First Indian Space Weather Conference (ISWC-2022)

11-12 January 2022

Physical Research Laboratory, Ahmedabad

Platinum Jubilee Celebrations of PRL

BOOK OF ABSTRACTS

https://www.prl.res.in/iswc2022/

About ISWC

The First Indian Space Weather Conference (ISWC-2022) is aimed to bring together the researchers working in different domains of the variations in the Sun that are responsible for causing disturbances in the interplanetary medium, effects in the magnetosphere and the ionosphere-thermosphere-atmosphere systems of the Earth and other planets. The variations originating from the Sun also affect planets and solar system bodies like Moon with thin/no atmosphere and/or no magnetosphere. The active solar regions often result in highly transient and explosive events, such as, solar flares, coronal mass ejections, etc. The magnetic fields in these active regions open up into the interplanetary space, release transient massive outflows like, jets, high speed solar wind streams, and co-rotating Interaction regions. Determining the effects of energy deposition and exchange of momentum across different spatial and temporal scales are crucial aspects in the investigations of the Sun-planet systems under varying space weather conditions. Planets having their own magnetosphere are much more dynamic as compared to those without it. The energetics of the particles after interaction with the planetary magnetospheres gets modified and most often is accelerated to very high energies which can affect many space systems orbiting at these altitudes. Hence, it is extremely pertinent now, than ever before, to understand the solar-terrestrial interactions that drive changes in the charged and neutral particle environments around the Earth as well as other planets, where man-made assets (spacecrafts) lie. With several space missions being planned for solar, terrestrial, and planetary studies, this annual conference is specifically focused on the space weather science and space weather applications.

The science themes that will be deliberated on in the ISWC are: Solar Cycle studies, Simulations of solar transients, Space weather forecasting models, Source regions of solar disturbances, Response of the magnetosphere to solar forcing, Space weather impact on the ionosphere-thermosphere system of planets, and Space weather modeling studies.

Scientific Organizing Committee

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Scientific Sessions

Session 1: Space weather drivers and processes.

Conveners: N. Srivastava, K. Sankarasubramanian, and D. Banerjee

This deals specifically with solar flares, CMEs, ICMES, CIRs, and SEPs, that cause space weather effects in terrestrial and planetary atmosphere-ionospheres-magnetosphere system as well as surface. This session will also deal with the accelerations and decelerations of solar winds, shocks in the interplanetary medium etc.

Session 2: Impact of space weather on the Earth's magnetosphere, ionosphere, and thermosphere

Conveners: D. Pallamraju, S. Gurubaran, D. Chakrabarty and Varun Sheel

This session will deal with the space weather effects on the earth's atmosphere, ionosphere, and magnetosphere, due to solar storms. These will also include the application aspects of the space weather.

Session 3: Space and ground instruments for space weather research

Conveners: A. K. Patra, R. Ramesh, T. K. Pant and T.P. Das

This session will deal with results/outcome of new instruments developed for space weather research

Program at a Glance

Day 1: 11 January 2022

09:00 – 09:30	Webex log in

09:30 – 10:15	**Inauguration of ISWC-2022**
10:15 – 10:30	Break
Session 1: Space weather drivers and processes Conveners: N. Srivastava, K. Sankarasubramanian, and D. Banerjee	
10:30 – 11:35	S1.1 : Solar cycle studies *Chairs: D. Banerjee, N. Srivastava*
11:35 – 12:30	S1.2 : Space weather forecasting models *Chairs: N. Srivastava, D. Banerjee*
12:30 – 13:00	S1.3 : Source regions of solar disturbances *Chairs: K. Sankarasubramanian, R. Ramesh*
13:00 – 13:45	**Lunch Break**
13:45 – 14:45	S1.4 : Simulations of solar transients *Chairs: R. Ramesh, K. Sankarasubramanian*

Session 2: Impact of space weather on the Earth's magnetosphere, ionosphere, and thermosphere Conveners: D. Pallamraju, S. Gurubaran, D. Chakrabarty and Varun Sheel	
14:45 – 16:00	S2.1 : Response of the magnetosphere to solar forcing *Chairs: S. Gurubaran, D. Chakrabarty*
16:00 – 16:15	Break
16:15 – 18:15	S2.2 : Space weather impact on the ionosphere/thermosphere system of planets *Chairs: S. Gurubaran, D. Pallamraju*

Day 2: 12 January 2022

09:30 – 10:00	Webex log in

10:00 – 11:30	***PRL ka Amrut Vyakhyaan* By Prof. Daniel N. Baker** on **Societal and Economic Impacts of Space Weather**

Session 2: Impact of space weather on the Earth's magnetosphere, ionosphere, and thermosphere (Contd.) Conveners: D. Pallamraju, S. Gurubaran, D. Chakrabarty and Varun Sheel	
11:30 – 13:30	S2.2 : Space weather impact on the ionosphere/thermosphere system of planets *Chairs: T. K. Pant, Varun Sheel*
13:30 – 14:15	**Lunch Break**
14:15 – 15:25	S2.3 : Modelling studies for Space Weather Research *Chairs: Varun Sheel, D. Chakrabarty*
15:25 – 15:40	Break

15:40 – 17:15	**Session 3: Space and ground instruments for space weather research** Conveners: A. K. Patra, R. Ramesh, T. K. Pant and T.P. Das *Chairs: A.K. Patra, T. P. Das, T. K. Pant*

17:15 – 18:15	**Sessions' summary, feedback, and discussions on the way forward** Chair: Anil Bhardwaj

Contents:

Session: 1

Space weather drivers and processes

S 1.1 - Solar cycle studies

S 1.2 - Space weather forecasting models

S 1.3 - Source regions of solar disturbances

S 1.4 - Simulations of solar transients

Session no: 01

Investigation on variation in solar wind Helium abundance during the last four solar cycles

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Abstract:

The primary constituent of solar wind is Hydrogen. Helium is the second most abundant element in the solar wind. The helium abundance in the solar wind with respect to hydrogen is expressed as A_{He} = n_{He}/n_H*100 wherein n_{He} and n_H are the concentration of helium (alpha particles) and hydrogen (proton) respectively. The solar wind consists of ~95 % of hydrogen ions and 2-5% of helium ions. A_{He} is solar cycle dependent and it varies with solar wind velocity. In our work, it is shown that A_{He} variations are distinctively different in solar cycle 24 as compared to the last three cycles. The inter-calibrated A_{He} data obtained from the first Lagrangian point of the Sun-Earth system are analysed to understand the changes in Ahe variation in last 4 solar cycles. it is shown that the frequency of A_{He} = 2–3% events is significantly higher in slow/intermediate solar winds in solar cycle 24 as opposed to the dominance of the typical A_{He} = 4–5% events in the previous three cycles. Further, the occurrence of A_{He}>10% events is significantly reduced in cycle 24. Not only that, the changes in delay of A_{He} with respect to peak sunspot numbers are less sensitive to changes in solar wind velocity in cycle 24. The investigation suggests that the coronal large-scale magnetic field configuration started undergoing systematic changes starting from cycle 23 and this altered magnetic field configuration affected the way helium got processed and depleted in the solar atmosphere.

Session no: 01

The unusual behavior of CMEs and solar wind in the last two decades that baffles heliospheric physicists

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Abstract:

The study of evolution characteristics of coronal mass ejections (CMEs) and solar wind is of great significance and is one of the challenging problems in heliospheric physics. The studies on interplanetary CMEs (ICMEs) in the heliosphere over solar cycles 23 and 24 have gathered attention since the observations of the extremely weak and unusually long minimum phase of cycle 23. In my talk, I will begin with an overview of the earlier studies on the solar activity observed over the last two solar cycles. Following this, I will discuss the variation in the mass-loss rate via CMEs and solar wind as a function of solar magnetic variability and the contribution of CMEs to the total solar wind mass flux in the ecliptic and beyond. Further, my talk will highlight the influence of the heliospheric state on the expansion behavior and radial sizes of coronal mass ejections (CMEs) in the last two solar cycles. Also, I will discuss the variation in the charge states and abundances of CMEs and solar wind plasma observed at 1 AU over the solar cycles 23 and 24. Succinctly, my talk aims to summarize the observed solar behavior in the last two decades and discuss the possible causes and consequences of our findings relevant for future studies.

Session no: 01

Type II radio bursts and their association with coronal mass ejections

Anshu Kumari [1], D. E. Morosan[2], E. K. J. Kilpua[3], and F. Daei[4]

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Abstract:

Metre wavelength type II solar radio bursts are the signatures of shock-accelerated electrons in the 'middle' corona. A study of these bursts can give information about the initial kinematics, dynamics, and energetics of CMEs in the absence of white-light observations, for example, a stealth CME. We investigate the occurrence of type II bursts in solar cycles 23 and 24 and their association with coronal mass ejections (CMEs). We also explore the possibility of the occurrence of type II burst in the absence of a CME. We performed a statistical analysis of all type II bursts that occurred in the solar cycle 23 and 24 and found the temporal association of these radio bursts with CMEs. We also categorized the CMEs based on their linear bursts and angular width and studied the distribution of type II bursts with 'fast', 'slow', 'wide' and 'narrow' CMEs. Our analysis shows a total of 768 and 435 type II bursts in solar cycles 23 and 24, respectively. We found that 80% and 95% of the type II bursts were associated with CMEs in solar cycles 23 and 24, respectively. Most of the type II bursts in both the cycles were related to 'fast' (54 %) and 'wide' (79 %) CMEs. We also set a typical drift rate and duration for type II bursts, 0.1-0.4 MHz/s, and 5-20 min, respectively. The results indicate that most of the type II bursts had a white-light CME counterpart; however, there were a few type II which may be related to flare blast waves.

Session no: 01

Investigation on solar cycle dependence of interplanetary suprathermal populations

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Abstract:

Study of suprathermal particles in the interplanetary medium is important to understand and predict the behavior and severity of solar energetic particle events that may be hazardous to space based resources and technologies. Although some characteristic features of these non-thermal populations are known, exact mechanism(s) by which these particles are generated in the interplanetary medium is (are) not understood properly. The Sun is very dynamic and variation in sunspot numbers is known to represent the varying degrees of solar activity. It is found that quiet-time suprathermal heavy ion ratios (Fe/O, ^{3}He/^{4}He etc.) compositionally resemble the composition of solar energetic particles during solar maxima and that of corotating interaction region or solar winds during solar minima. This indicates that suprathermal ion pool in the interplanetary medium is fed with remnant particles from previous energetic particle events. To understand the variation of this feedback effect with respect to the varying cycle of solar activity, more critical investigation on the dependence of suprathermal particles on solar processes is required. In the present work, we have analyzed suprathermal flux data from the Ulta Low Energy Isotope Spectrometer (ULEIS) on board Advanced Composition Explorer (ACE) satellite over almost two solar cycles. This analysis includes the calculation of time delays (lags) between averaged quiet-time-suprathermal particle fluxes of various elements and sunspot numbers as well as phase-wise spectral index calculation during the two solar cycles. The results show noticeable variation of lags and spectral slopes depending on different solar cycles. These dependencies will be discussed.

Session no: 01

DH Type II Radio Bursts During Solar Cycles 23 and 24: Frequency-Dependent Classification and Their Flare-CME Associations

Binal D. Patel[1,2], Bhuwan Joshi[1], Kyung-Suk Cho[3], and Rok-Soon Kim[4]

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Abstract:

It is well accepted that the type II solar radio bursts are caused by magneto-hydrodynamic shocks which propagate through the solar corona and interplanetary medium. Type II bursts are associated with flares and coronal mass ejections (CMEs), hence their investigations provide important insights toward understanding the influence of transient solar activity in the corona and heliosphere. We present the characteristics of decameter-hectometer (DH) type II bursts for the Solar Cycle 23 and 24. For the present study, we have classified the bursts according to their end frequencies into three categories, i.e. Low Frequency Group (LFG; 20 kHz ≤ f ≤ 200 kHz), Medium Frequency Group (MFG; 200 kHz < f ≤ 1 MHz), and High Frequency Group (HFG; 1 MHz < f ≤ 16 MHz). We find that the sources for LFG, MFG, and HFG events are homogeneously distributed over the active region belt. Our analysis shows a drastic reduction of the DH type II events during Solar Cycle 24 which includes only 35% of the total events (i.e. 179 out of 514). Despite having a smaller number of DH type II events in the Solar Cycle 24, it contains a significantly higher fraction of LFG events compared to the previous cycle (32% versus 24%). The events of LFG group display strongest association with faster and wider (more than 82% events are halo) CMEs, whereas at the source location, they predominantly trigger large M/X class flares.

Session no: 01

Solar Wind plasma parameters and magnetic field intensity in relation with Geomagnetic Storm intensity and Variability in Solar cycle 24

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Abstract:

The solar wind is a continuous stream of protons and electrons in a plasma state that travels outward from the Sun. The solar magnetic field is imbedded in the plasma and is carried outward by the solar wind. Solar wind of varying speeds and densities is produced by different areas of the Sun. Coronal holes generate high-speed solar wind, ranging from 500 to 800 km/s. Because the Sun's north and south poles contain enormous, continuous coronal holes, high latitudes are filled with rapid solar wind. These solar winds impact the Earth's magnetic field and cause geomagnetic storm. The geomagnetic data weighed by Dst < -50 nT observed during Solar cycle 24 (2008-2019) corresponding to the solar wind plasma parameters (Vector B magnitude (nT), B_z (nT), SW Plasma Temperature (K), SW Proton density (N/cm^3), SW plasma speed (km/s), Flow pressure, Plasma beta. The analysis showed a significant relation between magnetic field intensity but direct dependency of Dst-index is not found with the SW parameters. However, low SW plasma temperature, proton density, flow pressure and plasma beta lead to higher Dst minima > -250nT. SW plasma speed > 450 km/s are found to be causing moderate to extreme geomagnetic disturbances. The overall analysis shows that the Geomagnetic storm intensity weighed by Dst depends partially on the solar wind plasma parameters but cannot be used as a perfect way to find the dependency.

Session no: 01

Study of Most Energetic Solar Proton Event of 23rd Solar Cycle and Associated Secondary Neutrons

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Abstract:

The most energetic Solar Proton Events (SPEs) (greater than 100 MeV) are associated with the high speed Coronal Mass Ejections (CMEs) and intense solar flares. CMEs drives fast-mode Magnetohydrodynamic (MHD) shocks, which accelerates the solar protons and electrons. The high energetic protons penetrate the Earth's neutral atmosphere and produce secondary neutrons. The secondary neutrons are recorded as sudden increase in cosmic ray intensity and count neutrons as a proxy for cosmic rays. In this paper, the X7 flare and CME that occurred on 20 January 2005 is analyzed. They produced the hardest and most energetic proton event of Cycle 23 with highest proton flux level recorded with energies greater that 100 MeV since October 1989. This event is analyzed to understand CME related shock driven capabilities, relative timings of the release of protons at the Sun and associated secondary neutrons detected as a ground level enhancement event. Solar protons with energies greater that 100 MeV are peaked with 652 pfu at 0710 UTC on 20 January 2005 and associated secondary neutrons are found greater than 200 percent observed in Oulu neutron Monitor situated in Northern Finland.

Session no: 01

Modelling the magnetic vectors of ICMEs sequentially detected at radially aligned multiple spacecraft using INFROS

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Abstract:

Interplanetary flux rope simulator (INFROS) is an observationally constrained analytical model dedicated for forecasting the strength of southward component (Bz) of magnetic field embedded in interplanetary coronal mass ejections (ICMEs). In this work, we validate the model for six ICME events which were sequentially observed by the radially aligned multiple spacecraft at two different heliocentric distances. The six selected ICME events in this study comprise of cases associated with isolated CME evolution as well as the adverse heliospheric conditions that include the interaction of the ICMEs with the high-speed streams (HSS) and high-density streams (HDS). For the isolated CMEs, our results show that the model outputs at both the spacecraft are in remarkably good agreement with the in-situ observations. However, for the interacting events, the model could capture the CME evolution at the first spacecraft until the interaction occurs and subsequently under-estimate the field strength at the second spacecraft as the ICME evolution ceases to be self-similar due to its interaction with the HSS and HDS. Our results show that INFROS can be used as an efficient tool to forecast the magnetic vectors of ICMEs for the cases of isolated CMEs. This work also presents a quantitative estimation of the enhanced field strength of the ICMEs due to interaction which may lead to severe space weather conditions. We conclude that the assumption of self-similar expansion provides the lower limit for the magnetic field strength estimated at any heliocentric distance, based on the remote sensing observations.

Session no: 01

Exhaustive Machine Learning analysis on CMEs associated with flares and filaments

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Abstract:

The major solar events that create geomagnetic storms and communication disturbances in earth are flares, CMEs and CIRs due to coronal holes. Among them Coronal Mass Ejections (CMEs) are type of abrupt events which are capable of reaching earth in less than a day. CMEs are composed of plasma that are entangled with magnetic fields. CMEs are thrown suddenly into the interplanetary space, when a magnetic reconnection occurs in the huge loop-like structure. They can occur either independently or in conjunction with major flares or prominences. Though the underlying physical mechanism of both flares and CMEs are common, flares are observed minutes after they occur, while CMEs takes around 18 hours to 3 days to reach earth. Hence, studying the degree of association of CMEs with flares and filaments will be helpful for the prediction. In this paper, we did an exhaustive machine learning analysis of whether a flare will be associated with CME or not, using SHARP features as input. We found that among the eight tested Machine Learning (ML) models (SVM, Decision tree, Bagging classifiers, KNN, boosting classifiers, Naïve Bayes, Logistic regression), Adaboost shows a better performance, with area under the curve (AUC) greater than 95%. Further we had also analyzed whether any filament association is there for the CMEs that are unassociated with flares using the ML techniques.

Session no: 01

Modeling a Coronal Mass Ejection as a Magnetized Structure with EUHFORIA

G. Sindhuja[1] , Jagdev Singh[1], E. Asvestari[2] , and B. Raghavendra Prasad[1]

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Abstract:

We studied an Earth-directed coronal mass ejection (CME) that erupted on 2015 March 15. Our aim was to model the CME flux rope as a magnetized structure using the European Heliospheric Forecasting Information Asset (EUHFORIA). The flux rope from eruption data (FRED) output was applied to the EUHFORIA spheromak CME model. In addition to the geometrical properties of the CME flux rope, we needed to input the parameters that determine the CME internal magnetic field like the helicity, tilt angle, and toroidal flux of the CME flux rope. According to the FRED technique geometrical properties of the CME flux rope are obtained by applying a graduated cylindrical shell fitting of the CME flux rope on the coronagraph images. The poloidal field magnetic properties can be estimated from the reconnection flux in the source region utilizing the post-eruption arcade method, which uses the Heliospheric Magnetic Imager magnetogram together with the Atmospheric Imaging Assembly (AIA) 193 Å images. We set up two EUHFORIA runs with RUN-1 using the toroidal flux obtained from the FRED technique and RUN-2 using the toroidal flux that was measured from the core dimming regions identified from the AIA 211 Å images. We found that the EUHFORIA simulation outputs from RUN-1 and RUN-2 are comparable to each other. Overall using the EUHFORIA spheromak model, we successfully obtained the magnetic field rotation of the flux rope, while the arrival time near Earth and the strength of the interplanetary CME magnetic field at Earth are not as accurately modeled.

Session no: 01

A parametric study of performance of solar wind forecasting models during 2006 to 2011

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Abstract:

There is an increasing need for the development of a robust space weather forecasting framework. It can help us study space weather events, mainly coronal mass ejections (CMEs) consequently their impact on the Earth. State-of-the-art MHD forecasting frameworks for space weather are based upon the Potential Field Source Surface (PFSS) and Schatten Current Sheet (SCS) extrapolation models for the magnetic field using synoptic magnetograms. These models create a solar wind background for the simulations using empirical relations of Wang, Sheeley and Arge(WSA) Model for the CMEs, at the inner boundary of heliosphere. They have been used to simulate CMEs for specific cases in many earlier studies. Other than those MHD frameworks, there is a Heliospheric Upwind eXtrapolation(HUX) technique that can extrapolate solar wind from inner heliospheric boundaries (2.5 or 5 solar radii) to Lagrangian point L1 and can give a very good estimate of the solar wind velocity at L1 comparable to MHD models but in negligible computational time. We here present an extensive parametric study of the performance of the forecasting framework of PFSS+SCS+WSA+HUX and PFSS+WSA+HUX of solar wind prediction at L1. We implemented these framework on 61 Carrington rotations (CRs) from CR2047(August, 2011) to CR2107(February , 2011) which includes the declining phase of solar cycle 23 and the ascending phase of solar cycle 24. Our simulated solar wind velocity profiles at L1 show a correlation coefficient (cc) of up to 0.90 with the observed velocity profiles obtained from the OMNI database. We report an unexpected decrease in the framework's performance during the deep minimum phase of cycle 23, which is attributed with the decreased coronal hole area at the low latitudes observed during this period. As cycle 24 begins as expected the decreasing trend in the model performance vanishes due to increase in the coronal hole area at the low latitudes.

Session no: 01

Flattening of ICME Magnetic Cloud: An In-situ attestation

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Abstract:

Various studies suggest that the cross-section of an ICME magnetic cloud (MC) can vary from cylindrical, elliptical, pancaked, etc. Here, we proposed a unique morphological characteristic of ICME MC at 1 AU, where MC transformed into a flattened quasi-2D structure named planar magnetic structure (PMS) using in-situ data from ACE spacecraft. Statistically, we noted that 136 (29%) out of 469 ICME MCs from 1998 to 2017 shows PMS characteristic (thus, planar MCs), whereas 333 (71%) MCs does not have PMS characteristic (non-planar MCs). Interestingly, the IMF strength, the average plasma parameters, i.e., density, beta, thermal and magnetic pressure in the planar MCs, are significantly higher than non-planar MCs. Also, planar MCs are narrow compared to non-planar MCs. Moreover, the southward/northward magnetic field components have double strength during planar MCs. It implies that planar MCs are more geo-effective than non-planar MCs. These observations suggest that high compression could be the leading cause of planar MCs. Furthermore, to answer the problem: Is planar MCs a local or global phenomenon? We investigated an ICME observed by the multi-spacecraft (STA, STB, and Wind), longitudinally separated with each other at 1 AU. The STA and STB are separated by 40.8 degrees, while Wind was situated between them. We unambiguously confirm that the ICME observed at three spacecraft is highly flattened and has a PMS signature. Thus, the study concludes that the flattening of ICME MC is a global phenomenon. A detailed study is needed to investigate the origin and effect of planar MCs on the heliosphere and solar-terrestrial physics.

Session no: 01

Cause of extreme eruptive events from solar active region NOAA 12673 - the source region of many powerful outbursts including the largest flare of solar cycle 24

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Abstract:

During 2017, when the Sun was moving toward the minimum phase of solar cycle 24, an exceptionally eruptive active region (AR) NOAA 12673 emerged on the Sun during August 28-September 10. During the highest activity level, the AR turned into a βγδ-type sunspot region, which manifests most complex structure of magnetic fields from the photosphere to the coronal heights. The AR 12673 produced four X-class and 27 M-class flares, along with numerous C-class flares, making it one of the most powerful ARs of solar cycle 24. Notably, it produced the largest flare of solar cycle 24, namely, the X9.3 event on 2017 September 6. In this paper, we provide the results of our comprehensive multi-wavelength analysis and coronal magnetic field modeling to understand the evolution and eruptivity from AR 12673. We especially focus on the morphological, spectral and kinematical evolution of the two X-class flares on 2017 September 6 and quantitatively assess the link between the magnetic field storage in the active region with the intensity of subsequent outbursts during the X-class flares. We also provide a detailed investigation of various aspects of magnetic flux rope structures along with the topology of coronal magnetic fields. The study also reports very interesting cases of the anomalous expansion of the CME at the source region during which the flux rope-filament erupted non-radially and drastically changed its direction while erupting through the overlying corona. We explore existing ideas in both ideal- and resistive-MHD eruption models to understand the CME initiation process in the source region.

Session no: 01

What causes a failed solar eruption during an energetic HXR flare?: A multi-wavelength case study

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Abstract:

Study of the origin of solar eruptions is an important topic of solar physics because of their space-weather consequences. Years of observations have led to a development of the understanding of the pre-eruption signatures at the flaring sites. However, the true causes of the failed solar eruptions are yet to be fully understood and it has emerged as one of most studied topics in the contemporary times. In this work, we carried out comprehensive investigation of a failed-eruptive M-class flare from the active region NOAA 11302 which was associated with extremely high non-thermal emission. Photospheric observations and coronal magnetic field modeling results revealed that the flaring region had a complex quadrupolar configuration with a pre-existing coronal null point situated above the core field. The pre-flare phase was characterized by multiple periods of small-scale Soft X-ray flux enhancements from the location of the null point. Such configuration and evolution are in line with the breakout model, albeit at much lower coronal heights. The core of the flaring region was characterized by the presence of two flux ropes in a double-decker configuration. During the impulsive phase of the flare, one of the two flux ropes initially started erupting but resulted in a failed eruption. Magnetic decay index analysis revealed a saddle-like profile where decay index initially increased to the torus unstable limits within the heights of the flux ropes before decreased rapidly reaching to negative values, which was most likely responsible for the failed eruption of the initially torus unstable flux rope.

Session no: 01

Linkage of Geoeffective Stealth CME with the Coronal Plasma Channel and Jet-like Structure

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Abstract:

We understand the filament channel's dynamical behavior akin to the solar filament and its association with a geoeffective stealth CME. We also explore the linkage of geoeffective stealth CMEs associated with an eruption of filament-associated Coronal Plasma Channel (CPC). The CPC is analogous to the filament channel, a confined hot coronal plasma that does not contain cool prominence plasma. However, it may be observed in terms of the magneto-plasma system in coronal EUV emissions. The CPC has erupted firstly with its low-lying and a very faint coronal signature in the solar corona. The spreading CPC interacts with the open field lines of the coronal hole and is responsible for the triggering of the thin flux rope and rotating jet-like structure with a very faint signature in the lower corona. These eruptions were collectively associated with the stealth-type CMEs and CME associated with a jet-like eruption. These eruptions launch the CMEs towards the Earth. Upon arrival, the Dst index reaches a negative value of -176 nT. It exhibits a strong geomagnetic storm and reduces the z-component of the interplanetary magnetic field up to -18 nT with kp index=7. The detailed analyses of the various counterparts of the eruption have been analyzed, starting from the chromosphere and inner corona to the outer corona. The response of the observed stealth CMEs in creating space weather at Earth is determined and estimated. This work is a vital example that even an invisible prominence-like channel (which does not appear at less temperature; CPC) can cause a silent eruption of stealth CME (without its low coronal signature) and is responsible for an intense geomagnetic storm.

Session no: 01

Source region dynamics of solar coronal transients

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Abstract:

Solar coronal transients, particularly the solar flares and coronal mass ejections, are the primary drivers of space weather. Generally, the transients are believed to be caused by magnetic reconnection: a process in which, magnetic field lines change their connectivity along with acceleration of charged particles and generation of heat. In absence of a reliable measurement, a novel procedure is to extrapolate the coronal magnetic field using photospheric magnetograms and subsequently use the same as an initial condition to explore magnetic field line dynamics and magnetic reconnection through numerical simulations. In the presentation, focus will be made on these so-called data-constrained simulations and results for selected cases will be discussed.

Session no: 01

Magnetic Reconnection and Particle Acceleration in High Lundquist Number Systems

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Abstract:

Magnetic reconnection is a ubiquitous phenomenon in laboratory and astrophysical plasmas and is believed to be an essential process of energy conversion and particle acceleration in such environments. The process of reconnection is prevalent in the solar corona and turbulent regions where multiple current sheets exist close to each other is common. Such current sheets are often also accompanied by the presence of a parallel velocity shear. Reconnection is also attributed to be the key process responsible for mass and energy transfer from the solar wind to the earth's magnetospheric system. We have investigated the evolution of a plasmoid dominated double current sheet system exhibiting an explosive reconnection phase in the presence of a parallel shear flow using resistive magnetohydrodynamic simulations in a 2D slab geometry and have explored the mechanisms of particle acceleration and their dependence on the shear flow in such rapidly evolving systems. Our results show a deviation in the reconnection rate from the theoretical scaling and the same is found to be dependent on the structure of the magnetic islands past the early evolution stage. The results from our test particle simulations also demonstrate the effects of various mechanisms such as magnetic island merger and island contraction in the acceleration of particles in a manner to produce a power-law spectrum of the non thermal population of accelerated particles. Furthermore, as an extension of the study to more realistic and complex environments, we perform 3D global MHD simulations with adaptive mesh refinement (AMR) to study the formation, evolution and large scale effects of flux rope structures produced due to bursty magnetic reconnection at the dayside magnetopause of a planet harboring a dipolar magnetic field. Such flux transfer events or FTEs are responsible for the impulsive injection of large amounts of mass and energy into the planet's magnetospheric system.

Session no: 01

Understanding the Particle Acceleration in ICME shocks

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Abstract:

Shock waves driven by the Interplanetary Coronal Mass Ejections (ICMEs) are considered to be efficient particle accelerators giving rise to Solar Energetic Particle events (SEPs). Using the Magnetohydrodynamic-Particle In Cell (MHD-PIC) module of the PLUTO code, we have studied the dynamics of energetic protons on the background of such ICME shocks. The particle energy spectra indicate the dominant role of Diffusive Shock Acceleration (DSA) in parallel shock. The density and transverse magnetic power spectra reveal the dominant role of Bell instability in driving the solar wind upstream turbulence. Our simulated parallel shock also hints at a possible action of small scale dynamo in enhancing the downstream magnetic field. On the other hand, simulations of quasi-perpendicular shocks show that particles are mainly accelerated by the Shock Drift Acceleration (SDA) mechanism, which can be evident from the particle velocity distribution and orientation of the magnetic field. However, the maximum energy gained by the accelerated particles in quasi-perpendicular shock is much less than the parallel shock having similar Alfvenic mach.

Session no: 01

Physics-based Algorithm for Solar Wind using Adaptive Numerical Framework

Prateek Mayank[1], Bhargav Vaidya[1] and D. Chakrabarty[2]

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Abstract:

Solar Wind streams, acting as a background, govern the propagation of coronal mass ejections in the heliosphere and drive geomagnetic storm activities. Therefore, predictions of the solar wind parameters are the core of space weather forecasts. Typically, line-of-sight observations of a magnetogram is used to derive the global coronal magnetic field structure and then a solar wind model is used for forecasting solar wind plasma parameters. Here, we present an indigenous 3D Solar Wind model aiming to compliment the in-situ measurements of Aditya-L1, in particular we will discuss our recent results of data driven solar wind prediction at L1. This numerical framework for forecasting the ambient solar wind is based on a well-established scheme which uses semi-empirical coronal model and physics-based inner heliospheric model. We will demonstrate a more generalized version of WSA relation which provides speed profile as an input to MHD domain. We will also confer how final results are affected based on the choice of input magnetograms. Conclusively, we are going to validate our results by comparing essential solar wind magnetic and plasma properties at L1 for multiple Carrington rotations and also review the directional dependent characteristic features of stream interaction regions (SIRs) which will be observed by ASPEX (Aditya-L1). Additionally, we will present our magnetic field outputs that will complement the in-situ measurements of MAG (Aditya-L1).

Session no: 01

Comparison of the Hall MHD and MHD evolution of a flaring solar active region

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Abstract:

Explosive phenomena on the Sun such as flares, coronal mass ejections and jets are all manifestation of magnetic reconnection. Reconnection is a multi scale process and occurs due to the generation of small length scales in consequence of large scale (~Mm) magnetic field dynamics. A back-of-the-envelope calculation based on observed impulsive rise time of hard X-ray emission (~few minutes) during the solar flares, suggests that reconnection length scale is of the order of few tens of meters. A straightforward order analysis of the induction equation at reconnection scale length indicates the significance of Hall effects during magnetic reconnection on the Sun. Hall MHD supports the faster reconnection while also capturing the effects of small scale processes over large length scales. A detailed comparative study is carried out using the extended EULAG MHD model, in the presence and absence of Hall forcing term. This study focuses on understanding the possible magnetic reconnections causing flare brightening in solar active region NOAA 12734. The key findings from Hall MHD simulation are faster reconnection at flaring location and the rotating field lines in a circular pattern at a cospatial chromospheric region where the plasma is seen to be rotating in AIA/SDO observations.

Session: 2

Impact of space weather on the Earth's magnetosphere, ionosphere and thermosphere

S 2.1 - Response of the magnetosphere to solar forcing

S 2.2 - Space weather impact on the ionosphere/thermosphere system of planets

S 2.3 - Modelling studies for Space Weather Research

Session no: 02

What Fraction of the Outer Radiation Belt Relativistic Electron Flux at L ≈ 3-4.5 Was Lost to the Atmosphere During the Dropout Event of the St. Patrick's Day Storm of 2015?

Sneha A Gokani[1,*], Mike Kosch[2,3], Mark Clilverd[4], Crag J. Rodger[5], and Ashwini K. Sinha[1]

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Abstract:

Observations of relativistic energetic electron fluxes in the outer radiation belt can show dropouts, that is, sudden electron flux depletions during the main phase of a geomagnetic storm. Many recent studies show that these dropouts typically involve a true loss of particles, that is, nonadiabatic losses in nature. Precipitation into the atmosphere of relativistic electrons driven into the bounce loss cone, through wave-particle interactions, is envisaged as one of the primary loss mechanisms. Such precipitation can be studied using ground-based observations such as VLF narrowband radio waves, due to the deposition of energy into the lower ionospheric D-region, thereby modifying the subionospheric waveguide. The present study focuses on the dropout event observed during the St. Patrick's Day storm of March 2015. Perturbations lasting several hours were observed in the received VLF amplitude and phase of the NAA transmitter signal measured at Seattle and Edmonton and the NML transmitter signal received at St. John's and Edmonton. All these $L \approx 3$–4.5 paths were located on the nightside of the Earth during dropout phase of the storm. Observations of relativistic electron characteristics from Van Allen Probes, and ionospheric perturbation characterization from VLF radio waves, are used to calculate that during the time interval of the dropout event, <0.5% of the relativistic fluxes involved in the dropout event were lost to the atmosphere. This leads to the conclusion that relativistic electron precipitation was not the major contributor to the observed dropout event at $L \approx 4$ that occurred during the St. Patrick's Day storm of March 2015.

Session no: 02

The impact of two successive interplanetary shocks on plasmaspheric hiss waves using Van Allen Probes observations

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Abstract:

In this presentation, we will discuss about a plasmaspheric hiss event observed by the twin Van Allen probes in response to two successive interplanetary shocks occurring within an interval of ~2 hours on December 19, 2015. The first shock arrived at 16:16 UT and caused disappearance of hiss waves for ~30 minutes, followed by its recovery from ~16:45 UT. The second shock arrived at 18:02 UT and generated patchy hiss persisting up to ~19:00 UT, after which the hiss waves regained their pre-storm wave intensity. Using detailed calculations of linear wave growth rate and electron phase space density, it was found that combined effects of varying plasmapause location, wave-particle interactions with radiation belt suprathermal electron population and even wave-wave interactions with shock-induced ULF waves resulted in such dramatic hiss variability during the interval of study. Plasmaspheric hiss waves play important role in controlling radiation belt dynamics by efficiently scattering electrons leading to their precipitation into the atmosphere. Therefore, understanding their variability is an important topic in radiation belt studies. Earlier studies on plasmaspheric hiss waves showed their intensification as well as disappearance following a single interplanetary shock impact. In this study, we provide the first direct observational evidence of plasmaspheric hiss wave variability in response to two consecutive interplanetary shocks. This investigation highlights the important roles of interplanetary shocks, substorms, ULF waves and background plasma density variation in the generation and variability of plasmaspheric hiss waves.

Session no: 02

Energetic Ion variations at near Earth plasma during Substorms events and associated magnetic field Dipolarization using Van Allen Probe observations.

Trunali Shah, B. Veenadhari, Megha Pandya

Indian Institute of Geomagnetism, Navi Mumbai, India.

Abstract :

The Earth's inner magnetosphere is a very dynamic region with energies spanning from sub-eV cold ions in the plasmasphere to relativistic protons and electrons in the radiation belts with energies up to hundreds of MeV. During a geomagnetic storm, the ring current ion composition in the inner magnetosphere changes considerably. The quiet time ring current consists of mainly protons (H+), while the intense storm time ring current is dominated by oxygen (O+) ions. On the other hand, the phenomenon of magnetospheric Substorms are responsible for the discrete injection of energetic ions at the geosynchronous orbit. In this work, we intend to study the effect of the Substorm on variations of energetic ions H+, He+, O+ in the inner magnetosphere (a geocentric distance of r < 6.6 Re). Generally, Substorms are accompanied with the magnetic field dipolarization. However, not much attention has been given to magnetic field dipolarization at r < 6.6 Re. So, we combinely study the substorm onset events from the year 2017-2019 using the Van Allen Probes observations. We analyze H+, He+, O+ data from Helium Oxygen Electron flux (HOPE), and magnetic field data from the Electric and Magnetic field instrumentation Suit and Integrated Science (EMFISIS) instrumentation suit on board the satellite. Using this data, we study some good number of Substorm onset events for energy range of 1eV to 50keV energetic ions. We classify events into different categories based upon the L value at the onset of the Substorm. Our current studies will provide the quantification of the observed energetic ions at different energies and there correlation with different interplanetary parameters. The detailed results with the analysis of statistically significant number of events and the related mechanisms will be discussed in the meeting.

Session no: 02

Investigations on Space Weather correlated anomalies in Geosynchronous Spacecrafts during 2017-2021

M. R. Rajesh Kannan, R. Subramani, D. Srinivasa Murthy, M. N. Subramanian and H. P. Shenoy

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Abstract:

Geosynchronous spacecrafts are susceptible to hostile space environment. Occasionally these spacecrafts encounter anomalies due to interactions with high energetic charged particles and magnetic field disturbances attributed to high solar activity. Interaction with charged particles cause spacecraft internal charging and can trigger electro-static discharge events. Spacecraft anomalies impact the mission based on its severity, which ranges from minor, moderate, inoperable payload, mission critical and end of mission. Master Control Facility, ISRO is responsible for critical spacecraft operations and orbit maintenance of Indian geosynchronous spacecrafts. As a part of Geosynchronous Space Situational Awareness, MCF analyses the space weather events on daily basis with help of publicly available data. During the solar minimum period; year 2017 to 2021, MCF has recorded anomalies across the spacecrafts. In this paper, we present the investigations carried out for geosynchronous spacecraft anomalies correlated to solar activity such as solar energetic particle event and/or geomagnetic storm. We classify the observed anomalies based on their type of interaction, impact on mission, sub-system, spacecraft local time and recurrence. Technical insights gained in this study would help in alerting the spacecraft operations team to handle anomalies in real time and spacecraft sub-system team for improving the design aspects for future missions.

Session no: 02

The supersubstorms (SML less than 2500 nT) of solar cycle 24: The sources, energy coupling and impacts on the solar wind-magnetosphere-ionosphere system

Sritam Hajra[1] and N. Dashora[1,*]

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Abstract:

This study presents robust and quantitative analyses of 3 supersubstorms from the solar cycle 24 identified by the super magnetic lower (SML) index <-2500 nT. These events have been associated with moderate geomagnetic storms. The energy input and total energy dissipation in all these cases have been found to be a few orders more than that of an average 'Akasofu-type' substorm. This is found to depend upon the energy coupling rates and coupling parameters rather than solar activity. Clear imbalance between magnetospheric energy input and magnetospheric-ionospheric sinks indicates presence of other energy sources and channels of energy flow. The dissipation through Joule heating and ring current has been found to be the most and the least among the major energy sinks. The SW-magnetosphere and the magnetosphere-ionosphere coupling efficiencies range about 0.6%-2.2%, and 37.7%-77.9%. The magnetometers located in the co-latitude bands of 56°-63° show complete reversal (positive) of phase of the H-component observations during the maximum depression in the SML index. A strong inter-hemispheric asymmetry in H-component variations is observed which is attributed to the seasonal dependence of the growth and decay of high-latitude ionospheric currents. The rate of change of geomagnetic flux (dB/dt) during supersubstorms is observed to be the highest in the latitude band 60°-75° leading to enhanced induced currents which underscores a serious space weather threat to modern technological infrastructure. Finally, the solar cycle 24 is found to be the weakest in the space-age in terms of the occurrence of supersubstorms with no occurrence during solar maximum.

Session no: 02

High to Low latitude Space Weather Coupling: Inferences from study of daytime E-region ionospheric zonal drifts at 8.3 m scale size

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Abstract :

There are no direct methods available for the continuous measurement of the E region electric field, which drives the electrodynamics of the ionosphere. The study of variation in the electric field is important to understand the response of ionosphere to various solar conditions. The 18 MHz HF radar at Thumba gives an opportunity to study the plasma irregularities of scale size 8.3m in the EEJ. The Doppler shifts obtained from the radar echoes correspond to the zonal drifts of the irregularities, from which the electric field can be estimated. Continuous daytime ionospheric measurements were carried out in campaign mode during 15th - 30th July 2021 and 20th September-5th October 2021. The drift velocities of the irregularities measured by the 18MHz radar during the period 21st July 2021 to 20th August 2021 shows large day to day variability with different trends. Our study reveals that the drifts on any given day during this period are very strongly influenced by the polarity and the variability of the north-south component of the interplanetary magnetic field, IMF Bz. The north-south fluctuations of the IMF Bz are direct indicators of the direct coupling of solar wind with earth's magnetosphere. This daytime changes in the polar/auroral region manifest promptly through electric field coupling with the equatorial ionosphere. The importance of this study is in the fact that the effect of space weather changes in the equatorial electrojet region at 8.3 m scale size of irregularities have not been studied systematically so far. These results will be presented and discussed in detail.

Session no: 02

Asymmetric response of the low latitude ionosphere over East South Asia to 2015 solstice storms

Bitap Raj Kalita (1,2), P.K Bhuyan (2), Mayur Choudhary (1),
D.Chakrabarty(3), K. Wang(4), K. Hozumi(5), T. Komolmis(6), C. Y. Yatini(7), M. L. Huy(8)

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Abstract:

The response of the low latitude ionosphere to the geomagnetic storms occurring on 22-23 June, 2015 and 20-21 December, 2015 is investigated over East South Asia around 100°E. GNSS TEC, Ionosonde NmF2 and the topside TEC from SWARM A/B satellites are utilized. During the main phase on 23 June the VTEC indicated positive effect over the equator and Cocos but went negative over northern low latitudes. In sharp contrast to VTEC, the NmF2 over Cocos remained unchanged on 23 June as compared to the quiet day values. In December, both GPS TEC and NmF2 showed large enhancement over low latitudes during the main phase (20 December) whereas TEC/NmF2 decreased on the recovery day (21 December) only in the southern hemisphere. SWARM A/B measurements of the electron density at 467-511 Km and topside TEC on 23 June showed large enhancement above the F2 layer peak in the forenoon, which is consistent with ground VTEC enhancements. The altitudinal variation in the ionospheric response noted in June 2015 may be accounted for by the stronger intensity of the storm. Similar difference in the GPS TEC and NmF2 response over Cocos is noted in another June solstice storm of (14-17 July 2012) moderate intensity. Therefore, differential interaction of the neutral winds with the field aligned ionospheric plasma during June and December solstice is suggested as the primary driver of the asymmetric altitudinal and latitudinal response.

Session no: 02

The response of the D and E regions of the equatorial ionosphere to solar flare events

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Abstract:

Using measurements from a ground-based magnetometer and an in-house developed quasi-two-dimensional theoretical ionospheric model (QTD), the differential response of D and E regions of the equatorial ionosphere to the solar flare events which occurred on 20 February 2002 (M1.5 class), and 24 September 2011 (X1.9 class) has been investigated. The ground-based magnetometer at Tirunelveli (8.71°N, 77.75°E, 2.9°S dip latitude) was used to monitor variations in the magnetic field (ΔH) during the two events. An abrupt increase in ΔH (positive Solar Flare Effect (SFE)) was noted during both the flare events, a signature of the prompt response to the flare. The H however was seen to get weakened (reversed SFE) on 20 February 2002 at a time delay of about 10 minutes post flare peak. The weakening in ΔH happened during local noon (~11:30 LT), a period when there was no sign of the counter electrojet (CEJ). The QTD model was used to simulate the ratio of field line integrated Hall to Pedersen conductivity and variations in the east-west currents during the flare events. Model simulations show differential response in the conductivity ratio at the D and E-regions of the ionosphere during the period when the ionospheric current system was undergoing alternations manifesting as ΔH variations in the ground-based magnetometer observations. We show that in addition to the changes in conductivity during a solar flare, the electric field variations also modulate ionospheric currents to produce differential footprints in ΔH as positive/negative SFE, SFE* or reversed SFE.

Session no: 02

Effects of geomagnetic storms on the gravity wave activity over low-latitudes

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Abstract:

The variabilities in the ionosphere-thermosphere system are strongly affected by the solar forcing, space weather phenomena, and associated geomagnetic storms. These drivers modify the background conditions, hence they are expected to influence the neutral wave acitivity of these regions of the atmosphere. We have developed an approach using digisonde measurements to derive the vertical propagation characteristics (time periods, propagation speeds, and wavelengths) of gravity waves present in the ionosphere-thermosphere regions. We have applied such method on nearly two-years of digisonde data from Ahmedabd, India, to understand the systematic variations in the vertical propagations of gravity waves in different geophysical conditions. Results on the effects of solar forcing and geomagnetic storms on the neutral wave dynamics of ionosphere-thermosphere system over the low-latitudes will be presented.

Session no: 02

On the August 2021 space weather event and its impact on Terrestrial ionosphere

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Abstract:

Earth-directed Coronal Mass Ejections (CMEs) are the major sources of space weather disturbances at Earth. Sometimes, geomagnetic storms at Earth are initiated by CMEs originated from solar filament eruptions. In this work, we study such an event in the current solar cycle. Earth was impacted by a coronal mass ejection initiated by a filament eruption on the Sun on 23 August 2021. The filament eruption north of the disk center could be seen in the images taken by the Solar Dynamics Observatory/Atmospheric Imaging Assembly (SDO/AIA) at 171, 193 and 211 Angstroms and subsequently, the erupted CME is observed in the STEREO-Ahead Coronographs. The event had a flux rope configuration without a very prominent shock signature. The CME arrived at Earth on 27 August 2021. Subsequently, the ionospheric topside electron density (in situ, by Langmuir probe) and total electron content observations by the SWARM satellites showed the signatures of positive and negative geomagnetic storms at different longitudinal sectors. These changes are observed to be related to the changes in the O/N_2 ratio measured by the TIMED/GUVI. The detailed results will be presented.

Session no: 02

Super-fountain effect linked with 17 March 2015 geomagnetic storm manifesting distinct multi-layer stratification

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Abstract:

Geomagnetic storms affecting the equatorial ionosphere have been a subject of intense investigation in the recent years. While many studies have dealt with the Total Electron Content (TEC) and F-layer critical frequency (f_oF_2) variations, changes in the height distribution of electron density in response to the geomagnetic storm have been less addressed. The existence of an additional stratification in the daytime equatorial ionospheric F region (the F_3 layer) was known since 1940s. However, its characteristics and the underlying physical mechanism have been uncovered only recently. In this paper, we present and discuss the F_3 layer characteristics observed by six ionosondes distributed over equatorial and low latitudes (-20° to +25° dip latitudes) in the Brazilian longitude sector during the strongest geomagnetic storm (DstMin = -223 nT) of solar cycle 24, the St. Patrick's Day storm of 17 March 2015. Two eastward prompt penetration electric field (PPEF) events, as seen in equatorial electrojet (EEJ), occurred during the main phase of the storm on 17 March 2015, a strong one (~100 nT) at around ~1200 UT and a weak one (~50 nT) at around ~1725 UT. Local time variations in the F_3 layer occurrence, and ionospheric base height (h'F), peak height (hmF) and peak electron density (Nmax) are investigated. Notably, the F_3 layer occurred at all six locations, more distinctly during the stronger PPEF event. The large latitudinal extend in the occurrence of the F_3 layer in opposite hemispheres (-20° to +25° dip latitudes) covering the equatorial ionization anomaly crests, observed for the first time is interpreted in terms of the combined effect of the super plasma fountain generated by the eastward PPEF and storm-time equatorward neutral wind.

Session no: 02

Distinct Ionospheric response to three different geomagnetic storms during 2016 using GPS-TEC observations over the Indian equatorial and low latitude sectors

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Abstract:

The ionospheric response during three typical moderate geomagnetic storms occurred during the year 2016 is investigated using GPS-TEC data from five different Indian equatorial and low latitude locations. Three geomagnetic storms are different from one another in the sustenance of the main and recovery phases and occurred at three different local times corresponding to Indian longitudes. This study brings out the major differences of these storms and their distinct effects on the equatorial and low latitude ionospheric responses. Significant changes in VTEC during main and recovery phases of these three storms are found to be mainly associated with the prompt penetration electric fields and thermospheric neutral compositional changes. During the storm of 20 January 2016, irrespective of increased solar wind velocity and disturbed prompt penetration electric fields, the disturbed TEC comes to its quiet time level during recovery phase. The complete main phase for the 6 March 2016 geomagnetic storm was occurred during night time and no changes in VTEC has been identified, which could be due to the weak background electron density. The main phase of the 13 October 2016 geomagnetic storm started during noon time around 1130 LT and continued till the morning hours (0530 LT) of the subsequent day. It is noticed that the TEC did not show any changes during the day time on 13 October 2016, while the positive storm effect is seen in the night time main phase and following recovery phases. The positive storm can be attributed to CIR induced enhanced thermospheric winds.

Session no: 02

Effects of 2020 September Geomagnetic Storm on the Nighttime Equatorial Ionization Anomaly (EIA) and Equatorial Plasma Bubbles (EPBs) as Observed by the GOLD Mission

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Abstract:

The present study investigates the effects of the 2020 September geomagnetic storm on the nighttime ionosphere over the South American, Atlantic, and West African longitude sectors, using 135.6 nm emission nighttime images taken by GOLD (Global-scale Observations of the Limb and Disk) imager. From the images, northern and southern crest latitudes of the Equatorial Ionization Anomaly (EIA) are obtained for all nights of September 2020. We have calculated the shifts in the EIA crest latitudes on the geomagnetically disturbed nights compared to the average latitude obtained from the undisturbed nights. On 27th September the poleward shifts in the EIA crests were maximum and the EIA crests were brightest. Further, we have obtained the locations of the Equatorial Plasma Bubbles (EPBs) on all the days of this month. More EPBs are observed during the geomagnetic active days. The maximum number of EPBs was observed on 27th September. On this evening the solar wind conditions were favorable for the penetration of interplanetary electric fields to the equatorial ionosphere over the longitude sector where GOLD takes the measurements. The penetrated electric field strengthened the prereversal enhancement of the zonal electric field and thereby enhanced the plasma fountain which is confirmed by the electric field data and ionosonde measurements. This study reports the first simultaneous investigation of EIA morphology and EPB occurrences during a geomagnetic storm.

Session no: 02

Effect of geomagnetic storms on ionospheric ion densities and Temperatures over the low latitude Indian region as measured using ROCSAT-1 satellite

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Abstract

To study the behavior of ionospheric ion densities and ion temperature to a weak (30 July 1999) and a moderate (13 November 1999) geomagnetic storm (GS) at low latitude Indian region using observed and modeled values has been analyzed. The study has been carried out by using ROCSAT-1 satellite data over the region encompassed between 5-35° geog N and 65-95° geog E at an average altitude ~ 600 km. A comparative study has also been done with the IRI-2016 modeled values. The ionospheric plasma parameters have shown anomalous behavior during disturbed days in comparison to the quiet days. For the weak GS, both the average O+ and H+ density have been increased by a factor of around 1.8 during disturbed and quiet days respectively as calculated by ROCSAT-1. For the moderate GS, the average O+ and H+ density has been increased by a factor of around 2.7 and 6.3 respectively during disturbed and quiet days respectively, as calculated by ROCSAT-1. A least or negligible variation has been observed in Ti for both measured and modeled values during weak and moderate GS.

Session no: 02

Regional Ionospheric TEC Modelling During Geomagnetic Storm in March 2015 – Data Fusion using Multi-instrument Observations

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Abstract:

Ionospheric Total Electron Content (TEC) and TEC structures are considered the basis to provide ionospheric corrections to improve the positional accuracy of Global Navigation Satellite System (GNSS) users. Therefore, it is necessary to develop a regional ionospheric model using multi-source data observations. Accessibility of TEC data from both multi-constellation satellite systems and ground-based sensors provides an opportunity to nowcast and forecast ionospheric behavior. However, data assimilation from different temporal and spatial scales is challenging to enhance the accuracy of the ground-based or space-based ionospheric model. Therefore, the data fusion method plays an important role in illustrating ionospheric variations and improving the prediction accuracy of ionospheric models under Equatorial Ionization Anomaly (EIA) and adverse space weather conditions. TEC data sources from GPS TEC observations of ground-based comprising of 26 GPS receivers, Radio Occultation of GPS from space-based Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC) and mini-satellite constellation SWARM, during 24^{th} solar cycle, the geomagnetic storm period, March 15th, 2015 to March 20th, 2015 are considered in the study. Spherical Harmonics Function (SHF) coefficients are computed from the geometry matrix, and TEC is obtained using the weighted least square method in the SHF model of order 2, followed by nine coefficients. The ground-based and space-based TEC data are validated using Ionosonde observations of Hyderabad Station (17.4° N, 78.5°E). The analysis indicates that the modeled coefficients after data fusion can demonstrate EIA entry, occupancy, and exit, particularly during ionospheric storm conditions.

Session no: 02

Space weather study of Ionosphere during ascending phase of 25th solar cycle over Varanasi

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Abstract:

Radio signal suffers fluctuations in both phase and amplitude during their passage through the irregular ionosphere which results failure in radio communication and navigation systems. These fluctuations in phase and amplitude of the signal are known as phase and amplitude scintillations respectively. The present study is carried out to observe the variation of occurrence of amplitude scintillations during ascending phase of solar cycle from November 2020 to October 2021 over equatorial anomaly region Varanasi (latitude 25.31° N, longitude 82.97° E). We have taken GNSS data from multifrequency GNSS receiver to study the occurrence of scintillation index S_4. To study the seasonal variation of S_4, three seasons are considered i.e., winter (November, December, January and February), Equinox (March, April, September and October) and summer (May, June, July and August). Diurnal and monthly variation of S_4 index is also analyzed. During the month of March 2021 maximum scintillation occurrence has been observed and scintillation activity is more prominent during night-time hours than daytime. We have taken solar moderate period to observe the effect of solar activity on S_4. Two solar indices Sun Spot Number (SSN) and $F_{10.7}$ (solar radio flux at 10.7 cm) are compared with S_4 individually to study the solar activity dependence of S_4. To study the effect of geomagnetic activity on S_4, we have taken an intense solar geomagnetic storm dated on 4th November, 2021 ($DST_{minimum}$ = -105 nT). Characteristics of various geomagnetic indices related to the storm (DST, Bz, Ey, Kp, Ap) are observed during the storm period. Daily Kp_{max} is compared with daily S_4 during storm time to see whether this storm suppress scintillation or not.

Session no: 02

Quantification of role of magnetic disturbance induced seed perturbations in modulating Equatorial Spread F day to day variability

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Abstract:
The present study investigates the role of magnetic disturbance induced seed perturbations in modulating Equatorial Spread F (ESF) day to day variability over geomagnetic equatorial location Trivandrum (8.5^0N, 77^0E), using ionosonde data and TIMED/GUVI neutral density data. This work is carried out for geomagnetically disturbed days (Ap>=18) of vernal equinox (ve) period for different years in the 22^{nd} and 23^{rd} solar cycles encompassing high, low and moderate solar activity levels. There is threshold level of a requisite seed perturbation for ESF triggering under the given background ionospheric condition. Seed perturbation values are estimated by doing wavelet analysis over temporal variation of foF2 data. Post sunset ionospheric height (h'F at 19 hr) is considered as the proxy for zonal electric field. As the altitude increases the amount of requisite seed perturbation for ESF triggering decreases. The comparison of threshold seed perturbation for ESF development during geomagnetically quiet and disturbed periods shows that the requisite seed perturbation amplitude increase significantly with magnetic activity with the variation is being more during high solar activity compared to low solar activity period. At a particular altitude region (~343 km) the requisite seed increases by a factor of ~3 (between magnetically quiet and disturbed times) for high solar activity period, while for low solar period the requisite seed increases by a factor of ~2.4. Based on the dependence of seed perturbation on ionospheric altitude and solar flux an empirical model is developed to hind cast ESF. The model is validated using observations of high (1991) and low (2005) solar activity periods. By using the solar flux for individual days for validation, any sporadic changes in the solar activity and the resultant effects on seed perturbation could also incorporated. There is 92% success in prediction for low solar activity year and for high solar activity year it is 50%. The results will be presented and discussed.

Session no: 02

Characteristics of Martian Electron Density Profiles: MGS Observations

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Abstract:

Early analysis of the first few sets of electron density profiles returned by the radio science experiment aboard MGS spacecraft provided a strong evidence for planetocentric longitude dependence of the photochemical controlled E and F1 layers of the Martian ionosphere (Bougher et al., 2001, 2004). Now, with the availability of several MGS data sets containing a total of 5600 electron density profiles, we re-examine the longitude dependence of the observed peak parameters (viz. height and density) as well as of other derived parameters, like the electron content and the atmospheric scale height of the E layers. We find that though there is a lot of variability, the distribution with longitude for each of these parameters is nearly uniform most of time. However, exceptions are periods during late spring and early summer (northern latitudes) when the longitudinal variations indicate the presence of crests/ troughs, in the observed as well as in the derived parameters, broadly spread around 0, 70 and 140 E longitudes. We also examined the electron density profiles during eight solar flares observed during the sunspot cycle 23. We report that flares majorly result in the formation of a prominent E layer peak, not always seen on other days. An increase of approx. 50 to 180 % in electron density was observed during these flare events. The increase in E –region electron density is found to be consistent with the relative increase in flux during flare events.

Session no: 02

Northward Propagation of Medium Scale Traveling Ionospheric Disturbances over Srinagar, J and K, India

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Abstract:

We report some interesting medium scale travelling ionospheric disturbances (MSTIDs) observed during the night of September 20, 2020 through an all sky CCD imager installed in Kashmir University (KU), Srinagar, India (34.08 ° N geographic latitude, 74.79 ° E and 25.91 ° N geomagnetic latitude). Three different MSTID events including a post-sunset MSTID, a mid-night MSTID and a pre-dawn MSTID are recorded in the airglow images during the night of interest. All the events are recorded during the geomagnetic quiet conditions. The post-sunset and pre-dawn MSTIDs are seen to propagate northward while the MSTID observed near midnight time propagates towards west. As the MSTIDs during the night times over the northern hemisphere generally propagate southwestward, the northward propagation of nighttime MSTIDs over Srinagar makes this result an interesting one. More importantly, three different MSTIDs are observed at different times during the single night whose directions of propagation are not same either. The detailed characteristics and evolution processes of these MSTIDs will be presented. The unusual northward motion of the MSTIDs over the Srinagar region will also be addressed. The upward propagation of atmospheric gravity waves into the ionospheric heights is believed to be the responsible factor for such unusual propagation direction of nighttime MSTIDs over the northern hemisphere.

Session no: 02

The study of space weather using VLF wave

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Abstract:

The dynamic variable conditions in the Ionosphere –Magnetosphere system can be changed by the solar activities and affects on the Earth's ionosphere and these dramatic changes is called as a Space Weather. VLF wave (3kHz-30Khz) propagates long distance through the Earth's ionosphere and enalbles the detection in the change of the propagation path. This change is characteristic by the observed of VLF emissions at the ground station's receiver. Ground based receivers provide a complementary data source for the study of Space weather. An Automatic Whistler Detector (AWD) has been installed in December 2010 for detection the VLF wave at Low Latitude Indian Station Varanasi(geomag.lat.= $14^0 55^/$N, Long.=$153^0 54^/$E). Whistlers and Tweek are the one of the famous VLF emissions and have been used as a cheap and effective tool for the study of Space Weather since last decades. Theses missions are enables to give the information about the propagation of the medium.

Session no: 02

Ionosphric response to co-occurrence of solar flare and geomagnetic storm during September 2017 event

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Abstract:

In this paper we report that the ionospheric variation during 6-10 September 2017 with purpose to reveal the solar flare effect in Indian longitude in terms of GNSS data. Results revel that the some features are related with solar flare, especially the response of total electron content (TEC) with a time delay. The study would identify the changes related to solar flares and separate those not related with flares. Not all changes are caused by flares, and only flares with enough intensity can bring observable changes in ionospheric parameters, including TEC. On September 6, two X class solar flares, namely X2.2 at 0857 UT and X9.3 at 1153 UT, were recorded with quiet geomagnetic conditions. A nearly 8% enhanced TEC level in latitudinal TEC profile is observed during evening sector on September 6 which shows level up of EEJ due to flares. The solar flares on September 7-8 were co-occurred with geomagnetic storms and observed large increments in TEC are additionally induced by prompt penetration electric field and the enhanced level of thermospheric compositional changes. On September 9, an increase in TEC is observed during M class solar flares under combined solar flares and disturbed dynamo electric field. Thus, this study has the potential to beef up our understanding of the impacts of solely solar flares on the ionosphere, as well as such impact when the effects of solar flares and geomagnetic storm are combined.

Session no: 02

Studies of Ionospheric Scintillation during Quite Space Weather Conditions on Basis of Computed S4-Index Using IRNSS Receiver's Data at Low Latitude Station-Panhala, Maharashtra

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Abstract:

Ionospheric scintillation is a common phenomenon observed over the low latitude Indian region. It occurs due to the rapid fluctuations in phase and amplitude of the signal and affects Global Navigation Satellite Systems (GNSS) and user position accuracy. In this paper, effect of ionospheric amplitude scintillation on L5 and S-band frequencies of Indian Regional Navigation Satellite System (IRNSS) during quite space weather conditions are studied on the basis of computed S4 index from Carrier to Noise (C/No) ratio measurements from IRNSS receivers installed at Panhala, Maharashtra. It found that the scintillation occurrence during quite space weather conditions is mostly in post sunset periods. It is also depends on solar cycle, receiver's latitude, frequency of the transmitted signal, elevation angle of the satellite, local time and season.

Session no: 02

Ionospheric response to solar and interplanetary disturbances

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Abstract:

Two types of solar events are mainly responsible for geomagnetic and ionospheric disturbances i.e., Coronal Mass Ejection (CME) and High Speed Solar Stream (HSS) associated with the coronal holes. Each type has a different ability to impact the ionosphere. Two solar events in 2015 were selected to study the ionospheric response above different latitude. Parameters like critical frequency of F2 layer, ionospheric scintillation and Total Electron Content has been considered for the study. Results show that the foF2 and TEC yield similar tendencies and often concurrently register pronounced decrease anomalies on the day of the solar event. The scintillation shows a seasonal effect characterized by intense values in the equinoctial months compare to that of the other season. A further investigation is carried forward to understand the mechanism involved in terms of penetration of electric field, penetration of neutral wind to the lower atmosphere and also modification of appleton anomaly belt by this magnetic storm induced processes.

Session no: 02

Study of TEC variation over Kolhapur region recorded by NavIC/IRNSS during geomagnetic storms of September 2017

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Abstract:

Solar fares are sudden burst of energy from a localized region on the Sun in the form of electromagnetic radiation, energetic particles, and mass motions, which significantly alter various physical and chemical processes in the Earth's upper atmosphere. This study investigates the ionospheric Total Electron Content (TEC) responses over Kolhapur to the solar flares and geomagnetic storms of 6-10 September 2017. In the present paper we studied the solar flares and geomagnetic storms of 6-10 September 2017 and the response of equatorial ionosphere–thermosphere system using the NavIC/IRNSS-derived Total Electron Content (TEC) over Kolhapur region. Weak TEC response to X9.3 of 6 September and X8.2 of 10 September solar flares are observed as TEC is also depending on solar zenith angle. Geomagnetic storms occurred during 7-8 September responsible for large increments in TEC with maximum on 9 September. An increase in TEC is observed during M class solars and geomagnetic storm recovery phase on 9 September.

Session no: 02

Mesosphere-Thermosphere temperature variability using TIMED SABER Satellite observations over Indian domain

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Abstract:

Earth's mesosphere and lower thermosphere are regions in which the transport and exchange of energy occur through subtle and complex processes. The dynamics of the region is dominated by waves and their effects The basic structure of the region is determined by momentum deposition by small scale gravity waves. We note that our knowledge on the day-to-day variability is highly limited on regional and global perspective. We report here studies on temperature variability in Mesosphere-Thermosphere region during December-February 2014 using TIMED-SABER satellite data.. We have done analysis of day to day variability of temperature over different grid boxes and examine its variability in day to day basis at various altitude grids in vertically from 60-110 km region. Presence of waves and its propagations observed. Its link with various processes and radiative energy examined. The solar energy influence and its association with various upper atmospheric processes are in progress. .

Session no: 02

Effects of Solar eclipse of 21st June 2020 on Equatorial Ionosphere

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Abstract:

Solar eclipse is an important transient event to study the behaviour of ionosphere-thermosphere system to the sudden changes in the solar radiation. The radar observations on the electrojet irregularities at 8.3m scale size were carried out from Thumba, Trivandrum to understand the electrodynamics of the upper atmosphere during the partial solar eclipse event of June 21, 2020. The E region electric field has been derived from the HF radar measured ionospheric drifts. Thereafter, incorporating the electron density obtained from Ionosonde measurements, the magnetic field that is induced on the ground by the EEJ current has also been estimated and compared with the magnetic field measured using a ground based magnetometer at Thumba. The two have been found to agree closely. The response of the equatorial E and F region to this partial solar eclipse which coincided with the summer solstice will be presented and discussed.

Session no: 02

Investigation of the response of Martian upper atmosphere to the interplanetary coronal mass ejections during June 2018

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Abstract:

Solar wind interacts directly with the extended atmosphere and ionosphere to form a magnetic barrier that deflect solar wind around planetary bodies like Mars that lack intrinsic global magnetic fields. The interaction of the solar wind can cause heating, acceleration and loss of their atmosphere. Hence, investigating the structure of the upper atmosphere and its variation during the extreme solar wind conditions during interplanetary coronal mass ejection (ICME) is significant in understanding the interaction and the physical processes that govern the escape of atmospheric species. The response of Martian ionosphere to the passage of interplanetary coronal mass ejection during June 2018 was investigated using the Neutral Gas and Ion Mass Spectrometer (NGIMS) and Langmuir Probe and Waves (LPW) instruments on board Martian Atmosphere and Volatile EvolutioN (MAVEN). The NGIMS ion observations and the electron density profiles during the event showed signatures of ionopause features at lower altitude compared to its quiescent condition. The ratio of O^+ to O_2^+ showed a preferential decrease of O_2^+ and an enhancement in O^+. The implication of these results on the interaction of ICME with the Martian atmosphere will be discussed.

Session no: 02

Deepening of radiation belt particles in South Atlantic Anomaly Region: A scenario over past 120 years

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Abstract:

The Sun is a source of energy for our planet, and it mainly controls the geospace around us. We know that solar wind characteristics determine quiet/disturbed time space weather of ionosphere-magnetosphere systems along with the geomagnetic field of the Earth. Apart from the source (Sun) variation, the state of the system (Earth), where its effects are seen, is equally important, particularly the geomagnetic field. Over the past several decades, the Earth's magnetic field has continuously decreased. Understanding the effect of this decreasing magnetic field on different space weather phenomena is important. The Earth's magnetic field has an unusual weak spot over South America and the South Atlantic Ocean, called South Atlantic Anomaly (SAA). The magnetospheric particles trapped in the geomagnetic field can reach deeper altitudes over SAA. It is attributed to the weakened magnetic field over SAA, resulting in a lower boundary of the inner radiation belt and ring current particles. Over the past 120 years, the magnetic field in the SAA region has decreased considerably. In some recent studies, a very rapid decrease of the magnetic field in the SAA region and the possibility of splitting have been reported. Therefore, we performed the test particle simulations to quantify the effect of the decreasing geomagnetic field on the inner boundary of the radiation belt. We found that particles of energies 100 keV-50 MeV, initially located at altitudes of 1-2 earth radii, are moving closer to the Earth at the rate of 3.8-4.7 km/year, which results in approximately 434-590 km decrease in their altitude over the SAA region during 1900 to 2020. Overall, the study shows that the changes in the Earth's internal magnetic field affect space weather besides the Sun.

Session no: 02

Performance evaluation of machine learning-based automatic CADI's ionogram scaling tool for Hyderabad Station during Geomagnetic Storm conditions in March 2015

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Abstract:

Automatic identification of various layer traces such as E, F1, and F2, and Sporadic E (Es) and Spread F (SF) events in the digital ionograms is necessary for analyzing the large ionogram datasets to distinguish the variabilities in the ionosphere and understand the behavior of ionosphere in response to the geomagnetic storm events. However, manual identification and scaling of ionograms are tedious and time-consuming since the number of ionograms generated per day from a single station globally is large. In this paper, a new model is presented on an open-source (Python) platform to detect the ionogram traces using deep learning Convolution Neural Network (CNN) and statistical methods to scale the ionospheric features from the ionograms. The ionogram traces, SF, and Es events are detected automatically by de-noising the ionogram and scaling the features by segmentation and quantifying the frequency and height points. The performance of the proposed technique is evaluated with the Canadian Advanced Digital Ionosonde (CADI) ionograms data recorded during the adverse space weather conditions (16th to 18th March 2015 and 22nd to 24th June 2015) at a low latitude station, Hyderabad, India (Lat: 17.47°N, Long: 78.57°E). The proposed scaling software outputs are compared with manual scaling and Univap Digital Ionosonde Data Analysis (UDIDA) software outputs. The proposed auto-detection module successfully detected the Es, RSF, and SSF events with an efficiency of 96.71%, 89.71%, and 93.39%, respectively. The auto-scale results of the proposed model are very much close to the manual scale values and mean absolute error (MAE) (0.36 MHz, 11.72 Km) and root mean square error (RMSE) (0.7 MHz, 22.36 Km) values show the model's fair performance. The proposed model output results show the significant performance of the results to initiate the protocols of the ionospheric space weather alerts in high-frequency communications and GPS systems.

Session no: 02

On the verge of another solar minimum: a prediction and veracity

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Abstract:

Variability of solar activity has significant role in space weather studies and its prediction play the key role. Various methods/models such as sound physical principles, precursor methods and statistical interpretations including spectral analysis and predictions by an extrapolation of the significant periodicities have been applied for future predictions. In the present study, we have predicted solar activity pattern for solar cycles 25 & 26. To that end we have applied Hurst exponent (H) which is a quantitative measure of the persistence of a time series. The earlier observed data of sunspots are analyzed and the time series were subjected to the Hodrick Prescott (HP) filter which is an influential tool in a number of familiar transformations, including deterministic detrending, stochastic detrending and differencing In order to search for the persistence in the time series of solar activity measurements, the rescaled range (R/S) analysis has been applied on the periodic component of each time series of observed solar parameters, which gave the value of the Hurst exponent (H) for each series. It is inferred that the solar activity will further reduce during solar cycles 25 & 26 and may reach to other solar minima in future. This declining trend of solar activity will affect the climate but anthropogenic factors will be more dominant as compared to solar factor.

Session no: 02

Radiative Cooling by NO in Lower Thermosphere during Solar Storms associated HILDCAAs

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Abstract:

Thermospheric infrared radiative cooling by Nitric Oxide (NO) play an important role in maintaining the energy budget of earth's upper atmosphere during space weather events. The lower thermospheric cooling pattern of NO radiative emissions observed during geomagnetic storms associated with High Intensity Long Duration Continuous Auroral Activities (HILDCAAs) was found to be significantly different to that observed during an isolated moderate geomagnetic storm. The objective of this paper is to investigate the variation in NO cooling pattern between these two. We have considered two moderate (SYM-H_{min} -80 nT; April 2005, and -65 nT; December 2006) and an intense (Dst_{min} -150 nT; May-Jun 2000) geomagnetic storms for this study. We have utilized the TIMED/SABER (Thermosphere-Ionosphere-Mesosphere Energetics and Dynamics/Sounding of the Atmosphere using Broadband Emission Radiometry), Envisat/MIPAS (The Michelson Interferometer for Passive Atmospheric Sounding), and SNOE (Student Nitric Oxide explorer) observations for this study. The difference in NO cooling pattern is mainly attributed to the variation in temperature, atomic oxygen density, and NO density during such events. An atmospheric chemistry based themospheric NO radiative emission model with NRLMSISE, IRI-2016, and SNOE datasets as input parameters was used to calculate the NO cooling emission rates during May-Jun 2000 event. The variation in NO density along with its collisional excitation rate calculated from TIE-GCM (Thermosphere-Ionosphere-Electrodynamics General Circulation Model) outputs correlates well with the observed pattern of radiative emission by NO.

Session no: 02

Prediction of Ionospheric Total Electron Content (TEC) based on Empirical Mode Decomposition (EMD) and Long Short-Term Memory (LSTM) Neural Network

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Abstract:
Prediction of ionospheric variability is one of the important parameters for the study of space weather. In this paper, we have developed and analyzed a technique based on Empirical Mode Decomposition (EMD) and Long Short-Term Memory (LSTM) Neural Network for ionospheric TEC prediction. In this work, multi-input Empirical Mode Decomposition (EMD) and Long Short-Term Memory (LSTM) Neural Network technique have been utilized and tested for evaluating its capability for prediction of ionspheric TEC data over Lhasa, China station (Longitude: 91.10397200 , Latitude : 29.65734166). The results were then compared with the TEC derived from the IGS network. The result shows that the model could recognize the variation trend of typical TEC profile and has a good performance of the short term ionospheric TEC prediction.

Session no: 02

D-region modelling using VLF observation during solar flares

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Abstract:

Propagation of Very Low Frequency (VLF) radio signal through the earth-ionosphere waveguide strongly depends on the plasma properties of the ionospheric D-region. D-region characteristics get affected due to energy perturbations coming primarily from the sun. The soft solar X-ray perturbs the D-region especially during solar flares. Such solar energetic events can be investigated remotely by systematic monitoring and analysis of VLF signal. We numerically model the VLF signature of the effects of solar flares of all possible classes on D-region. We also present some results regarding characteristic changes in D-region during a number of C, M and X classes of solar flares as obtained from simulations done on the basis of VLF observations.

Session: 3

Space and ground instruments for Space weather research

Session no: 03

Characterizing Spectral Channels of Visible Emission Line Coronagraph of Aditya-L1

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Abstract:

Aditya-L1 is India's first solar mission with the Visible Emission Line Coronagraph (VELC), which consists of three spectral channels taking high-resolution spectroscopic observations of the inner corona up to 1.5 Rθ at 5,303, 7,892, and 10,747 Å. In this work, we present a strategy for the slit width optimization of the VELC using synthetic line profiles by taking into account the instrument characteristics and coronal conditions for log(T) varying from 6 to 6.5. The synthetic profiles are convolved with simulated instrumental scattered light and noise to estimate the signal-to-noise ratio (SNR), which will be crucial to designing the future observation plans. We find that the optimum slit width for VELC turns out to be 50 μm, providing sufficient SNR for observations in different solar conditions. We also analyzed the effect of plasma temperature on the SNR at different heights in the VELC field of view for the optimized slit width. We also studied the expected effect of the presence of a CME on the spectral channel observations. This analysis will help to plan the scientific observations of VELC in different solar conditions.

Session no: 03

Recent developments in space weather research with high fidelity low-frequency spectro-polarimetric imaging using SKA-low precursor

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Abstract:

Low-frequency radio observations have been proven to be an important tool for space weather observations ranging from coronal mass ejections (CMEs) to solar winds. Radio observations can be done from the ground, which allows gathering observations at the high temporal and spectral resolution, which is otherwise difficult for space-based instruments. With the advent of new generation instruments, like Murchison Widefield Array (MWA), which is a future square kilometer array precursor instrument has become an ideal instrument for space weather monitoring using type-II radio bursts, radio emissions from CMEs, and interplanetary scintillation (IPS). Recently, we have successfully implemented precise polarization calibration of the instrument, which allows us now to use the polarization information also. Here we will show some new interesting science results important from a space weather perspective and also discuss future possibilities. These include measuring the plasma parameters and magnetic fields of CMEs up to 8.5 solar radii (highest heliocentric distance reported in the literature) using gyrosynchrotron modeling to measurements of heliospheric Faraday rotation using numerous background radio sources even with the Sun in the field of view. At the end, we will discuss how these spectro-polarimetric observations combined with simultaneous IPS measurements would become a routine space weather monitoring method and the importance for future SKA (SKA-like solar arrays).

Session no: 03

Ionospheric study using GMRT

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Abstract:

Radio interferometers have recently been used to model the Earth's ionosphere, in addition to studying celestial sources. To minimize the effects of the ionosphere, observations taken from radio telescopes require a rigorous calibration method; additionally, the same calibration data can be used to examine the ionosphere at low frequencies. Our motivation is to study the Equatorial Ionization Anomaly (EIA) region, which has a prominent plasma turbulence effect. The location and configuration of the Giant Metrewave Radio Telescope (GMRT) array are well suited to study geophysically sensitive regions between the northern crest of the EIA and the magnetic equator because this region comes under the highest concentration of electron-ion density.The observational data have been taken from a bright radio galaxy (3C68.2) at the sub-GHz frequencies to demonstrate the capability of GMRT to detect small-scale ionospheric variability. The observed ionospheric phase for the pair of antennas is proportional to the difference in the total electron content (TEC). Our study reveals for the first time that the GMRT can measure the differential TEC between two antenna elements with precision about the order of a few mTECU, which is more sensitive than current GPS-based TEC measurements. Furthermore, the measurement of the TEC gradient has been computed for the GMRT array, and small-scale fluctuations in the two-dimensional TEC values have been observed. These fluctuations are used for measuring the micro-scale variation in the ionospheric plasma. The obtained results show that a sensitive instrument like GMRT can be a perfect probe for ionospheric fluctuations.

Session no: 03

On the assessment of day-to-day variability in the occurrence of equatorial plasma bubble

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Abstract:

In this paper, we address the day-to-day variation in the development of equatorial plasma bubble (EPB) using simultaneous observations made by the 30 MHz Gadanki Ionospheric Radar Interferometer (GIRI) and ionosonde (DPS-4D) from Gadanki and C/NOFS. We show that wave-like variations with horizontal wavelengths of 200–660 km observed prior to sunset have a close connection with EPB spacings. We also show that the locations of EPB development at their origins, which varied on a day-to-day basis, were as large as 2600 km from Gadanki. A detailed analysis clearly reveals the cause of such variability and provides clue as to where the background ionospheric conditions led to the growth of the Rayleigh Taylor instability (RTI) generating EPB and where they failed. Results clearly show that while ionosonde observations show great potential for understanding day-to-day variation and predicting EPB development overhead (within ±1° longitude), they are inadequate to assess the growth potential of EPB at longitudes away from a longitude zone of about ±1° from overhead. A detailed analysis suggests that the day-to-day variability in EPB development is governed by large scale wave structures (LSWS) and it is inferred that the LSWS troughs (low electron density) are the sites for the EPB development. Results further suggest that LSWS with horizontal wavelength of 200–660 km acts as seed for the growth of the RTI resulting in EPBs with same spacing. While the sources of LSWS remain to be identified, it is suggested that observations with longitudinally distributed ground-based sensor, viz., ionosonde, preferably separated by 250–300 km, would be an immediate step forward in this effort.

Session no: 03

IDEA payload on PS4 Orbital Platform: Development and On-orbit Performance

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Abstract:

Electron density and Electric field are two most important parameters in the ionospheric F-region which play a key role in understanding major physical processes in equatorial and low latitude ionosphere, and are susceptible to multiple space weather effects. Insitu measurements of these parameters are obtained with specially designed probes and sensors, normally flown as payloads in sounding rockets. Making use of the opportunity to conduct scientific experiments using the fourth stage of ISRO's Polar Satellite Launch Vehicle (PSLV) as an Orbiting Platform, the Ionization Density and Electric Field Analyzer (IDEA) payload was developed for measurement of the above parameters. This payload consisting of the indigenous Electron density and Neutral Wind (ENWi) probe and Langmuir Probe (LP) sensors with a common payload electronics, became India's first scientific experiment on the PS4 Orbiting Platform for ionospheric studies. The payload electronics was designed to measure the very low current from the sensors and provide interface to the PSLV Telemetry Unit. The available resources on the PS4 stage were used to accommodate the payload data, and as per scientific requirement, the payload data was collected during the equatorial crossing-times. The payload data was then downloaded as part of total telemetry data and separated out for further analysis. The payload flown aboard the PSLV-C38 mission launched from SHAR, was kept active from Launchpad itself and had worked satisfactorily till end of mission. An overview of the payload development, testing and performance evaluation during the mission is presented.

Session no: 03

Occurrence Characteristics of Ionospheric Scintillations over Indian region from Latitudinally-aligned Geodetic GPS Observations

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Abstract:

Ionospheric scintillations are known to be imparting serious threats to the satellite-based communication and navigation systems services, particularly in the highly dynamic platforms such as aircraft's navigation and landing and high-performance applications like maritime navigation, geophysical exploration, and timekeeping, etc. The scintillation occurrence characteristics can be effectively monitored by specialized scintillation monitoring receivers which are less abundant as compared to the relatively low-resolution geodetic global positioning system (GPS) from which the amplitude scintillation proxy indices (S4) can be extracted. In the present work, we analyzed the S4 index from a latitudinal array of three GPS stations observations over the Indian longitude sector during the period from 2014 to 2017 that refers to the descending phase of 24th solar cycle. The results show predominant occurrences of higher scintillations limited between post-sunset and night-time periods over each location. The strong amplitude scintillations during 2014 and 2015 and their lowest magnitudes during 2016 and 2017 reflect its solar activity dependence. Prevalent occurrence of intense scintillation towards equatorial location and weaker amplitude at far low latitude station are seen in the observations. The study demonstrates occurrence of intense scintillation in high solar active years and equinox season at all stations while the equatorial location perceives added occurrences in winter followed by summer. The amplitude scintillation frequency during the period is further compared with the solar and geomagnetic indices. Our results emphasize further studies on scintillation occurrences for developing effective forecasting and mitigation models over the Indian low latitude region.

Session no: 03

A ground based GNSS network designed by Unsupervised Machine Learning Algorithm and NeQuick-G Model for Space Weather Studies over Indian region

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Abstract:

Understanding the impacts of space weather on the low latitude Ionosphere requires consistent data with high spatial and temporal resolution. The Indian peninsular landmass imposes limitations with regard to ground placement of GNSS receivers for such imaging. Hence, a new effort is made to obtain the area specific ground network for the equatorial and the crest regions. A proper trade-off between the spatial resolution and confidence bound with respect to geographic range is required while dealing with the gridded observables. The identification of the optimal locations of 15 GNSS receivers is accomplished by using an unsupervised machine learning based clustering algorithm. The locations are chosen such that two different temporal (30 min, 1 hour) and three spatial (50x50, 100x100, 300x300 km) grids are formed for the optimal placement. Simulations are performed to test the performance of the algorithm by varying different combinations of the spatial and temporal resolutions, outer geographical area range and also the total number of receivers. Optimal receiver locations are found in each resolution size for each outer domain. The results are restricted based upon number of blank (no observations) grids. Additionally, the algorithm outcomes are translated into the Global NeQuick-G model to capture the day-to-day, monthly and seasonal variability through 2D maps of the vertical total electron content (VTEC). The results are utilized to design an Observing System Simulation Experiments (OSSE's) to build a hybrid data assimilation and machine learning based TEC forecasting system over the Indian region for space weather and severe ionospheric conditions.

Session no: 03

A case study of equatorial spread-F associated airglow depletions near the crest of ionization anomaly in India on 16 April 2012

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Abstract:

We present in this study Equatorial Spread-F (ESF) associated airglow depletions in OI 630.0 nm imaging nightglow in post sunset hours over Ranchi (23.3^0 N, 85.3^0 E, mlat. ~19^0 N) on 16 April 2012. Since start of imaging at 2006 IST, several eastward drifting depletions were seen. We explored ionosonde measurements from Tirunelveli (mlat. ~1.5° N) and Total Electron Content (TEC) from Bangalore (mlat. ~6.7° N) and Hyderabad (mlat. ~12.0° N) to study its possible ESF association. Ionosonde measurements showed that (i) h'f, increased from ~220 km to ~370 km during 1630-1930 IST, and (ii) ESF activity beyond 1930 IST. Several investigators have reported the imaging observation of ESF associated depletions in the ~16°-35° mlat. range (apex height, A_H, ≥ 500 km) [Liu et al., 2011; Makela and Kelley, 2003; Otsuka et al., 2002]. Sekar et al. [2008] have reported the ESF irregularities over Gadanki (mlat. ~6.8° N), India with plume structures extending up to ~ 425-600 km in Range-Time-Intensity maps. At 2030 IST, A_H of prominent depletion was ~600-640 km. Rate of change of TEC index (ROTI) measurements every 30 min during 2015-2045 h showed that an increase (i) from 0.36 to 0.63 over Hyderabad, and (ii) from 0.29 to 0.66 over Bengaluru; thereby, indicating the presence of the EPBs in these low latitude stations. Altogether supported with ionosonde, ROTI and Sekar et al. [2008] radar observations, we interpret that airglow depletions seen at Ranchi were possibly ESF associated. A preliminary report of their development is presented.