to be used. We use the MGM method elaborated by us, which is capable of making a self-consistent selection of trends from a data set and singling out harmonics with varying phase and amplitude. C^{14} is produced in the troposphere and stratosphere. Source is galactic cosmic ray flux, which is controlled mainly by solar activity and geomagnetic field. We use a set of C^{14} (9700 yr BC – 1980 yr AD). Main aim is to analyze the most power nonstationary and long-term components for the results to compare with the BEs and temperature (GIPS cores). The trend described by sinusoid at T=18.6 kyr has the highest amplitude and can be interpreted as a term in climate precession of Milankovich. The trend is coming to the C^{14} absolute minimum for now. A nonstationary sinusoid at T=2600 yr shows intervals of damping and building-up oscillations (decrease and increase of amplitude). The amplitude began to rise rapidly long before AD era (a manmade cause is eliminated) and increased the value at the end of BC era by twice at present. The cycle is coming to absolute minimum in C^{14} (warming). Nearness of the minimum to the trend minimum points to reorganization of geophysical systems in the future. The power nonstationary sinusoid at T=2230 yr also shows intervals of damping and building-up oscillations. The amplitude also began to rise during years BC, but one has not yet reached maximal values. We show how variations of the 2230-yr and 2600-yr sinusoids create recurrent T~1500 yr of the abrupt changes (BEs). We discuss connection of the spectral periods with periods of astronomical origin and possible physical mechanisms. Finally we propose expected evolution of climate in the near future.

WAVE AMPLIFICATION DURING SOLAR EVENTS BASED ON THE OBSERVATIONS OF ELECTRIC PARAMETERS OF THE NEAR GROUND ATMOSPHERE

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Spectral analysis of meteorological (air temperature, humidity, pressure) and of electric quantities (quasi-static electric field strength and air electrical conductivity) in the near ground atmosphere has been carried out. In the presence of the prevailing component with the period of 24 hours, an additional component with the period of 48 hours appeared in the power spectra of meteorological quantities during solar events in "fair weather" conditions. In the power spectra of atmospheric electric conductivity and electric field strength, the components of both thermal tidal and planetary waves were observed with the development of solar and geomagnetic activity. Intensities of the components with the periods of planetary waves increased by an order. In the power spectra of galactic cosmic ray fluxes accompanying strong solar flares, the components with the period of 48 hours prevailed with the appearance of additional components of weaker intensity with the period of 24 hours. Simultaneous intensification of the components with the period of 48 hours in the power spectra of electric conductivity and electric field strength indicate the fact that during strong solar flares and geomagnetic storms, mainly the galactic cosmic rays are the acting ionizers of the lower troposphere.

DIFFERENCES IN THE INTENSITY OF THE STRATOSPHERIC CIRCULATION MERIDIONALITY FOR THE SOLAR MAXIMA AND MINIMA CONDITIONS

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Differences in the intensity of the stratospheric circulation meridionality for the solar maxima and minima conditions were investigated using NCEP/NCAR Reanalysis and ECMWF ERA-Interim 1968–2010. We found that in the stratosphere of both hemispheres meridionality index in the solar maxima periods is lower than in the solar minima periods for all seasons except summer in the Northern Hemisphere (June–August) and autumn in the Southern Hemisphere (March, April).

LONG-TERM VARIABILITY AND TREND OF THE MESOSPHERE BASED ON PHASE-HEIGHT MEASUREMENTS OVER EUROPE

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Phase-height measurements of low frequency radio waves are used to study the long-term variability and trend of the mesosphere (D layer, about 80 km altitude) over Europe. The concept of standard phase heights (SPH) warrants the continuity of the series in the case of slight frequency changes. The advantages of the method are the low costs and the simplicity of operation. The signal was received at Kühlungsborn (54° N, 12° E, Mecklenburg, Northern Germany). Since February 1959, that means over more than 5 solar cycles, field strength measurements of the broadcasting station, Allouis (Central France), have been maintained and reanalyzed. The mean annual cycle of SPH-series shows a negative winter anomaly known to be due to enhanced downward transport of NO and subsequent photo-ionization. Stratospheric influences of QBO-like and ENSO-like oscillations on mesospheric SPHs have been shown for solar minimum phases. The SPH-series are partially anti-correlated to the solar cycle because stronger photo-ionization is linked with higher number of electrons, which reduces the SPH. Furthermore the statistical analysis of the SPH-series shows a significant overall trend in the order of hundred meters per decade induced by a shrinking stratosphere due to global warming but with strong intra-decadal variability in winter. In order to exclude the influence of the winter anomaly in the determination of column-integrated mesospheric temperature trends, our procedure is confined to summer months. The derived thickness temperature of the mesosphere decreased statistically significant over the period 1959–2008 after pre-whitening with summer mean of solar sun spot numbers. The trend value is in the order of about –1.05 K/ decade if the stratopause trend is excluded. The linear regression is stronger, –1.35 K/ decade for the period of 1963–1985 (2 SCs), but weaker, –0.51 K/ decade during 1986–1908 (last 2 SCs).

THE ENERGY BUDGET OF THE MESOSPHERE AND THERMOSPHERE — RESULTS FROM 15 YEARS OF SABER, SORCE, AND SEE OBSERVATIONS

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The energy budget of the mesosphere and thermosphere (MLT) is exceptionally complex. Energy in the form of ultraviolet radiation is deposited from the Sun, setting off a chain of photochemical processes leading to the generation of heat and airglow in the region. Collisional and radiative processes internal to the MLT result in the lowering of the kinetic temperature through loss of energy by infrared radiation. All of these heating and cooling processes occur far from local thermodynamic equilibrium, and are said to be in "non-LTE." The SABER instrument, now in its 16th year of operations on the NASA TIMED satellite, was designed to provide measurements from which nearly all of the individual processes contributing to the energy budget of the MLT could be derived. These processes include the absorption of solar radiation by molecular oxygen and ozone from Ly-α to visible to near-infrared wavelengths; seven

exothermic chemical reactions; and infrared radiative cooling. In this talk we will present the MLT energy budget as derived from SABER observations with solar irradiances provided by the SEE instrument on TIMED and instruments on the SORCE satellite. Approximate balance between heating and cooling is found in annual timescales. There is a clear solar cycle dependence evident in all terms of the energy budget and in the total heating and total cooling terms. Energy balance also provides a critical test for some SABER data products such as atomic oxygen, and these will be reviewed in detail. The talk will conclude with a look to the future on concepts to continue these observations after the end of the TIMED epoch.

CLIMATE VARIATIONS INITIATED BY JOINT EFFECT OF SOLAR UV VARIABILITY AND THE ACTIVITY OF PLANETARY WAVES (SIMULATIONS WITH ARM AND DATA ANALYSIS

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GCM ARM (Atmospheric Research Model [Krivolutsky et al., 2015] was used to simulate global response of atmospheric temperature and wind to variability in solar UV radiation. Upper boundary of ARM is at 135 km. Global fields of radiative-active gases were incorporated from 3D global photochemical model CHARM [Krivolutsky et al., 2015]. Planetary waves structure in the model. The results of simulations showed that temperature response has wave-like structure with its amplitudes which are more than several K. So, revealed response has several minima and maxima along the latitude. Using reanalysis data the similar wave-like restructure was found.

INFLUENCES OF CLIMATE FORCING FACTORS ON TEMPERATURE ANOMALIES AT REGIONAL SCALES

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Statistical regression models describing temperature anomalies change include several climate factors. Usually external factors as atmospheric CO2 content, volcanic emissions, and the total solar irradiation and some internal factors as teleconnections are included in the models. The factors are taken into account directly or as indices in a linear regression model. If the models are used to describe global or hemispheric temperature anomalies the number of internal factors is reduced. Depending on the used temperature data sets and whether temperature anomalies over land or sea are modelled, only one or two internal factors, namely the El Niño-Southern oscillation or the stratospheric aerosols loaded by volcano eruptions have a significant climate impact. In the case of the estimation of the temperature anomalies at regional scales in the model predictors describing the Pacific decadal oscillation and the North Atlantic oscillation have to be included. As it is well known they have an important influence on the temperature and on other climate parameters at large regional scales and generate weather phenomena. Globally, the influence of the solar irradiation on the climate is small and in general is less than 0.1 °C, but

it becomes larger at regional scales. Based on the HadCRUT version 4.4.0.0 gridded annual temperature data set we have constructed global maps presenting the influence of different climate factors on the temperature and maps showing their estimated significances for the time period from 1900 to 2015. In addition to the mentioned above factors contributing to temperature changes we studied also the influence of the Atlantic multidecadal oscillation. The maps were constructed by estimation of the temperature impacts of all factors simultaneously in all 5 deg. x 5 deg. grid points by solving the multiple linear regression equation. Besides we present maps for the warming and cooling phase of the climate factors. The results are briefly discussed.

LONG-TERM GLOBAL TEMPERATURE VARIATIONS UNDER TOTAL SOLAR IRRADIANCE, COSMIC RAYS, AND VOLCANIC ACTIVITY

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The effects of total solar irradiance (TSI), cosmic rays, and volcanic activity on long-term global surface air temperature variations (GSAT) during solar cycles 19–24 was studied. It was shown that a large proportion of climate variations can be explained by the mechanism of action of TSI and cosmic rays (CRs) on the state of the lower atmosphere and other meteorological parameters. The trends of sunspot numbers, CRs, and IMF B (module of interplanetary magnetic field) for 20–24 solar cycles do not show a significant effect, whilst the global temperatures (GSAT) trend is very large, and significant. This is a forcible argument to attribute GSAT trend to human activity. The role of volcanic signals in the 11-year variations of the Earth's climate can be expressed as several years of global temperature drop. Conversely, it was shown that the effects of solar, geophysical, and human activity on climate change interact. It was concluded that more detailed investigations of these very complicated relationships are required, in order to be able to understand issues that affect ecosystems on a global scale.

THERMOSPHERIC RESPONSE TO SOLAR VARIABILITY FROM MORE THAN 15 YEARS OF SABER DATA

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Infrared radiation, from nitric oxide (NO) at 5.3 μm and carbon dioxide (CO_2) at 15 μm, is the dominant mechanism by which the thermosphere cools to space. The Sounding of the Atmosphere using Broadband Emission Radiometry (SABER) instrument on the NASA Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) satellite has been measuring thermospheric cooling by NO and CO_2 since January, 2002. Physically, changes in

NO emission are due to changes in temperature, atomic oxygen, and the NO density, while for CO2, the emission change is most directly related to temperature and atomic oxygen. These physical changes are driven by changes in solar irradiance and geomagnetic conditions. We see evidence of these changes on timescales from minutes to days, over a single solar cycle and, through reconstruction using multiple linear regression fits, over multiple solar cycles. As the coronal structure of the sun changes over a solar cycle, new periodicities are seen in the data set. And in our most recent analysis of solar storm impacts, we find infrared cooling effects at the sub-storm level, on the order of minutes. These findings provide valuable insight into the global infrared energy budget and chemistry of the thermosphere over a variety of time periods.

ON THE MECHANISM OF INFLUENCE OF HELIOGEOPHYSICAL DISTURBANCES ON THE EARTH TROPOSPHERE

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Observational data of characteristics of heliogeophysical disturbances influencing on Earth, and data of the troposphere properties are analyzed. Taking into account an open character of climate system through which a considerable energy flux from the Sun passes, and insignificant external actions on climate system, a considerable response is shown to be only if there is an influence on the climate system parameters, which control solar energy passing through the climate system. As shown from the analysis the most effective mechanism of an influence on an energy flux passing is that modulates optical properties of the atmosphere in long-wave (infrared) spectral range. The features of the mechanism, developed in ISTP are discussed in detail. It is noted that the analysis of observations carried out during of the heliogeophysical disturbances does not reveal data disagreed with that. The mechanism allows us to explain some peculiarities of the troposphere response to heliogeophysical disturbances. The peculiarities are spatial inhomogeneity and ambiguity of the response, as well as variability of its spatial structure. The time lag of the troposphere temperature response to separate heliogeophysical events of less than one hour duration is estimated.

LONG-TERM SPECTRAL COMPONENTS OF GLOBAL AND HEMISPHERE TEMPERATURES OVER THE LAST MILLENNIUM AND SOLAR FORCING

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Variations of solar radiation reaching the Earth have two main causes. The first is related with the 11-yr solar cycle: at the maximum the total solar irradiance was larger by 0.1 % than at the minimum, which could cause surface temperature changes of a few tenths of degree of Celsius. Recent oppositely directed trends in solar climate forcing and global mean surface air temperature shows that recent rise in the temperature cannot be attributed to solar effects. The second cause is related with solar radiation (insolation) reaching the Earth due to varying

distance from Sun. Milankovich theorized that three geometric relations between Earth and Sun (eccentricity, axial tilt and longitude of perihelion) resulted in cyclical variation of solar radiation (insolation) reaching the Earth and influenced on climate. Astronomers estimate that in 1246 the December solstice was on the same day as the Earth reached its perihelion. One of the aims of the study was to detect response of trends in the Global, North and South hemisphere temperatures (T_{gl}, T_{nh} and T_{sh}) to the Earth's transition the special year. The problems are trends, quasi-periodicities and noise in climate processes. We use the Method of Global Minimum elaborated by us, which is capable of making a self-consistent selection of trends from a data set and singling out harmonics with varying phase and amplitude. Annual anomalies in temperature from 17 sites worldwide for the last 1000 yr and annual sunspot numbers W for the last 205-yr are used. Trend in Tnh described by nonstationary sinusoid at period T=1270 yr shows maximum near 1300 (medieval time), minimum at 1700 (Maunder) and rise since 1700. We obtained the period in spectrum of carbon C^{14} for the last 12.000 yr and showed its relation with climate and axial precession. Trend in T_{gl} described by nonstationary sinusoid at T=1000 yr shows warming near 1350, deep cooling at 1750 and stable warming after 1750. We also obtained the period in spectrum of C^{14} and showed its connection with climate and precession of perihelion. The results lead to expected maximum of T_{gl} near 2250. We demonstrate parameters of the 1000-yr cycle: its amplitude decrease before 1250 (damping of oscillations) and the amplitude increase with constant velocity after the year (building-up of oscillations). The amplitude for present in the data is six times the amplitude in 1250 and one is 3.7 times larger than the amplitude of the 200-yr cycle in T_{gl}, which varies in phase with the 200-yr cycle in W. Finally we present results of our analysis of common periods from spectra of T_{gl} and W for influence of the sunspot activity on climate to understand.

PECULIARITIES OF THE GEOMAGNETIC FIELD VARIATIONS IN QUIET AND DISTURBED CONDITIONS

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In the present study we consider different aspects of the geomagnetic field activity on the base of global indexes and magnetometers data for Northern hemisphere. From the analysis of K_p–A_p indices it has been found that in quiet geomagnetic conditions the significant part of day-to-day geomagnetic field variations are caused by gravity field variations due to lunar-solar tidal forcing. This produces the geomagnetic field variations with periods 9.1, 13.66 and 27.55 days that are especially strong during the low solar activity periods. The longitudinal structure of the geomagnetic field variations is studied on the base of two magnetometer chains in the Northern hemisphere each consisted of 12 magnetometers located near latitudes ~55° N and 70° N. It has been found that the geomagnetic field variability has irregular longitudinal structure due to difference of geographic and geomagnetic poles. During the low geomagnetic activity in geographic coordinates the zone of high geomagnetic field variations is obviously shifted toward the magnetic pole meridian ~270°. However, during the magnetically disturbed periods two active zones form symmetrically opposite to the geomagnetic pole at ~40° and ~130° longitudes. Between these two zones a sector with lowest geomagnetic field variations always forms at longitudes 80–110°.

CONTRIBUTION OF RELATIVISTIC ELECTRON PRECIPITATION FROM RADIATION BELT TO THE TOTAL OZONE CONTENT OVER HIGH LATITUDES AND ENTIRE GLOBE

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In this work we investigated a response of the total ozone column on precipitations of relativistic electrons from the radiation belts. Here we used the method of superposed epoch analysis and as key dates were chosen the events of relativistic electron precipitation from 1961 to 2014. The list of events was prepared by members of the balloon experiments of the Lebedev Physical Institute of RAS. For our study, we selected the events registered during the winter (from November to February) and summer months (from June to August) since 1970 to 2012. These years were chosen, based on the data of the total ozone column obtained during the measurements SCIAMACHY, OMI, GOME. A long series of measurements of the total ozone column allowed studying 90 winter and 101 summer events of relativistic electron precipitation. The results of superposed epoch analysis show that total ozone column responds to relativistic electron precipitations. In the polar region the total ozone content is reduced after relativistic electron precipitation (in winter time) and the minimum is observed on the first day after the event. The obtained ozone sensitivity to summer and winter REP events is more clear pronounced in the middle and higher latitudes of the Northern Hemisphere, with the latitudinal maxima about 50 NH.

RADIOCARBON EVIDENCE OF SEASONAL ATMOSPHERE—OCEAN GAS EXCHANGE

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In nuclear explosions in the atmosphere neutrons react with air nitrogen forming radiocarbon. As a result, by October 1965 when the international treaty banning nuclear tests in the atmosphere came into force the content of radiocarbon in the atmosphere exceeded its level of 1950 more than twice. However, then measurements of its concentration showed an exponentially fast decrease. In the atmosphere radiocarbon is present in the form of $^{14}CO_2$. Its absorption by water, as well as all chemical reactions of radiocarbon and stable carbon isotopes are identical. A joint study of regular trends in concentrations of ^{14}C and CO_2 as well as their seasonal variations provides unique information on gas exchange between the atmosphere and the ocean.

DYNAMICAL PERTURBATIONS OF THE THERMOSPHERE IN THE SOUTHERN HEMISPHERE INFERRED FROM SATELLITE OBSERVATIONS OF O(1D) NIGHTGLOW AND TEC

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The Midnight Temperature Maximum (MTM) is a large scale neutral temperature anomaly with a wide-ranging effect on the nighttime thermospheric dynamics at low latitudes. The focus of the current study is an investigation of the extent of the MTM to southern low and mid-latitudes (5–40° S) employing multi-year observations of O(1D) airglow volume emission rates (VER), Doppler temperatures (DoT), and neutral winds over the altitude range of 190–300 km by the Wind Imaging Interferometer (WINDII) experiment on board the Upper Atmosphere Research Satellite. The MTM dependence on longitude, season, local time and altitude has been examined. The observed perturbations in the O(1D) VER and temperature were out-of-phase with respect to longitude. Latitude/longitude maps of the VER and DoT revealed wave-1 and wave-3 signatures most persistently seen after local midnight in summer, with very little day-to-day variation in phase, while the amplitude varied with time. WINDII meridional wind observations, as well as correlative in time TOPEX TEC (Total Electron Content) data have been employed to investigate the mechanisms underlying the observed enhancement in O(1D) VER and DoT, including the possible relationship to the Weddell Sea Anomaly in the observed perturbations.

UPPER ATMOSPHERE CONDUCTIVITY MODEL AND CONDUCTIVITIES EFFECTS ON MODELING OF ATMOSPHERIC TIDES AT DIFFERENT LEVELS OF SOLAR ACTIVITY

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Middle and Upper Atmosphere Model (MUAM) is used for numerical simulation of atmospheric tides amplitudes changes due to effect of different levels of solar activity. The level of solar activity (SA) is specified using different radio flux values of the sun radiation with wavelength 10.7 cm. Ionospheric conductivity model developed allows to take into account latitudinal, longitudinal, and temporal conductivity variations at the different solar activity levels. The calculations are performed for January-February and the low, medium and high SA. The analysis of the effect exerted by different levels of solar activity in migrating and non-migrating tides latitude-height structure is performed.

EMPIRICAL MODEL OF SPATIAL-TEMPORAL VARIATIONS IN THE INTENSITY OF CARBON DIOXIDE (15 MICRONS) INFRARED RADIATION IN THE UPPER ATMOSPHERE

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We present the results of systematization and analysis of long-term data from rocket and satellite measurements of the carbon dioxide CO_2 (15 microns) infrared (IR) radiation in the upper atmosphere. This radiation originating at the upper mesosphere and lower thermosphere (MLT) heights plays a very important role in forming the thermal regime of the upper atmosphere and energy balance at these altitudes. The importance of studying the IR spatial-temporal variations is caused by the necessity to take into account the peculiarities of regional variations in the upper atmosphere temperature regime in predictive estimations of the global pattern of the upper atmosphere cooling processes at different latitudes over different time intervals during a year (diurnal and seasonal variations, etc). Photochemical atmospheric processes, leading to the origin of the 15 microns CO_2 emission, were analyzed. Based on the statistical analysis of the published data from rocket and satellite measurements of carbon dioxide IR radiation in the upper atmosphere over recent 30 years, we obtained analytical equations (empirical model). The model describes height distribution of the 15 microns emission intensity, its seasonal and latitudinal variations, and its dependence on solar activity. The CO_2 emission intensity behavior dependence on the solar activity is shown to have a nonlinear character. Analysis of seasonal variations in CO_2 emission intensity revealed its minimum in summer and maximum in winter. Latitudinal behavior of CO_2 emission intensity was studied. Analyzing the dependence of the annual mean CO_2 emission intensity on the geographical latitude revealed that the intensity increases in both hemispheres as the latitude increases. In the equatorial region, there is a small maximum in the CO_2 emission intensity. This study was supported by the Russian Foundation for Basic Research (Project No. 16-05-00120-a).

SOLAR ACTIVITY VARIATIONS INDUCING EFFECTS OF LIGHT SCATERRING AND REFRACTION IN THE EARTH`S ATMOSPHERE

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Possible mechanism of solar activity effect on scattered radiation as well as the intensity of exchange processes in the earths troposphere is discussed in this paper. In particular, the response of the Earth's atmosphere optical characteristics to the 11 year variations of the sunspot formation activity is considered. Analysis of the radiation data show that significant growth of the mean annual values of scattered radiation is observed while a total solar activity decreasing in certain years. This earth`s atmospheric characteristic is related to the quality of images of space objects — called seeing in astronomical practice. The effect of solar activity on the scattered radiation fluctuations is most pronounced over a long time periods, the duration of which is more than 11 years. The effect of any connection becomes invisible at short time intervals, when high-frequency perturbations are imposed.

MESOPAUSE TEMPERATURE UNDER GLOBAL CLIMATE CHANGE FROM LONG-TERM OBSERVATIONS AND MODEL SIMULATIONS

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Coherences of temperature variations near mesopause from long-term measurements at the Zvenigorod Scientific Station of the Obukhov Institute of Atmospheric Physics RAS in 1960–2015 with solar variability and with variations of surface air temperature are analyzed. Together with variations of temperature at the mesopause Tms from measurements of the hydroxyl emissions we analyzed the temperature variations near mesopause Tm reduced to the same level of solar activity. The observed strong decrease in temperature near mesopause during last decades, particularly in winter, with its tendency to slow down since the 1980 s was detected against the background of general increase in the surface air temperature of the Northern Hemisphere TNHs and the Earth as a whole. It was revealed a sharp drop in winter temperature near mesopause in 1970 s and its synchronicity with the shift in climatic conditions at the surface associated with changes in formation of El-Niño events and their impact on the global climate. This temperature shift is more clearly manifested for Tm than for Tms. The general significant negative correlation of temperature variations near mesopause and surface air temperature for the Northern Hemisphere detected from 56-year observational data was not accompanied by any significant coherence between the most long-period temperature variations from the cross-wavelet analysis. To assess the possible manifestation of this coherence the results of numerical simulations with a global climate model were used. According to model simulations for the 20–21 centuries taking into account anthropogenic forcings for significant coherence between long-term variations Tm and TNHs the prolonged observations are required for temperature near mesopause — about a century or more.

EXCITED COMPONENTS OF THE ATMOSPHERE AS THE POSSIBLE CAUSE OF LIDAR BACKSCATTERING IN THE MESOSPHERE AND UPPER ATMOSPHERE

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The results of two-frequency lidar sounding of the atmosphere from the altitudes of 25–400 km are presented. The data were obtained in 2008–2016 at a lidar site located in Kamchatka. One lidar channel is applied to investigate the aerosol formations in the middle atmosphere and to record the resonance scattering on excited ions of atomic nitrogen in the upper atmosphere. Nd:YAG laser operating on the wavelength of 532 nm is used in this channel. A dye laser with tunable frequency is applied in the second channel. The wavelength corresponds to the chosen dipole transition between the excited states of atomic oxygen. The possibility of reconstruction of excited atomic oxygen N_h-profile is shown. It may give information on precipitated electron spectra. The methods for the measurement of background signals and for consideration of photomultiplier pulse effects useful for the lidar investigation of the upper atmosphere are described. Possible manifestations of the resonance scattering in the region of the mesosphere are discussed.

THE SOLAR UV OBSERVATIONS IN ANTARCTICA (NOVOLAZAREVSKAYA STATION) IN THE GROWTH PHASE OF THE 24TH SOLAR ACTIVITY CYCLE

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Spectral measurements of the UV irradiation were carried out in zenith of free atmosphere at the station Novolazarevskaya (Antarctica) with spectrometer AvaSpec-2048 (www.avantes.com) in 2008–2015. The results of spectral measurements revealed the strong UV fluctuations in range of 297–330 nm, which are related to solar cosmic rays and solar radio-emission making strong impact on the upper mesosphere parameters, such as altitude and magnitude of mesopause, the ice water content, the ozone content, and other mesopause constituents (AIM, [http://aim.hamptonu.edu]). Time series analysis of the daily mean standard deviation (SD) for the UV fluctuation intensity in the summer local season demonstrates that the UV fluctuations are linearly connected with radio-emission over the range 245–8800 МГц [http://www.sws.bom.gov.au]. The maximal correlation (R~0.9) takes place for the low-frequency (245 MHz) radio-emission from solar corona, which intensity does not demonstrate obvious dependence on the solar activity cycle, in contrast to the high-frequency (>2800 MHz) radio-emission from solar chromosphere. These results strongly suggest that state of the upper mesosphere can be related to other factors than the solar activity variations.

GEOMAGNETIC ACTIVITY SIGNATURE IN MESOPAUSE TEMPERATURE OVER YAKUTIA

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OH excitation (87 km) and its connection with geomagnetic activity was studied. The measurements were performed by an infrared spectrograph at the Maimaga station (63° N, 129.5° E). The nightly averaged rotational temperatures of OH(6-2) obtained from 1999 to 2015 were considered. As a proxy of geomagnetic activity, the index A_p was taken. The maximum of the solar activity was about two years ahead of the maximum temperature of the mesopause. The fluctuation of the seasonally averaged temperatures (from August to May) correlated with the inter-annual change in geomagnetic activity. The correlation coefficient was R=0.51–0.1 (p<0.05). The temperature data was divided into high geomagnetic activity (A_p>8) and low geomagnetic activity (A_p<=8) years. Then the time series of each group was superposed by day of year, and daily averages for the same day of year were calculated. We found hat in the years with high activity the temperature of winter mesopause is about 10 K higher than in years with low activity. In autumn and spring, there is no dependence of temperature on the level of geomagnetic activity. Work was funded by the grant No. 17-05-00855 of the Russian Foundation for Basic Research.

THE PERFORMANCE OF THE TEC INPUT OPTION OF THE IRI-PLAS MODEL AT TWO EQUATORIAL STATIONS

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One major application of ionospheric models such as the International Reference Ionosphere (IRI) model is to evaluate the environmental effects on spaced-based communications and navigation systems. In the IRI extended to the plasmasphere (IRI-Plas) model, the height limitation of the IRI model is overcome and also the modeling framework is capable of assimilating measured value of some ionospheric observables into it, thus capturing the dynamics of the ionosphere. In this paper, the results of the investigation of the performance of total electron content (TEC) assimilative option of the IRI-Plas model over the "no input option" at two equatorial stations during quiet and disturbed conditions was presented. The result obtained showed that TEC predicted by the adaptation technique produced smaller error at the equatorial trough than near the crest for both quiet and disturbed periods. Also, there is substantial improvement in storm-time predicted TEC. The prediction is however independent on the storm's severity. With TEC assimilation, the f_oF2 estimation error is generally higher/smaller at the trough/crest for both quiet and disturbed conditions. IRI-Plas-hmF2 predicted with TEC adaptation option is poor at both locations during both quiet and disturbed conditions. Consequently, in other to obtain a more realistic F2 layer peak parameters from the IRI-Plas model, adapting the model alone to the TEC value may not be sufficient.

MITIGATION OF CHALLENGE OF RECALIBRATION OF SUNSPOT NUMBERS USING PROXIES OF SOLAR ACTIVITY FOR THE IONOSPHERIC MODELS

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The International Reference Ionosphere (IRI) and its extension into the Plasmasphere (IRI-Plas) are facing a challenge of misleading effects if used with the newly revised sunspot number, SSN2, due to the fact that these models are developed using the predecessor SSN1 index. In the present study different solar activity proxy indices, such as *F*10.7 solar radio flux, EUV fluxes (26–34 nm, 0.1–50 nm), Lyman_a (121.6 nm) and MgII-core-to-wing-flux-ratio (280 nm) are considered as candidates for the model driving indices. The ionosonde-based IG-index is already incorporated into IRI and the Global Electron Content (GEC) index is included by IRI-Plas as solar proxies for the F2 peak predictions. As a new option the Ionospheric Total Electron Content (IT) index scaled to the pre-defined SSN1 time series is proposed based on GPS-derived TEC-noon measurements at 288 IGS stations listed at http://www.izmiran.ru/ionosphere/weather/tec/indexcur.html during the 23–24 solar cycles. This study is partly supported by TUBITAK EEEAG 115E915.

FUSION OF IONOSONDE MEASUREMENTS AND TEC ESTIMATIONS USING STATISTICAL TECHNIQUES

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Ionosphere is a plasma layer which extends between 60 and 1000 km in altitude. This plasma structure has very complex characteristics depending on several effects such as solar and geomagnetic activity. Satellite and HF communications directly affected from this structure. The determination of statistical properties of ionosphere is very important for estimating the overall behavior. One of the most important parameters for understanding ionosphere is Total Electron Content (TEC) which is obtained from GPS measurements. Another way to measure ionospheric parameters is ionosonde measurements. Ionosondes are specialized sounding radars which 'measure' the ionospheric parameters. Ionosonde stations are sparser than GNSS stations. Therefore, the ionosonde measurements are less dense compared to TEC measurements from GPS stations. The variability of the ionosphere can be identified using Probability Density Functions (PDF). In this study, within-the-hour spatio-temporal characteristics of GPS-TEC, the critical frequency of F2 layer, f_oF2, and maximum ionization height, h_mF2, obtained from ionosonde measurements are described as a jointly parametric probability density function (PDF). Due to the physical dependency of all parameters, the joint PDF can provide a description of the joint relation between ionosonde measurements and TEC estimates that can result in a unified structural representation of ionosphere at F2 layer. Statistical observations on joint PDF estimates of TEC and f_oF2, h_mF2 measurements of the ionosphere will contribute to developing virtual ionosonde network model, which can further be used to derive virtual f_oF2 and h_mF2 values.

SUITS/SWUSV: A SMALL-SIZE MISSION TO ADDRESS SOLAR SPECTRAL VARIABILITY, SPACE WEATHER, EXTREME EVENTS AND SOLAR-CLIMATE RELATIONS

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We present the SUITS/SWUSV microsatellite mission investigation: Solar Ultraviolet Influence on Troposphere/Stratosphere, a Space Weather & Ultraviolet Solar Variability mission. SUITS/SWUSV was developed to determine the origins of the Sun's activity, understand the

flaring process (high energy flare characterization) and onset (forecast) of coronal mass ejections (CMEs). Another major objective is to determine the dynamics and coupling of Earth's atmosphere and its response to solar variability (in particular in the ultraviolet) and terrestrial inputs. It therefore includes the prediction and detection of major eruptions and CMEs (Lyman-Alpha and Herzberg continuum imaging), and the solar forcing on the climate through radiations and their interactions with the local stratosphere (ultraviolet spectral irradiance measurements from 170 to 400 nm). The mission is proposed on a sun-synchronous polar orbit 18h–6h at 700–750 km (for almost constant observing) with a 7 instruments model payload of some 80 kg / 80 W: SUAVE (Solar Ultraviolet Advanced Variability Experiment), an optimized telescope for FUV (Lyman-Alpha) and MUV (200–220 nm Herzberg continuum) imaging (sources of variability); SOLSIM (SOLar Spectral Irradiance Monitor), a spectrometer with 0.5 nm spectral resolution from 170 to 340 nm; SUPR (Solar Ultraviolet Passband Radiometers), with UV filter radiometers at Lyman-Alpha, Herzberg, MgII index, CN bandhead and UV bands coverage up to 400 nm; HEBS (High Energy Burst Spectrometers), a large energy coverage (a few tens of keV to a few hundreds of MeV) instrument to characterize large flares; EPT-HET (Electron-Proton Telescope — High Energy Telescope), measuring electrons, protons, and heavy ions over a large energy range; ERBO (Earth Radiative Budget and Ozone) NADIR oriented; and a vector magnetometer. Complete accommodation of the payload has been performed on a small platform of PROBA type very nicely but could fit several others. Alternately or in complement, a small coronagraph is also envisaged. Heritage is important both for instruments (SODISM and PREMOS on PICARD, LYRA on PROBA-2, SOLSPEC on ISS,…) and platform (PROBA-2, PROBA-V,...), leading to high technology readiness levels (>7). SUITS/SWUSV was initially designed in view of the 2015 ESA/CAS (Chinese Academy of Sciences) Call for a Small Mission; it is now envisaged for joint CNES/NASA opportunities or future European Calls for a possible flight in 2022.

OBSERVATIONS OF DYNAMICS IN THE HIGH ARCTIC MESOPAUSE REGION AND THERMOSPHERE

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The Dynamics of the Neutral Thermosphere project is a multiple site, multiple instrument observatory. The instruments are located in the Canadian Arctic at Yellowknife, Resolute Bay (75° N, 95° W) and Eureka (80° N, 85° W) and include meteor radars, high resolution interferometers, and all sky imagers. Measurements include wind, temperature and airglow irradiance at the latter two sites and a meteor radar at the former site. Inter-instrument and inter-site comparisons of time series are being undertaken and provide insights into the dynamical processes in the high Arctic mesopause region and thermosphere, and information on the various observing techniques. Studies are under way, to determine whether common tidal and gravity wave signatures can be observed at both sites and in the mesopause region and thermosphere. Airglow irradiance, winds and temperatures are observed with several different instruments and comparisons between the associated time series are revealing the consequences of the different

observing processes. For example, Doppler shift wind measurements in airglow using interferometers are irradiance weighted averages of the wind in each airglow layer whereas the meteor radar provides wind profiles. During the 8 years that the instruments have been taking observations, several sudden stratospheric warmings have occurred. Similarities and differences in wind, airglow and temperature time series between the different warmings will be summarized.

Session 7: DATA ARCHIVING AND ANALYSIS TOOLS

NCEI SUN TO EARTH: SPACE ENVIRONMENT ARCHIVE, TECHNIQUES, TOOLS AND RESULTS

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The NOAA Solar Terrestrial Physics Program within the US National Centers for Environmental Information (NCEI) is dedicated to the observation and characterization of the natural environment from Sun to Earth. NCEI's environmental data sets from ground to orbital platforms are vast in both space and time, with worldwide contributions of solar imagery, geomagnetic and ionospheric measurements and interpretations dating long before the 1957/1958 International Geophysical Year (IGY). With technological advancements, continuous operational measurements of the near-Earth space environment have trended towards the use of fully instrumented space-based assets. Space platform measurements in NOAA's current archive provide (non-inclusively) irradiance measurements of the solar disk and plasma and magnetic properties of the equatorial radiation belt charged particle environment sensed by the Geosynchronous Operational Environmental Satellites (GOES), similar plasma properties and upper atmosphere energy inputs sensed by the low earth Polar Orbiting Environmental Satellites (POES), the European Meteorological Operational (MetOp), and Defense Meteorological Satellite Program (DMSP; multi-institution collaboration) satellites. NOAA's strong observational commitment continues with two flagship programs: the Deep Space Climate Observatory (DSCOVR) which provides NOAA with a new operational solar wind monitoring capability, and the new GOES-R program (GOES-16 launched November 2016) which will advance our solar observations and GEO radiation environment monitoring. The aggregated expertise within NCEI provides a powerful resource supporting many key, internationally valuable activities. These include leadership roles in cal/val and product development for GOES-R and Swarm, the development of the standard International Geomagnetic Reference Field (IGRF), the World Magnetic Model and its Extension (WMM and EMM), several ionosphere focused products (e.g. the Swarm-based Dedicated Ionospheric Field Inversion (DIFI) model, and automatic scalings of real-time ionograms), satellite anomaly investigations, NOAA's foray into the Big Data arena, and numerous contributions to the operations and research communities. We present on the best practices and lessons learned, our new DSCOVR data extraction and visualization portal, GOES-R analysis tools, new products and plans for advanced discovery, visualization and dissemination, our geomagnetic and electric field products and services, and key scientific results realized using our comprehensive Sun to Earth archives (www.ngdc.noaa.gov/stp/).

METHODICAL AND SOFTWARE TOOLS FOR THE PROCESSING OF THE RAW DATA OF THE MAGNETIC OBSERVATORIES

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The raw magnetic data obtained by regular observations at magnetic observatories are the basis for research in many fields of science. The reliability, regularity and efficiency of the data ensure the quality and effectiveness of researches, including in the field of the space weather forecasts. Hardware developers with technical and technological advances provide observatories with the wide range of digital magnetometers, the modern information and communication systems of the data storage and database formation provide the scientific community with access to the results of the measurements. Processing of raw data on the primary analysis step has a significant importance. The report shows that much of this work cannot be delegated to the outer data centers, and must be carried out directly at the observatories. First of all, this is due to the need to consider local environmental factors that affect the results of the measurements, as well as monitor the state of the equipment and make timely operational decisions for possible faults, failures, etc. In spite of the intensive development of information and communication systems and technologies, there are substantial gaps in methodological (to a lesser extent) and software (largely) support of the magnetologist workplace, which are being addressed in this work. The authors developed specialized software system, including all stages of the processing of the magnetic data, since their primary analysis to high-tech mathematical methods for the study of processes in the magnetosphere-ionosphere system. Much attention is paid to the creation of effective, reliable and user-friendly software for magnetologist, including procedures on identification and removal of noise, control the baseline values, filling gaps in the data, as well as the preparation of the final data with the status of Adjusted, Quasi-definitive and Definitive, required by the INTERMAGNET standards. A significant part of the programs implemented and effectively used at Paratunka, Khabarovsk, Magadan and Cape Schmidt magnetic observatories of IKIR FEB RAS (Russia), testing the individual modules is performed at Hyderabad and Choutuppal observatories of CSIR-NGRI (India). This work was supported by Indo-Russia collaborative project of RFBR No 16-55-45007.

DATABASE OF COSMIC-RAY NEUTRON FLUXES HELD BY WDC FOR COSMIC RAYS

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The World Data center (WDC) for Cosmic Rays was established in 1957 in RIKEN, Tokyo, as a C2 center of the ICSU WDC. This data center has been moved to the present Institute for Space-Earth Environment Research, Nagoya University, in 1991. The principal data

held by the WDC are pressure-corrected and scale-adjusted one-hour counts of cosmic-ray neutron data since 1953 which are provided by ground-based stations (about 50 at present) distributed in a wide range of the geographic longitude and the latitude. Data are opened through the Web page given below after fundamental quality control. This database will be useful for studies of variations of cosmic-lay flux with time scales ranging from hours to years (http://center.stelab.nagoya-u.ac.jp/WDCCR/).

WDS ASIA-OCEANIA CONFERENCE, 2017

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The World Data System (WDS) of ICSU will promote the conference entitled WDS Asia-Oceania Symposium, 2017 to be held in Kyoto, Japan, from 26 to 28 September 2017. The associated workshop on data analysis of current solar-terrestrial events will be held also on 25 September 2017 through the collaboration with the VarSITI community of Japan. Details on the conference are posted at http://wdc2.kugi.kyoto-u.ac.jp/wds2017/. WDS is an interdisciplinary body of the International Council of Science (ICSU) whose mission is to promote international collaborations on long-term preservation and provision of quality-assessed research data and data services across a range of disciplines in the natural and social sciences. Among 90 members of WDS at present, only 14 members have been enlisted from the Asia-Oceania area. Increase the number of WDS members in this area is one of the principal action items of WDS because this area is important in various research disciplines, including solar-terrestrial science. Although WDS has been evolved from the World Data Center (WDC) system established in the IGY era, a number of former WDC members, particularly in China and Japan, have faced to difficulty to be members of WDS due to various reasons, including the change of interest of hosting organizations. Establishment of a system to assure long-term preservation and provision of their data holdings is urgent. In addition, infrastructures of data management in the Asia-Oceania region are still in the stage of development, instead of importance of this region in the Future Earth program of ICSU. In this conference, we will discuss on future actions to enforce collaboration.

IUGONET TOOLS FOR SOLAR-TERRESTRIAL PHYSICS RESEARCH

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We present useful tools for solar-terrestrial physics (STP) research, developed by Inter-university Upper atmosphere Global Observation NETwork (IUGONET) project. IUGONET is a Japanese inter-university project that aims at developing infrastructure to share upper

atmospheric data, including solar and planetary data, which have been separately archived by Japanese universities and institutes, and to promote interdisciplinary studies on STP. We have developed two tools, i.e., a metadata database and an analysis software for the upper atmospheric data. Our metadata database, called IUGONET Type-A, allows users to cross-search various kinds of the upper atmosphere data distributed across the IUGONET members. It provides a one-stop web service to search data, show metadata and quick-look (QL) plot of the data, find interesting STP events, interactively examine the data, and lead users to more detailed data analysis by using our analysis software. Our analysis software is based on Space Physics Environment Data Analysis Software (SPEDAS) that is a grass-roots software written by Interactive Data Language (IDL) and is capable of dealing with data from multiple missions. We have provided a plug-in tool for SPEDAS, which enables analysis of data from the ground-based observations by solar telescope, ionospheric and atmospheric radars, imagers, riometers, magnetometers, etc. with SPEDAS. Since we are collaborating or are planning to collaborate with several science projects such as ERG, PWING, Pulsating Aurora Project, EISCAT_3D, Equatorial MU radar, and so on, the data from these projects will be further available in our tools. In addition, we hold tutorial seminars to explain how to use these IUGONET data and tools in Japan and sometimes foreign countries several times a year. We believe that these tools are useful for the Variability of the Sun and Its Terrestrial Impact (VarSITI) program, in particular, Specification and Prediction of the Coupled Inner-Magnetospheric Environments (SPeCIMEN) and Role Of the Sun and Middle atmosphere thermosphere/ionosphere in Climate (ROSMIC).

IRNSS/GPS DATA ANALYSIS FOR IONOSPHERIC STUDIES AT SANGLI (LATITUDE: 16º51' N, LONGITUDE: 74º34' E)

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Data archiving plays significant role in the field of space communication, space weather studies etc., as this archived data is an only source to gather desired information as per the predefined objectives of respective system. Dedicatedly designed receivers for particular satellite system will receive the signal from satellites. IRNSS data lot of seven days from extracted files can be selected and proceed further with IRDAS software which will generates plot of each satellite existing in system in various manners and for different parameters. IRDAS initially deals with the reference position of receiving station so as to generate an output. Hence, real time data logging and its weekly record maintaining will be achieved by these sophisticated software's The proposed project objectives demand to have some more and different parameter to archive and proceed than IRDAS tool. Hence, paper presents estimation and its preliminary results of comparative analysis of ionosperic delay and TEC from IRNSS/GPS/SBAS data using different softwares.

CURRENT STATUS OF CATALOG OF LARGE-SCALE SOLAR WIND PHENOMENA

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During 2002–2007 we prepared a method of identification of large-scale solar wind structure on the basis of OMNI database of 1-h solar wind (SW) plasma and IMF parameters and we have made the "Catalog of large-scale solar wind phenomena for period 1976–2000" (see website ftp://ftp.iki.rssi.ru/pub/omni/ and paper [Yermolaev et al., 2009]). Our catalog identifies reliably 3 types of quasi-stationary streams of the solar wind (heliospheric current sheet (HCS), high speed streams from the coronal holes (HSS), and slow streams from the coronal streamers), and 5 disturbed types (compression regions before fast streams HSS (CIR), and interplanetary manifestations of coronal mass ejections (ICME) that can include magnetic clouds (MC) and Ejecta with the compression region Sheath (SHEMC and SHEEj) preceding them) as well as the interplanetary shock (IS). In the report we will described the procedures of SW type identification, data processing and visualization, and web site using. Current status (27 February, 2017: Calculation of parameters 1976–2015, Visualization of parameters 1976–2015, Identification of SW types 1976–2005, 2011–2015, Visualization of SW identification 1976–2005, 2011–2015. The work is supported by the VarSITI grant.

PROGRESS IN HANDLING AND ANALYSIS OF GROUND-BASED GEOMAGNETIC DATA STREAMS FOR ADVANCED MONITORING OF THE EARTH'S MAGNETIC ENVIRONMENT

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The continuous growth of geophysical observations requires adequate methods for their processing and analysis. On the other hand, geomagnetic studies require accurate and reliable measurements of the Earth's magnetic field (EMF) carried out from ground and space. The system analysis methods and data mining techniques are able to sustain the solution of these problems. This paper presents an innovative holistic hardware/software system developed for efficient management and intellectual analysis of geomagnetic data, registered by Russian geomagnetic observatories. The designed system provides sophisticated automatic detection and multi-criteria classification of extreme geomagnetic conditions, which may be hazardous for technological infrastructure and economic activity in Russia. The geomagnetic activity indicators include measure of anomalousness (MA), rate of change and amplitude of the geomagnetic field and near real-time *K* index. An essential feature of the developed system is its ability to deal continuously with real time data streams. It enables the online access to digital geomagnetic data and its processing results along with its visualization on conventional and spherical screens. In addition to recognition of increased magnetic activity, the fuzzy-logic based MA indicator is dually used for defining magnetically quiet periods. This feature makes the MA applicable for selecting quiet days and consequently more precise and timely determination of Sq variations at specified observatories, as compared to classical IAGA approach. This method also plays

important role in selection of observatory data for constructing proper geomagnetic field models of internal origin. With this respect, we give a description of the principally new approach to calculating magnetometer calibration values (baseline estimations), which is a crucial operation in producing continuous high quality measurements of the complete field vector at geomagnetic observatories. As opposed to the baseline estimation method, traditionally accepted in INTERMAGNET, this approach involves all information on the geomagnetic field variations (both, vector and scalar), available in between infrequent absolute measurements taken by observatory operators. As a result, it provides information on the observatory data errors, which is especially important in robust modeling of rapid core magnetic field variations. Secular variations (SV) of the EMF on short time intervals are detected by calculating the second time derivative (secular acceleration, SA) of the field. However, charting the SV and SA at the core-mantle boundary that might reveal sudden changes of SA polarity happening within a year or so is only possible for models derived from recent, high accuracy satellite observations. We propose a new way to SV modelling and detection of SA pulses that are direct manifestation of the dynamic processes in the liquid core, using observatory data solely. It enables retrospective historical data processing for recognition of SA pulses and geomagnetic jerks before 2000, when full-scale geomagnetic satellite observations started.

RESULTS FROM FY-3 SOLAR IRRADIANCE MONITOR OBSERVATION, A NEW TSI DATA RECORD

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FengYun (FY)-3 satellites are the second generation of Chinese polar-orbiting meteorological satellites. The main goal of FY-3 is the measurement of three-dimensional, multi-spectrum and global remote sensing under all weather conditions. It could provide the application on weather monitoring and forecasting, earth radiation budget and climate change et.al.The Solar Irradiance Monitor (SIM) is aim to capture variation of solar energy at the whole waveband from the top of atmosphere with Total Solar Irradiance (TSI).It is designed for climate research coupled with Earth Radiation Measurement together as an instrument group and began to work from June, 2008.. With the experiences from the first two satellites, the SIM on FY3C has two significant improvements by adding sun tracing system and temperature control system, which is named after SIM-II.TSI from FY3C/SIM-II has been evaluated by comparing with SORCE/TIM and RMIB composite data. The result shows a good consistency. Monitoring of strong solar activity during Oct. 2014, FY3C/SIM-II and SORCE/TIM showed the same level about solar energy change. This work shows the new results from recalibrated SIM TSI data record after improvement on background and aging correction and its capability on monitoring solar activities.

THE TECHNIQUE FOR ESTIMATION OF ABSOLUTE TOTAL ELECTRON CONTENT USING DUAL-FREQUENCY AND SINGLE-FREQUENCY GPS/GLONASS DATA

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We have developed a technique for total electron content (TEC) estimation from the dual-frequency and single-frequency data of an individual GPS/GLONASS station. Estimating is based on dual-frequency data of phase measurements and single-frequency GPS/GLONASS data of joint phase and group pseudorange measurements. The algorithm is based on TEC Taylor series expansion in space and time (TayAbsTEC). The validation was performed based on data from Global Ionospheric Maps (GIM) by CODE and JPL. We compared differences between absolute vertical TEC (VTEC) from GIM and VTEC evaluated by TayAbsTEC based on dual-frequency data. for solar minimum(full 2009), and for solar maximum (full 2014). It was found that the difference between JPL VTEC and VTEC by TayAbsTEC higher than the difference between CODE VTEC and VTEC by TayAbsTEC. The difference is higher for solar maximum (2014) as compared with solar minimum for both CODE and JPL. Also we compared single-frequency technique result with dual-frequency those. Estimated single-frequency vertical TEC agrees qualitatively and quantitatively with the dual-frequency vertical TEC. A typical value of the difference between the single-frequency vertical TEC and the dual-frequency one for the analyzed stations generally does not exceed ~1.5 TECU with RMS up to ~3 TECU. The distribution of VTEC differences has the form of a Gaussian distribution. Results of TayAbsTEC are in the agreement with GIM VTEC. The developed technique can be used for VTEC calculation based on dual-frequency or single-frequency GPS/GLONASS data from local stations.

THE IONOSPHERIC DYNAMICS AS MEASURED BY THE DOPPLER SOUNDING AND BY THE DIGISONDE TECHNIQUE

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Vertical ionospheric sounding produces ionograms and subsequently electron density profiles. Modern ionosondes arealso able to monitor dynamics of ionospheric layers by drift measurements. The drift measurements have been performed at ionospheric observatory of Pruhonice for the last 10 years with 15 min cadence. Since 2007, Continuous Doppler Sounding have also been carried out to monitor wave activity on short timescales, up to ~10 s. Both Digisonde and Continuous Doppler Sounder measure about the same volume in the ionosphere. Our contribution compares the potential of both measurements to investigate dynamics of the ionosphere. Several case studies are presented. Monitoring of the dynamics of the ionosphere has great potential for the prediction of ionospheric conditions.

KONUS-WIND HARD X-RAY AND SOFT GAMMA-RAY SOLAR FLARE DATABASE

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Konus-Wind is a joint US-Russian experiment for gamma-ray burst and solar flare studies. The experiment started on November 1, 1994. Being located in the interplanetary space (since July of 2004 — near Lagrange point L1) Konus-Wind doesnt suffer from “nights”. During its more than 22 year-long history Konus-Wind has accumulated a unique volume of solar flare observations in hard X-ray and soft gamma-ray range. Data registered by Konus-Wind in the triggered mode constitute the presented database, named KW-Sun. The data can be accessed via http://www.ioffe.ru/LEA/kwsun/ (at the time of writing the data for years 2005-2017 are available, the remaining data will be added soon). New solar observations will be added to the database as soon as they arrive. KW-Sun provides light curves with high temporal resolution (down to 16 ms) and energy spectra in wide energy range (now ~20 keV – 15 MeV) which covers the region of non-thermal emission from electrons and ions accelerated in solar flares. We present some statistics describing solar flares observed by Konus-Wind and compare flare properties between solar cycles 23 and 24.

INTERFERENCES ON THE CORRELATION DATA OF THE SIBERIAN RADIOHELIOGRAPH

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The first phase of the Siberian Radioheliograph (SRH) is a 48-antenna array. One type of radioheliograph data represents correlation plots. In evaluating the covariation of two-level signals, these plots are sums of complex correlations, obtained for different antenna pairs. Bearing in mind that correlation of signals from an antenna pair is related to a spatial frequency, we can say that each value of the plot is an integral over a spatial spectrum. Limits of the integration are defined by a task. Only high spatial frequencies are integrated to obtain dynamics of compact sources while the whole spectrum is integrated to reach maximum sensitivity. These data are affected by the some interference: the radio emission of the geostationary satellites for the about 0 declination, the forest emission especially for negative declinations. In this work we show how to mitigate the influence of these interferences on the correlation plots of the SRH.

MODELING INTERFEROGRAM IMAGES FOR THE OUTPUT DATA SIMULATION OF FABRY–PEROT INTERFEROMETER

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The determination of winds and temperatures in thermosphere is quite important for global atmospheric model developments. One of the instrument used for solving such a task is an imaging Fabry–Perot Interferometer (FPI). This study is devoted to the simulation of 2D images for Keo Scientific Arinae FPI equipped with CCD sensor. The numerical process was based on calculating an integral sum of Airy function as an apparatus function of FPI with the weights defined as Gauss distribution function of a source spectrum. To approach the reality, scattering, vignetting and other deviations from the ideal apparatus function were taken into account. Two types of images were made during the simulation: "He-Ne laser" calibrating interferograms at the wavelength λ=632.8 nm and "sky" interferograms for observing the emission caused by the dissociative recombination of O_2^+ with the wavelength λ=630 nm. The latter images had a Doppler shift and broadening of spectrum connected with the emulated wind and temperature respectively. The simulated pictures were processed by FPI handling software (FPIHS). The values of wind, temperature, intensity and background restored with this software were found to be in good correlation with the parameters used in simulating. Also, the experiments with increasing noise were carried out for the signal noise ratio (SNR) resolution limit determination of FPIHS. In addition, the images for a composite spectrum with varied intensities of input emission containing contamination of O^+ and OH lines were simulated and processed by FPIHS. This resulted in decreasing temperature measured when the OH line was stronger but its local increasing when the intensities were equal. All the aforementioned were done assuming the homogeneous distribution of winds and temperatures in the observation field. Moreover, studying the heterogeneous distribution of winds and temperatures for further research was begun. This includes the simulation of small regions with particular wind and temperature in the field of observation with different wind and temperature values.The data used in this work were obtained from FPI included in CCU "Angara".This research was carried out with the support of financial funds of "Studying dynamic processes in neutral atmosphere—ionosphere—magnetosphere of the Earth", project UN 0344-2014-0006. RN CITIS – 01201281656.

A STUDY OF POSSIBILITIES OF "GNU RADIO COMPANION" FOR CHIRP SIGNAL PROCESSING

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This paper shows the possibilities of the GNU Radio Companion for signal processing. The GNU Radio Companion is free software for working with various signals such as data from SDR (Software Defined Radio) receivers or data from sound card. Using the digitized output signal from the receiver (Icom IC-R75) ionograms were constructed. Methods for improving the quality of the received data using the built-in functions of GNU Radio are considered. At same time, data from this receiver are obtained by standard, paid software. At the end, the obtained data were compared. It was shown that the GNU Radio Companion software can be used for chirp signals processing, which are using to diagnostics of ionosphere.

METEOR TRAIL OBSERVATIONS AT EKB ISTP SB RAS RADAR.

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This work is based on coherent decameter radar EKB ISTP SB RAS (8-20MHz) located near Ekaterinburg. EKB is over-the-horizon radar with 50 degrees field-of-view sliced into 16 beams, with 15–45 km spatial resolution and 1–2 min time resolution over field-of-view (of 4–8 sec at single beam) in normal operating mode. In normal mode the radar transmit series of multi-pulse sequences (7–16 pulses in each sequence depending on sounding mode), then calculate an autocorrelation function (ACF) of the received signal for every range gate and accumulates them over several (~40) sounding sequences. In this paper we use raw data — quadrature (IQ) components of the received signal. Using this data becomes possible to study scattering from meteor trails (burning heights ~ 80–100 km). Monitoring of meteor echos is a common operating mode for the most part of SuperDARN radars, similar to EKB radar. The algorithms used in this mode are based on analysis of ACF, and time resolution is about 4-8 seconds. We implemented an algorithm that searches for meteor echos in IQ components of scattered signal. This allows us to reach time resolution up to 5 milliseconds. Algorithm is based on exhausting search of model parameters: meteor trail life-time and Doppler drift to find a pair with least mean square deviation with experimental data. Optimal model parameters allows to calculate the characteristics of meteor trail: azimuth, distance, meteor lifetime and line-of-sight velocity. The algorithm uses standard radar output files and can work in real time during radar operation. Algorithm had been implemented on EKB radar since December 2016 and used as common real-time radar data processing method. Also it can be used for retrospective data analysis. The meteor trail characteristics obtained from the radar data can be used to study the neutral atmosphere dynamic. In this paper we present the first statistical analysis of meteor trail characteristics over EKB radar data since early 2016 until now. The diurnal and season variation are also presented.

IRI-PLAS WITH TEC ASSIMILATION AS AN ONLINE SERVICE AT IONOLAB

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International Reference Ionosphere (IRI) is a joint task group of COSPAR and URSI, which is dedicated to provide a reliable and accurate climatic model for structural parameters of ionosphere. IRI is an empirical and deterministic model that uses hourly monthly medians of F2 layer critical frequency, foF2. IRI is originally developed in FORTRAN language and currently, it is available at http://irimodel.org/ with an online version. The IRI model can provide electron density profile, layer parameters and ion and electron temperatures in the general range of 80 to 2,000 km. Users can specify the location, date, time and the height profile boundaries for a single run. The outputs can be obtained in the text format or the profiles or distributions can be drawn according to user specifications. IRI is accepted as the international standard model of ionosphere. IRI Extended to Plasmasphere (IRI-Plas) is a recently developed version of IRI model by Dr. Tamara L. Gulyaeva of IRI task group. In IRI-Plas, the region of interest can

include the plasmasphere up to the GPS satellite orbital height of 20,200 km. IRI-Plas provides structural model of ionosphere up to plasmasphere in regions where ionosonde data are not available. IRI-Plas is available as a FORTRAN code at ftp://ftp.izmiran.rssi.ru/pub/izmiran/SPIM/. IONOLAB Group has been using IRI-Plas as a basis of various research products provided in www.ionolab.org as space weather services such as IRI-Plas-MAP, IRI-Plas-STEC, and algorithm for computerized ionospheric tomography, namely, IONOLAB-CIT, and novel electromagnetic wave propagation algorithm in ionosphere, IONOLAB-RAY. In order to facilitate the usage of IRI-Plas for other possible users, IONOLAB group has implemented the online version at www.ionolab.org. The input page and the output of the program are similar to the internet access page of IRI-2016. The most important aspect of Online IRI-Plas is the automatic assimilation of Global Ionospheric Map (GIM) Total Electron Content (TEC). The user can also supply the TEC by typing in the value in the designated slot. Also, the user can run the algorithm with various input sets in a batch which is an advantage to avoid multiple runs. The user friendly online IRI-Plas algorithm allows for ionospheric modeling up to the height 20,200 km for any ionospheric state, date, time and location. This study is supported by grant from TUBITAK EEEAG 115E915 project.

APPLICATION OF A ROBUST CRITERION FOR FILTERING TIME SERIES OF IONOSPHERIC PARAMETERS

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Nowadays filtering is widely used as a method of data processing. Frequency filtering has been studied quite well, and there are many algorithms and methods of such filtering (spectral analysis). However, at the present time, filtering, based on statistical significance is becoming popular, the simplest example of which is wavelet filtration, where the criterion of quality is the minimum root-mean-square error. Such a criterion gives excellent results for data whose probability distribution is described by a Gaussian law. Unfortunately, for data with a different distribution, this approach may not be correct. So, the development of a universal sustainable criterion becomes an urgent problem. One of the most famous universal criterion is the maximum likelihood method, which, however, requires knowledge of the type of distribution for recording the quality criterion. Here there are two key difficulties: Distribution is not always known;It is rather difficult to record the quality function for some types of distribution.Such complexity can be circumvented, using as a criterion of quality a criterion that does not depend on the type of distribution. The series criterion is one of them - in this case the Ramachandran-Ranganatan criterion was used, which is written as follows: The filtering in this case will be based on the minimum amount of squared series length multiplied by the number of such series,assuming that random events do not organize long series, thereby allowing to separate meaningful signals from random ones. To minimize the error, it is suggested to use genetic algorithms — one of the stochastic optimization methods. To compare the filtration methods, the series were modeled, with different distribution of the noise component. The results of filtering by different methods showed the advantage of the serial criterion over the criterion of the minimum mean square error. Also these algorithms were used for filtration of temporary ranks of ionospheric parameters, namely ranks of critical frequencies of a layer of F2 to search quasiperiodic variations. Results of such researches also showed advantage of serial criteria.

CAPABILITIES OF MOBILE ROBOTS TO MAP ELECTROMAGNETIC RADIATION OF LITHOSPHERIC ORIGIN

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The main aim of the work is the construction of a system for mapping of electromagnetic radiation of lithospheric origin (ERLO) based on the application of a self-organizing wireless sensor network (SWSN). When solving the problem, we assume that an object for ERLO mapping is known, the number of measurement points is not exactly defined and deliberately exceeds the number of network sensors. The problem is assumed to be solved by mobile robots (drone, ground, above- and under-water vehicles). Mobile robots are applied as intelligent agents and form a distributed multi-agent system based on the SWSN. Some functions of mobile robots are: construction of self-organizing structures of antenna distribution; formation of a self-organizing wireless sensor network including ground and mobile segments; geographically-distributed acquisition of data from SWSN sites; organization of the interaction of a SWSN mobile segment with a ground one; distributed registration of electromagnetic radiation in a given area; accurate arrangement, distribution over a territory, movement, removal, reprogramming, charging and replacement of power sources at SWSN sites; planning of cooperative behavior of mobile robots in the process of solution of a SWSN functioning general aim and reconstruction of SESN sites based on the aims and current measurements of the whole SWSN. We can show the following stage process as one of possible examples of ERLO mapping. At the first stage, the sensors measuring ERLO are arranged in priori or randomly chosen positions (i.e. a SWSN ground segment is built) by mobile robots. During the following repeated stages, ERLO preliminary distributions are estimated, ERLO distributions are mapped, ERLO local maxima are determined, constant level lines and gradient lines of ERLO are drawn, the positions appropriate for sensor location are calculated based on the obtained information, SWSN sites are rearranged based on the aims and current measurements of the whole SWSN. The process of data acquisition is stopped when the aim or a stop criterion is achieved. Possible applications are monitoring of seismic activity, engineering facilities and exploration of minerals.

AUTHOR INDEX

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ABSTRACTS

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