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Algeria

Review of the D Region study using the AWESOME VLF Receiver in Algeria

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In this contribution, we will present our results about the ionospheric D region disturbances study using the AWESOME Very Low Frequencies receiver at Algiers observatory. Since 2006, the years that the instrument was installed, several works were done to study and characterize the disturbances of the lower layer of the ionosphere, the D region. These include: the connection between the TLE events and the Early/Fast VLF signal perturbations, characterization and simulation of some Long Recovery Early events associated with an Elve and GJ captured in the Mediterranean Sea, Solar flare D region disturbances, gravity wave VLF signal perturbations during the Atlantic cyclone activity, the connection between the CME-geomagnetic storms and the anomalies observed in the VLF signal and finally characterization and simulation of lightning induced electron precipitation after the intense geomagnetic storms. These works enlarged our knowledge about the D region behavior due to the natural forcing.

KEYWORDS: AWESOME VLF Receiver, D-region disturbance, Ionosphere-Magnetosphere coupling

Algeria

Ionospheric models comparison of single-frequency GPS positioning in Algeria

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Positions provided by Global Navigation Satellite Systems (GNSS) is affected by various errors, which include satellite ephemeris error, clock error, ionospheric delay, tropospheric delay and others. The ionospheric delay is one of the most important error sources affecting the accuracy of GNSS. It is a dispersive medium for radio signals, and for multi-frequency receivers, most of its effects can be eliminated. The problem arises for single-frequency receivers, where a correct model must be used. This error is depending mainly on solar activity, season, local time, latitude and geophysical conditions.

The GNSS offers the possibility to correct this type of error generally by using ionospheric models whose parameters are sent in their navigation messages. The objective of this study is to analyse the accuracy of GPS single-frequency positioning by using four ionospheric broadcast models: PS Klobuchar model, Beidou (KBDS) Klobuchar model, NeQuick (Galileo) as well as the EGNOS ionospheric grid delays. These models are compared to the Global Ionospheric Maps (GIMs) from the International GNSS Service (IGS) in the IONosphere map Exchange (IONEX) format. The performance of these models is evaluated at four sites in Algeria, which latitude varies from 35.85° (Oran) to 20.31° (Djanet) and longitudes are between -8.14° to 9.52°.

In order to perform this study, real data from the four sites located in Algeria at different geographical latitudes and longitude were used, inside and outside the EGNOS service area.

The obtained results showed a significant improvement accuracy, using the ionospheric grid transmitted by EGNOS for Oran and Tindouf sites compared to the results obtained using the ionospheric broadcast models of Klobuchar or Beidou or even NeQuick. The accuracy is between 0.76 m and 0.94 m for EGNOS, while it varies between 1.15 m and 1.48 m for the three other models. For Djanet and In Guezzam sites which are located outside EGNOS service area (< 25° in latitude and between 6° and 9° in longitude), the application of these three models provides better results than EGNOS. The accuracy obtained, which can reach 45.27 m, is caused by the lack of EGNOS Ranging Integrity Monitoring Stations (RIMS) in Algeria.

KEYWORDS: Ionospheric models, Single-frequency, Accuracy

Azerbaijan

Analysis of small-scale magnetic field generation in mhd-shell model

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The mechanism of stellar large-scale magnetic field formation, including the eleven-year solar cycle, is currently generally understood. In particular, its linear mode, in which the reverse effect of the magnetic field on the velocity field can be neglected. However, the non-linear reverse influence, which stabilize the growing average magnetic field, is not completely clear. The most possible reason of the nonlinear stabilization of this process is assumed the hydrodynamic helicity, but the balance of hydrodynamic and magnetic helicity and its transport along the spectrum remains to be studied. The present report is devoted to this problem. An exponential growth of magnetic energy at sufficiently high magnetic Reynolds numbers can be observed in a random short-correlated plasma flow at small-scales relative the velocity correlation length. Magnetic helicity is generated in this case together with the small-scale energy of magnetic field. And despite the fact that this phenomenon is traditionally studied by using the Kazantsev's approach, we are trying to recreate this process of small-scale generation by a mhd shell approach, which is more convenient for the subsequent study of the balance and energy/helicity transport from small scales to large ones. To do this, in the complex shell model we add a small magnetic field to the well-established Kolmogorov spectrum and, by observing the exponential growth of magnetic energy on small scales, we compare the generation process with the magnetic small-scale Kazantsev dynamo. We select the correlation time for the velocity field and the working spectral regions to show that, in general, both approaches describe the same process with the same generation rates and scales. Thus, we show that the shell approach can be used for the future study of small-scale energy/helicity transport along the spectrum and for the problems of large-scale stellar dynamo processes stabilization. This work was supported by the BASIS Foundation grant no. 21-1-3-63-1.

KEYWORDS: Small-scale dynamo, shell model, Kazantsev's approach

Azerbaijan

Local anisotropy in Parker's solar dynamo model

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The mean-field model is one of the most used models of mhd-dynamo theory, which describes the magnetic field generation in a turbulent astrophysical plasma. It was firstly obtained by Steenbeck, Krause and Rädler for two-scale turbulence under local isotropy and uniformity assumptions. In this work, we develop the multiplicative integral approach, obtaining similar equations for a short-correlated random velocity field in anisotropic streams. This approach was proposed by Molchanov, Ruzmaikin and Sokoloff in 1985 and it is very close to the functional integrals method used in quantum mechanics. It does not require the assumption of a spatial two-scale velocity field and allows deriving dynamo equations for both: the first and the second moments of the magnetic field. The approach is based on two assumptions: first, the velocity field with short time correlations is considered, which makes it possible to do the averaging over the magnetic and the velocity field independently to each other. Second, the trajectories of liquid particles are replaced by Winner beams trajectories, averaging over which allows one to take into account dissipative effects. Note that this approach traditionally uses the magnetic induction equation written for the magnetic field, while in our report we use the equation for the vector potential. The goal here is not to prove the applicability of the multiplicative approach for the potential, but rather to demonstrate the advantages of this modification of the method for an anisotropic and non-uniform setting. To obtain a system for the Parker solar dynamo, we use a spherical coordinate system and divide the magnetic field into the sum of the poloidal and toroidal components. Using anisotropic equations, we analyse the classical system of the Parker's solar dynamo: the emphasis is on the anisotropy associated with azimuthal rotation that means turbulent media is considered with different average characteristics along and perpendicular to the axis of rotation. We demonstrate the influence of local velocity field anisotropy on the generation properties in this approach. A number of interesting anisotropic effects were analyzed, one of which, for example, is the possibility of generating a magnetic field at zero helicity. This work was supported by the BASIS Foundation grant no. 21-1-3-63-1.

KEYWORDS: MHD-dynamo, method of functional integrals, Parker's solar dynamo

Azerbaijan

Geomagnetic Disturbances and Psychophysiological Characteristics of Adult Female

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Space weather changes undoubtedly affect not only technologies but also influence all living organisms, including human beings. Among these various factors, geomagnetic field disturbances play a special role. Human brain's bioelectrical activity reacts to changes in the Earth's magnetic field.

Studies of the potential impact of geomagnetic storms on the human brain's activity always attracts attention of scientists from various fields. The influence of geomagnetic storms on the functional activity of the human brain, as well as on the emotional and characterological sphere of personality of different aged human beings has not been studied sufficiently and well-known studies as usual do not consider the severity of geomagnetic disturbances, as well as the ontogenetic and sexual aspects of the considered problem.

We conducted an analysis of psychophysiological researches, including registration of the bioelectrical activity of the human brain, and the study of the profile of personal characteristics of practically healthy female aged 50-60 years on days with different heliogeomagnetic conditions on the Earth, in various functional states - calm and active wakefulness. Our studies were personalized which enabled us to avoid the influence of the variability of individual characteristics on the results obtained. To assess the reactivity of the human brain, a functional test was used with the opening of the eyes - the transition from calm state to active wakefulness. Using software "Neuron-Spectrum-NET" we analyzed 10-second artifact-free electroencephalogram (EEG) segments of both brain hemispheres with the determination of the frequency-amplitude and index characteristics of the frontal, central, parietal, occipital and temporal regions of brain in states of calm and active wakefulness. Frequencies, amplitudes, and indices were analyzed for the entire spectrum of EEG-rhythms. In order to reflect the emotional and characterological basis of the personality, psychological non-verbal testing was used with the help of Luscher test. The characteristics reflecting anxiety, emotional and vegetative basis, as well as the level of working capacity were analyzed. Information about the Space Weather changes in Baku was provided by the Department of Astrophysics of the Baku State University. We used the Kp- index of geomagnetic activity in our studies.

Obtained results clearly demonstrate that the increased geomagnetic activity is mainly accompanied by disturbance in the brain's response to eye opening, which reflects adaptive reactivity. Violations are traced in the slow-wave spectrum and in the low-frequency range of fast activity. There is an opposite correlation of theta- and predominantly delta-waves with a low-frequency beta-rhythm. A functional test with eye opening is accompanied by a disturbance of the balance observed at rest between the activating and deactivating mechanisms of nonspecific brain systems, with a predominance of deactivating processes. The results of a psychological study indicate that in old females, a decrease in the autonomic tone and level of performance is significantly pronounced and was observed both on calm days and on days of geomagnetic disturbances. A high level of anxiety and

an emotional-characteristic basis was also revealed which is not related to the level of geomagnetic activity and apparently reflects the surrounding situational environment.

KEYWORDS: geomagnetic disturbances - electroencephalography - Luscher test

Azerbaijan

Kelvin-Helmholtz MHD instabilities of supersonic shear layers with heat flux in anisotropic space plasmas

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The linear MHD Kelvin-Helmholtz instability (KHI) in an aniso-tropic plasma is studied in an external magnetic field direction. The MHD equations obtained from 16 moments of Boltzmann-Vlasov kinetic equations are applied to describe collisionless plasma as a fluid. Dispersion equations for the KHI of quasi-transverse modes are derived by considering the finite width of the transition zone between supersonic flows along the magnetic field. The growing rates are calculated as functions of the aniso-tropic plasma properties. In the most challenging problem of KHI formation in an anisotropic collisionless magnetoactive plasma with the natural presence of heat flux, quasi-transverse modes grow faster regardless of the width of the transition layer between supersonic flows (tangential discontinuity or finite width of the transition zone with linear and smooth velocity profiles). The plasma parameters are controlled so that the fundamental plasma instabilities (firehose and mirror) do not affect the KHI. KHI's characteristics are comparable to isotropic theory's results when applied to vital limiting instances. These limited cases are solved analytically, which is essential for numerical simulation.

In contrast to the tangential discontinuity, the finite width of the transition layer confines KHI excitation as the wavenumber in-creases. In the general case of oblique propagation (when a heat flux complicates the problem), the boundary value problem is solved to determine the spectral eigenvalues. In particular, it is ob-served that fundamental plasma instabilities that arise in the tran-sition zone between flows with a finite width can modify and considerably enhance KHI.

KEYWORDS: Solar wind plasmas – MHD – turbulence - waves

Azerbaijan

Space Science and Technology: Diversity and Sustainability

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Today science and education takes a vital in all aspects of human life - economic development and natural balance, in other words sustainable development. It is very important to undertake human capital as the main sources of achievements and sophisticated problems solutions for society. Especially it has to be considered in the almost daily changes and developments new technology capacity and capability demanding new approaches of education as well as science activities meeting existing modern cercumstances and environment.

There are number of arguments/needs for integration of education, science and business – unique scientific, educational and business spheres and number of socio-economical directions. It demands to consider integration education, science and business within the regional framework for achievement expected results based on mutually benefits in development of innovation and research development. No doubt that it creates an excellent environment for making education more adequate to requirements of up to date market economy.

The diversity is the fundamental principle widle using in different condition and environment and can be accepted and understood in variety aspect of approaches. The devirsity is explaining in some of cases as platform of acceptance of many people and visions into the same of matter or obtion.

In order to assess of integration effectiveness of science, education and business it is vital to monitor and diversify of this area making possible timely identification of problems in terms of development strategic plans for further management of effective commercialization of research activities and being able to create environment for timely response of any changes during the process.

- The use of up-to-date technology envorinment demands to consider special approach of education processes opening opportunities closely integration all segments of human intellectual capacity. It can be pointed out below segments contenting effectively achievement expected outcomes:
- Science and education as the basic factor for sustainable development;
- Science and education as the factor of human resources development; and
- The role of science and education in capacity building.

KEYWORDS: Sustainability, diversity, integration of science, education and innovation, management system.

Belgium

ICARUS: A new highly optimized heliospheric model for forecasting purposes

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Coronal Mass Ejections (CMEs) are the main drivers of interplanetary shocks and space weather disturbances. One of the key parameters that determine the geo-effectiveness of the CME is its internal magnetic configuration. Strong CMEs directed towards Earth can have a severe impact on our planet and their prediction can mitigate possible damages. Thus, efficient space weather prediction tools are necessary, in order to produce timely forecasts for the CME arrival at Earth and their strength upon arrival.

The novel heliospheric model Icarus (Verbeke et al. 2022), which is implemented within the framework of MPI-AMRVAC (Xia et al. 2018) introduces new capabilities to model the heliospheric solar wind and real CME events. Ideal MHD equations are solved in the co-rotating reference frame with the Sun. This guarantees a stationary solution after obtaining the relaxed solar wind in the domain. Different CME models are injected in the domain on top of the stationary solar wind.

To optimize the simulations advanced techniques, such as adaptive mesh refinement and gradual radial grid stretching are implemented. By imposing these techniques, we avoid cell deformation in the domain and only the necessary/desired areas are refined to higher spatial resolutions (and coarsened again when the high resolution is no longer necessary, e.g. behind a travelling shock wave). The refinement and coarsening conditions are controlled by the user. Currently, we have implemented various refinement criteria based on the CME models. We refine the CME interior, the shocks associated with the CMEs, the shocks at the CIRs, etc. Different refinement techniques are described in detail in Baratashvili et al. 2022 (in review). The biggest advantage of the AMR in MPI-AMRVAC is that you can design the refinement in the simulations according to the purpose of the run. These techniques result in optimised computer memory usage and a significant speed-up, which is crucial for forecasting purposes.

In order to demonstrate the capabilities of the code we model a particular CME event. We use a radially stretched grid in the Icarus simulations. The solution mesh refinement is applied to the CMEs in order to model its arrival time and interior magnetic field better. To analyse the results, the plasma variables are compared to the original EUHFORIA simulations and the observed data. As a result, the new heliospheric model provides accurate results and gives various options to apply to the domain in simulations, while the simulations are much more efficient and save significant amounts of computational resources and time.

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KEYWORDS: Heliosphere – Coronal Mass Ejections – Space Weather Modelling

Belgium

Space weather forecasting with the Virtual Space Weather Modelling Centre and recent coronal model development

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Space weather forecasting is a complex problem which involves modelling of the solar plasma all the way from the solar corona down to the Earth's atmosphere. For that reason, not a single one model is sufficient for this process - in general, to simulate the transfer of the energy from the Sun to the Earth, we require coronal models (for distances of roughly 0.1AU), heliospheric models (to propagate the plasma through the planetary system), ionospheric/ magnetospheric models (to predict the interaction of the solar plasma with the Earth's environment) and tools to estimate the indices Kp and Dst to evaluate the space-weather event's potential impact. All of these models require different expertise and as a consequence, these models are generally built and maintained by different groups from different institutes – and often developed and executed separately.

To unify all these efforts with the aim of making space weather forecasting more accurate and accessible for everyone, KU Leuven has recently launched an initiative (Poedts et al., 2019) to integrate and couple all these models in a virtual, interactive space weather modelling platform - the Virtual Space Weather Modelling Centre (VSWMC). Though this platform is currently still in development, 19 separate models from different institutes have been already implemented so far and more are still to come. The models can be either run separately or in a coupled way for any user, in an open-access fashion, in line with the Open Science philosophy promoted by UNESCO. Since many of the models are contributed from and maintained by different institutes, this effort also greatly supports international collaboration beyond simple common usage of VSWMC.

Since the accuracy of the modelling chain is only as good as its initial piece - the coronal model simulations which are based on the measured solar magnetogram data - we also present recent developments in coronal modelling which led to the open source coronal model COCONUT. This tool solves 3D MHD equations with an implicit scheme in a heavily parallelised fashion, which means that it can obtain accurate results within a time span of 1 to 3 hours even for solar maxima. This makes this tool very useful for real-time space weather forecasting, and thus it will be soon also implemented in VSWMC to further improve the accuracy and reliability of the forecasting predictions.

KEYWORDS: magnetohydrodynamics - modelling - forecasting

Belgium

Nonlinear self-deformation of unidirectional surface Alfvén waves and aspects of uniturbulence

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One of the primary goals of this research project is to create new three-dimensional numerical simulations of propagating transverse waves to understand better the physics of turbulence caused by the non-linearly self-cascading model of unidirectional surface Alfvén waves (Ismayilli et al., Frontiers, 2022). In addition to the numerical simulations, we also established an analytical model for the evolution of uniturbulence in surface Alfvén waves. Currently, we are comparing the simulation results for Yaglom's law (predicted energy dissipation) with the results from our analytical model. Additionally, we aim to predict the turbulent flow's inertial range. Plasmas in the solar corona and solar wind are known to be structured across the magnetic field, suggesting that uniturbulence may play a role in these regions. The uniturbulence might provide an extra channel for turbulent cascade and enhance dissipation, particularly in regions with open magnetic fields. Uniturbulence may also be relevant in closed magnetic settings, such as coronal loops, due to the coherence of the interaction. In the future, we would like to clarify our results with the relevant observational data.

KEYWORDS: magnetohydrodynamics (MHD), MHD turbulence, Surface Alfvén waves

Belgium

Employing advanced coronal mass ejection models in EUHFORIA for space weather forecasting

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Huge eruptions of magnetised plasma from the Sun, the coronal mass ejections (CMEs) are one of the major drivers of space weather as they propagate in the solar wind to reach the planets and satellites. As magnetic reconnection enables the plasma and energetic particles to enter the Earth's magnetosphere, CMEs pose a risk to the high-latitude flyers, ground-based technologies and in turn, the overall life and economy on Earth in addition to the space-based technologies and the astronauts/cosmonauts. This motivates the need for forecasting the arrival of the CMEs. How can we predict whether a CME will impact Earth, and how large this impact will be? This can be done by employing both real-time observations of the Sun and physics-based modelling of the processes involved in the initiation and propagation of the CMEs. A flux-rope structure is manifested by CMEs in the interplanetary medium that can be modeled with several types of geometry and internal magnetic field structures. Different models possess different capabilities for operational space weather forecasting. In this work, we present the method of modelling the evolution of CMEs using the data-driven magnetohydrodynamic (MHD) model, EUropean Heliosphere FORecasting Information Asset (EUHFORIA; Pomoell and Poedts, 2018). The modelling consists of two parts, first, the solar wind background is modelled, followed by the injection of the CMEs which have been observed to have a magnetic flux rope structure while propagating in the interplanetary medium. We will introduce some of the CME models implemented in EUHFORIA, namely the spheromak model (Verbeke et al, 2019), the FRi3D model (Isavnin 2016; Maharana et al, 2022), and the torus model (Linan et al, in preparation). In this study, we try to find an optimal setup where the geometry is better than the spherical plasma blob and the simulations are still fast enough for operational forecasting setup. Therefore, we tried a torus geometry for our novel flux rope CME model. In this toroidal CME, we adopt the analytical constant alpha force-free magnetic field configuration of Miller and Turner (1981). With an example of an observed CME event, the observations-based modelling of the CME propagation using EUHFORIA will be demonstrated and the geo-effectiveness i.e., its capacity of causing geomagnetic disturbances, will be quantified. Finally, the current operational capabilities of this kind of modelling will be highlighted and the scope for future improvements will be pro-posed.

This research has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 870405 (EUHFORIA 2.0)

KEYWORDS: Coronal mass ejections, Space Weather Forecasting, Magnetohydrodynamic modelling

Cameroon

Comparison of the daytime variability of equatorial electrojet and vertical drift velocity inferred from ground-based magnetometers and C/NOFS observations in Africa.

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In this study, the longitudinal variability of the vertical drift velocity ($\boldsymbol{E} \times \boldsymbol{B}$) in the African sector has been investigated using ground-based and in-situ observations during quiet periods of years 2012 and 2013. We have utilized the Equatorial Electrojet (EEJ) computed with a pair of magnetometer stations at three longitudinal sectors as proxy for the $\boldsymbol{E} \times \boldsymbol{B}$. This was examined alongside drift data measured by the ion velocity meter (IVM) instrument on board the C/NOFS satellite, the equatorial electric field (EEF) derived from the equatorial electric field model (EEFM) and the winds data computed using the Horizontal Wind Model 14 (HWM14). Notwithstanding the limitation in data over Africa, the combination of ground-based and in-situ observations confirmed the existence of longitudinal differences in the $\boldsymbol{E} \times \boldsymbol{B}$ between the Atlantic, Western and Eastern African sectors. This was well reproduced by the EEFM which showed that during noon, the peak EEF was the lowest in the Atlantic sector, with an increasing trend towards the Eastern longitude. The HWM14 showed that the eastward zonal (poleward meridional) wind velocity was the lowest (highest) in the Eastern sector. Furthermore, the zonal (meridional) wind increased (decreased) from the Eastern to the Atlantic sector. These results highlight the contribution of the neutral wind velocity in driving the longitudinal difference in the vertical drift velocity over Africa.

KEYWORDS: Equatorial Electrojet, Vertical drift velocity, longitudinal variability

Chile

Search and identification of precursors of solar flares based on microwave observations of active regions

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One of the key factors of space weather is solar flare activity, the monitoring and prediction of which is an important task of specialized dedicated groups of space experts and solar astronomers. Solar flare forecasts are made on the basis of identifying and detecting so-called precursors, specific processes in solar activity events that occur before flares. The core selection of data which are becoming as important routine to analyze space weather and make prediction in todays practice is reduced to a few types of measurements made by ales than a dozen spacecraft. Ground based observations and monitoring nowadays are becoming more or less complimentary. Part of the reasons of this is a weather dependence of terrestrial telescopes. However, the solar radio-astronomy is all weather activity and the main issue here is about what new quality it can bring on the table. In retrospect the solar radio bursts were associated with flaring activity since fortieth of last century. Plus, the existing network of solar radio telescopes is now well established. We present the possibilities of fully steerable 32-meter radio telescope of Ventspils International Radio Astronomy Centre (VIRAC), Latvia, which can be useful for searching for new precursors of solar flares.

KEYWORDS: flares, solar activity, radio telescope

Chile

The limits of the solar events amplitudes: the occurrence of strong flares from the point of view of the underlying dynamo mechanism

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Powerful flares with energy releases much above of 10 in 32 erg are very rare events compared to habitual display of Solar activity, routine monitoring of which is already within the reach by the existing Space Weather network (even with a certain degree of predictability). However, much less is known about the scenarios of rare events (like for example the well-known Carrington-1859) or even on hypothetical Superflares, potentially extending the energy limits by orders of magnitude higher. We discuss various options for underlying physical mechanisms and their potential realization in the framework of Solar Physics (comparative analysis with other stars models is useful).

KEYWORDS: Superflares, solar activity, space radiation

Chile

Study and Monitoring of Earth Magnetic field using FASAT Charlie Magnetometer

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The Chilean Earth Observation Satellite, FASat Charlie, has been operative since December 2011. To fulfill their mission, the satellite FASat Charlie use several sensors and actuators, including a magnetometer. These sensors are used mainly by the satellite pointing process. In this information age, new data and studies are required in order to create new knowledge and tools that can be daily used. Considering this scenario, an electromagnetic field analysis was performed with FASat Charlie's magnetometer, specifically for the Earth magnetic field. The main purpose of this study was to geolocalize measurements of Earth's magnetic field and plot them. After this, a comparison with differents international models of the Earth magnetic field was done in order to check the precission of the measurements. An important analysis of this research is to observe, if exist, any change over time and it can affect the satellite operations. The latter was effectively analyzed by comparing differences between measurements with high precision instruments (as principal payload) and plataform equipment (which are less precise).

KEYWORDS: magnetic field, satellite operations, telemetry analysis.

Croatia

Statistical learning TEC predictive model for GNSS ionospheric delay mitigation in self-adaptive environment-aware SDR GNSS position estimation algorithm

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Complexity of space weather, geomagnetic, and ionospheric conditions render them the most prominent source of the Global Satellite Navigation System (GNSS) positioning performance disruptions and degradation (2, 8). Mitigation of space weather, geomagnetic, and ionospheric effects on GNSS positioning performance involve utilisation of generalised/global GNSS ionospheric correction models, and costly bespoke augmentation infrastructure (systems for additional signal and information provision) (2, 3, 8). GNSS operators have been required to ensure the quality of GNSS Positioning, Navigation, and Timing (PNT) service, despite the fact that the positioning environment that causes the GNSS positioning performance degradation is completely out of the operator's control (1, 5, 6, 8).

Recent scientific and technology advancements allows for redrawing the concept of GNSS position estimation algorithm and its deployment. The Software-Defined Radio (SDR) concept in GNSS receiver design renders the GNSS position estimation algorithm transparent and open for modifications and advancements, including development and deployment of bespoke GNSS position estimation algorithms tailored for specific GNSS applications (2, 5, 6). GNSS receivers are embedded in the mass-market mobile computational and communication platforms, such as modern smartphones, equipped with sensors, which may be used for observations of positioning environment conditions (6). The SDR concept combines with statistical learning methods in development and deployment of tailored GNSS ionospheric error correction model based on the situation awareness of the immediate positioning environment (i. e. space weather, geomagnetic, and ionospheric) conditions (4, 5, 6).

Here a novel concept for GNSS SDR position estimation algorithm is proposed, based on raw GNSS pseudorange observations corrected for Total Electron Content (TEC)- derived GNSS ionospheric effects through utilisation of a self-adaptive positioning environment-aware statistical learning correction model (5). The positioning environment awareness is accomplished either with the direct embedded sensor-based observations, or through mobile internet access to trusted thirdparty data (5). The TEC/GNSS ionospheric correction model adapts itself to the identified class of positioning environment conditions status, and produces correction based on its previous experience and the situation awareness of current positioning environment conditions (4, 5). We demonstrated success of the proposed self-adaptive environment-aware TEC/GNSS ionospheric effect mitigation approach in the proof-of-principle applied in several scenarios of disturbed ionospheric conditions at different latitudes (5, 7). Developed in the open-source R environment for statistical computing, the proof-of-principle selfadaptive environment aware TEC GNSS SDR ionospheric correction model is a development and a testing framework that will allow for further enhancement and improvement of

the proof-of-principle. Its ultimate goal is to become a personalised GNSS SDR ionospheric effect correction model that generates correction based on the previous experience of the process and the actual positioning environment conditions, as a more affordable alternative to existing not flexible models and the expensive infrastructure in augmentation of the GNSS position estimation process.

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KEYWORDS: GNSS ionospheric effects; statistical learning; positioning environment awareness

Egypt

The ionospheric response to geomagnetic storms in Asia using the GNSS network

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Ionospheric response has been a subject of recent interest. This research carried out from observation and analysis of TEC (Total Electron Content) using IGS network for CUSV station in Thailand the geomagnetic storms used was during end of solar cycle 24 (2019) and the start of solar cycle 25 (2021). The number of the magnetic storms contributed are 16 at the magnetic equator level. Studying the time of ionospheric influence using the selected region with the Dst deduced a correlation and equation that describe the behavior of the ionosphere. Even in weak magnetic storms there is a noticeable effect in the ionosphere The correlation values where 0.98 for 2019 and 0.95 for 2021. The relations show different behavior in both cycles.

The equation can be used to create ionospheric models for a better understanding to the TEC on the ionosphere during the geomagnetic storms and their response time.

KEYWORDS: Insert your keywords here – geomagnetic storms, ionospheric response- TEC calculation

Egypt

Monitoring the impact of solar event along Europe –African west chain

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The ionospheric spatial variation along west Europe –African GPS-Chain cross the North Crest Equatorial Anomaly has been studied associated to solar event. To understand the VTEC during the magnetic disturbance of November 2012, the GIM/CODG maps have been used.

The VTEC at longitude 15° from November 9 to 18, 2012 has been used to give comprehensive latitude coverage extending from the pole to the equatorial region. The Earth was under the influence of a high speed solar wind stream during four days, and IMF was southward during a very long period. The variation of the disturbed magnetic observations and GPS-VTEC are compared with the variation of quiet days during the same month in order to obtain the characteristics of GPS-VTEC and magnetic disturbances due to the solar event effect. The GPS-VTEC seasonal variation can be observed.

KEYWORDS: Equatorial Anomaly – GIM/CODG maps – Magnetic disturbances

Ethiopia

Equatorial and low-latitude ionospheric TEC response to CIR-driven geomagnetic storms at different longitude sectors

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In this study the response of ionospheric F-region to 18-21 September 2014, 19-24 January 2016, and 07-10 March 2016 CIR-driven storms in the equatorial and low-latitude region of America, Africa, Asia, and Pacific sectors are investigated. TEC data obtained from the Global Navigation Satellite System (GNSS) receivers, located in the four longitude sectors and electron density (Ne) measurements obtained from Swarm-A satellite were used. The storm time behavior of TEC was analyzed by computing its deviation from quiet monthly median TEC (ΔTEC). The rate of change of TEC index (ROTI) and the relative electron density perturbation (ΔNe/Ne) derived from GPS-TEC and Swarm-A, respectively, were used as ionospheric irregularity proxies. In this study, we have also analyzed the ionospheric current disturbances during the storm events using ground-based magnetic data. The result revealed that significant nighttime positive ionospheric storm reaching about 284% (Africa, nklg), 115% (Africa, dakr), and 191% (Pacific, naur) was observed during the storm main phase 19 September 2014, 20 January 2016, and 06 March 2016, respectively. This could be associated with oscillation in the IMF Bz and minimum value in ionospheric current disturbance (Diono). Nighttime negative ionospheric responses were also observed in the American sector during the storm main phase of 18-21 September 2014 and 19-24 January 2016 and in the Asian sector during 18-21 September 2014 events, possibly due to the combined effects of over-shielding/disturbance dynamo electric field and neutral composition change. During the storm recovery phases (21-23 January 2016, 07-10 March 2016), significant positive ionospheric storm were also noticed. The occurrence of ionospheric irregularities was observed over the equatorial and low-latitude region of America and Africa during the main phase of 18-21 September 2014, 19-24 January 2016, and 05-10 March 2016 storm events, possibly related with the enhancement in the zonal electric field observed during dusk period, when oscillation in IMF Bz exists. During main phase of the storms, while the occurrence of ionospheric irregularities over Asian and Pacific longitude sectors are suppressed, it frequently occurs over the American longitude sector. Postsunset behavior of plasma density irregularities observed by Swarm satellites is consistent with the ground-based observation of TEC fluctuations.

KEYWORDS: CIR-driven storm, Positive/negative ionospheric storm, Ionospheric irregularity

Germany

First joint STIX and LOFAR observations of a flare event on 06 June 2020

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A joint analysis approach is used to study solar flare signatures both in the low and higher corona. STIX, AIA and LOFAR data provide an extensive picture about different aspects of flare characteristics. Recent data by the STIX instrument complement the picture of accelerated electrons, which propagate along magnetic field lines towards the Sun. These observations are linked to the LOFAR data, which contain information about the electrons propagating away from the Sun through the corona above the active region. Although, the active region and its thermal evolution (Differential Emission Measure (DEM) reconstruction of AIA data), flare accelerated electrons and their radio traces (LOFAR, STIX) are in principal all associated with the energy release during the flare process, they are often studied separately. However, in order to derive a complete picture about space weather, the relation between various phenomena of solar activity is essential. Hence, the investigation of possible relations is part of this project. Solar magnetic fields as a binding element between low and high corona, accelerated electrons and heated flare loops are included in the analysis via a Potential Field Source Surface (PFSS) model. The circumstances under which an active region is going to transfers part of its non-potential magnetic field energy to particle acceleration and therefore may produce SEPs, are of great interest with respect to space weather. Groups of solar type-III radio bursts are observed in this event occurring only over very short time intervals. We aim to investigate whether this is due to a changing magnetic field configuration, i.e. from confined to open, or whether a change in the particle acceleration process itself causes the observed radio signatures. A better understanding of both, magnetic field configuration changes over the flare course, as well as the SEP emitting capability of an active region may contribute to future space weather forecast systems.

KEYWORDS: Solar Flare – Multiwavelength analysis - STIX

Ghana

Ionospheric plasma fluctuation response to space weather to space weather events in September 2017, August 2018, and March 2015 (St Patrick's Day) over the equatorial and low latitude region

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Using data collected by GNSS dual frequency receivers network, detrended TEC maps were generated to identify and characterize the medium-scale traveling ionospheric disturbances (MSTIDs) over equatorial region during solar cycle 24 space weather events. During the September 2017, August 2018, and March 2015 (St. Patricks day) geomagnetic storm, plasma fluctuations which have features of MSTIDs were observed in the low latitude and equatorial region and their characteristics were calculated. The present work serves as a strong foundation to unearth the mystery of the generation, propagation, and the entire morphology of traveling ionospheric disturbances TIDS over the equatorial and low latitude region during space weather events and consequently the contribute to the global ionospheric weather/climate. We also realized that the MSTIDs that occur during space weather events contribute to the plasma bubble generation.

KEYWORDS: ionosphere, space weather and plasma fluctuation

India

Cross wavelet analyses of convection electric field and excess equatorial ionospheric TEC

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The polar convection electric field caused due to the charge separation of the solar wind plasma and associated with the Region-1 current, is responsible for the generation of a zonal electric field generated at the geomagnetic equator. This electric field called the Prompt Penetration Electric Field (PPEF), occurs through the process of under shielding and over shielding of the convection electric field, when the z-component of the Interplanetary Magnetic Field, IMF Bz, switches its direction. This PPEF thus generated at the equatorial region in the East-West direction, in turn, causes upward drift of the equatorial ionospheric plasma. The raised plasma, due to the reduced recombination rate at greater ionospheric heights, leads to increased Total Electron Content (TEC) at the location. The work presented herein, utilizes a continuous Cross-wavelet transform (XWT) technique to analyze the quantitative extent of connection between the convection electric field and the increased TEC at an equatorial location. The excess values are derived upon comparing with the quiet day expectation values. Morlet wavelet is taken as the mother function. The XWT output points out the principal component of the input electric field, that has most significant contribution to the generation of the PPEF. It also reveals to quantitative cross-magnitude, lag time, nonstationarity, and coherency between these two geophysical variables. The time series of the input convection electric field values are derived from the Interplanetary Magnetic Field (IMF) and solar wind velocity while the vertical TEC values are obtained from the dual frequency GPS receivers. The data used is from the St. Patrick's Day storm, the most severe geomagnetic storm that occurred during the Solar Cycle -24. The XWT results obtained here, detect strong cross-amplitudes of strength about 0.9 between the input electric field and the excess TEC which is in the 8192 seconds period band. This result, not only reestablishes the causal relationship between the two parameters in question but also indicates the principal driving component to be of period shorter than 8 hours, which is corroborated by the earlier findings. Uniform phase differences in the region of high cross-amplitude strength, points towards a delayed manifestation of the effect of about 17 minutes.

KEYWORDS: Convection Electric Field, TEC, Cross Wavelet analysis

India

On the response of equatorial thermosphere-Ionosphere system to the annular solar eclipse on 26 December 2019: Preliminary results

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The present work discusses the role of energetics and dynamics playing in bringing the altitudinal distribution of plasma in the equatorial upper atmosphere during an annular solar eclipse on 26 December 2019. The study has been conducted at Thumba (8.5o N, 77o E, 0.05o dip) a dip equatorial station situated at the peninsular India. The primary results show that a transient pre-reversal enhancement (PRE) like situation has been evidenced in the equatorial region following a sudden decrease in the E region conductivity and the inhibited ExB drift has resulted in top and bottom side additional layering for a short span of time. The satellite data also supports the eclipse induced altered electrodynamics. The disturbed patterns in thermospheric winds can be one of the possible candidates for additional layering and accumulation of plasma. This layering has been very important implications as far as the dynamics are concerned. The present work discusses these aspects in detail.

KEYWORDS: thermosphere-ionosphere, solar eclipse

India

Comparison of IRI simulated top-side ionosphere with the in situ satellite observations

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Earth's ionosphere-thermosphere is a dynamically coupled complex system governed by the forcing from solar activities as well as lower atmosphere. The knowledge of ionospheric state and underlying processes is quite imperative due to their role in deciding space weather and influence on radio communications. An empirical model, namely the International Reference Ionosphere (IRI), which is recognized as the official standard for the ionosphere, can simulate a realistic state of the ionosphere. Several studies have reported the performance of the model. However, studies on evaluation of model simulation of top-side ionosphere is lacking specifically using the recently released (May 2022) improved version of the model, IRI-2022. In this regard, a study has been carried out for comparing the IRI simulated top-side ionospheric state with the satellite-based in situ observations. In situ measurements of ionospheric parameters at the altitude of ~600 km over +40° to -40° N by Ionosphere Plasma Electrodynamics Instrument (IPEI) on board Formosat-1 satellite during 1999-2004 (~5.5 years) have been used in the present analysis. First we analysed and detected the small scale (~80 km) ionospheric irregularities and excluded corresponding ionospheric parameters for the comparison with the IRI model simulated results. Collocated satellite and model simulated parameters were obtained at 10 second intervals, which were then gridded (4° x 4°) and monthly averaged. Grid by grid comparison of monthly mean Ion density, ion temperature and ion composition (O+, H+, He+, N+, NO+, O2+) were carried out. Our analysis showed that the model could reproduce the observed 60-80% variabilities besides the variable dependent positive or negative biases. In general, model performance is better around the magnetic equator (±10° degrees). However, there exists significant discrepancies at some of the regions, which need to be understood through a detailed analysis. The recent version of the IRI model also calculates the probability of occurrence of spread-F. Comparison between the spread-F probabilities from the model and those calculated from satellite observations is also being made. Detailed analysis is in progress and further results will be presented during the workshop.

KEYWORDS: International Reference Ionosphere, Formosat-1, Space Weather

India

Study of solar elemental abundances evolution during solar flares using satellite-based soft x-ray measurements

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Solar flares are violent energetic releases of stored magnetic energy from the Sun, originating from the solar corona. Understanding solar flares and associated mechanisms are of paramount significance due to their impact on space weather, ionosphere, and their association with coronal mass ejections (CME). The emission associated with the flares lies in the soft X-ray regime (0.1 - 4 nm) as the corresponding temperature is 10 MK over the coronal background temperature of 1 MK. The presence of continuum emission in these wavelengths makes retrieving absolute abundances easier than only relative abundances, unlike EUV spectral window. In view of this, various global satellite missions with soft X-ray measurement capability have been flown over the years to monitor the Sun's X-rays for the early detection of solar flares, coronal mass ejections, and other phenomena that influence space weather. Recently soft X-ray spectrometers, XSM (Solar X-ray monitor) onboard CHANDRAYAAN-2 and DAXSS (Dual-zone Aperture X-ray Solar Spectrometer) onboard INSPIRESAT-1 satellite, were launched in 2019 and 2022 respectively. Preliminary observations from these instruments are in good agreement with the general understanding of X-ray spectrum and flare-related emissions. This abstract reports preliminary results obtained through a modeling study of the temporal evolution of elemental abundances during solar flare events. Simultaneous observations of continuum emission and the spectral lines in the wavelength range of 0.1 to 10 nm have been utilized to retrieve various physical parameters such as temperature and absolute elemental abundances. The flare emissions are modeled assuming optically thin emission, and the CHIANTI atomic database is used to generate synthetic spectra. To avoid prohibitive computational time requirements, the synthetic spectrum is computed as the weighted sum of pre-calculated individual elemental spectra, with weights equal to individual elemental abundances. These synthetic spectra are fitted to observed spectra using Bayesian techniques, and Bayes factors of different models are compared to determine the better model. Our results show elemental abundances moving from coronal values toward photospheric values, showing support for the standard flare model and chromospheric evaporation. Detailed analysis is in progress and further results on model validation will be presented during the workshop.

KEYWORDS: solar flare, x-ray, elemental abundance

Iraq

Comparison between the position central angle of coronal mass ejections (CME) and its angular width for high and low solar activity and effects on magnetosphere

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Solar eruptive phenomena embrace a variety of eruptions, including flares, solar energetic particles, and radio bursts. Since the vast majority of these are associated with the eruption, development, and evolution of coronal mass ejections (CMEs), we focus on CME observations in this research. CMEs are a key aspect of coronal and interplanetary dynamics. They inject large quantities of mass and magnetic flux into the heliosphere, causing major transient disturbances.which means they can produce severe impact on Earth's magnetosphere .The data was obtained from the Solar and Heliospheric Observatory (SOHO) for the period of maximum and minimum solar

In this study it was compared the averaged number of CME that occur during of maximum solar activity (2001-2002) and the solar minimum (2008-2009) for solar cycle 23. And also was compared between number of CME that occur during of maximum solar activity (2013-2014) and the solar minimum (2017-2018) for solar cycle 24 depending on the position central angle of coronal mass ejections (CME) and its angular width activity of the solar cycle 23 and 24, And the increase was in the averaged number of CME appears in all four parts of the sun during high solar activity,Also increase in angular width for CME during that period.

Comparing the Daily Average events of coronal mass ejections (CME) For each of the four parts of the sun at depending on the position central angle (Pa) for coronal mass ejections (CME) During the minimum solar cycle 23 of the years 2008-2009 , and maximum of the years 2008-2009 . In addition to the minimum solar cycle 24 of the years 2017-2018, and maximum of the years 2013-2014.Presented results confirm that influential phenomena having solar origin,The Average for frequency of occurrence of CME. The CME rates were relatively larger during SC 24 than during SC 23.

2- Comparing the averaged number of CME that occur during of maximum solar activity (2001-2002) and the solar minimum (2008-2009) for solar cycle 23. And also was compared between number of CME that occur during of maximum solar activity (2013-2014) and the solar minimum (2017-2018) for solar cycle 24 depending on the position central angle of coronal mass ejections (CME) and its angular width

2. The increase in the averaged number of CME appears in all four parts of the sun during high solar activity,Also increase in angular width for CME during that period.

KEYWORDS: Coronal mass ejections , position angle , angular width

Italy

Space weather studies with the NeQuick Ionospheric Electron Density Model

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NeQuick is the three-dimensional and time dependent ionospheric electron density model developed at the Abdus Salam International Centre for Theoretical Physics in Trieste, Italy, with the collaboration of the University of Graz, Austria. It is an empirical quick-run model particularly designed for trans-ionospheric propagation applications that has been conceived to reproduce the median behavior of the ionosphere. It allows calculating the electron concentration at any given location in the ionosphere and thus the Total Electron Content (TEC) along any ground-to-satellite ray-path by means of numerical integration. To provide "weather-like" descriptions of the 3-D ionospheric electron density, different data assimilation techniques have been implemented. They are based on the model adaptation to ground and space-based GNSS-derived TEC data and ionosonde measured peak parameter values. In this contribution, specific examples related to the use of the NeQuick in Space Weather studies will be presented. In particular, the TEC data assimilation methods will be described and their effectiveness in retrieving the ionosphere electron density at a given location and for different heliogeophysical conditions will be analyzed.

KEYWORDS: NeQuick, Ionospheric Data Assimilation

Kazakhstan

Investigation of the relationship of electron flux enhancements with interplanetary and geophysical characteristics in 1994-2020

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Various parameters of solar and interplanetary activity, as well as measurements of high-energy electrons on GOES satellites, were used to study the relationship of increases in high-energy magnetospheric electrons with energy >2 MeV in geostationary orbit with solar, interplanetary and geophysical characteristics in 1994-2020. A catalog of electronic events has been created in which the electron fluence exceeds 10^8 cm–2·sr–1·day–1, where the characteristics of the increases of high-energy magnetospheric electrons, near-Earth and interplanetary medium are given. 484 events of fluence increases of high-energy magnetospheric electrons were analyzed, for which the delay time of the electron flux increase relative to the beginning of the geomagnetic disturbance and the increase in the solar wind velocity were calculated. It is shown that a dangerous increase of electrons in geostationary orbit is observed with a delay of about 1-2 days after the arrival of a shock wave in near-Earth space and an increase in the speed of the solar wind. The relationship of the delay time of electronic events is investigated and the distribution of the number of electronic events depending on their duration is obtained.

KEYWORDS: magnetospheric electrons, geomagnetic activity, solar wind

Kenya

Geomagnetically induced currents: The case of Kenyan electric power grid

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The Sun emits highly conducting plasma at supersonic speeds of about 500kms-1 into the interplanetary space as a result of the supersonic expansion of the solar corona. These particles cause geomagnetic storms when they interact with the Earth's magnetic field, leading to the development of an induced potential difference on the surface of the earth called Earth Surface Potential (ESP). The ESP produces Geomagnetically Induced Currents (GICs) in ground-based electrical conductor systems. GICs have been found to cause damage to electrical power transformers, oil and gas pipelines in high latitude regions such as Canada and Finland, mid-latitude regions such as South Africa and low-latitude regions such as Japan. No such studies have been carried out in Kenya although possibility exists that being a low-latitude region, technological systems that rely on electrical power could be affected by GICs. In this study, we calculated the magnitude of GICs in Nairobi, Kenya during geomagnetic storms within a low solar activity year and investigated the relationship between these GICs and observed transformer break downs and power blackouts in the power grid during these times. We used the Magnetic data from the MAGDAS Station and resistivity data from the Departments of Physics and Geology of the University of Nairobi, respectively. The maximum absolute value of modeled GICs was found to be 8 A and this occurred during a minor storm. The variation in the geomagnetic field was found to exceed the threshold of 30nT/min. It was found that for each geomagnetic event there was a corresponding power system event either on the same day of the geomagnetic event or later within one week. Nevertheless, our results are model-based and measurements of GICs also need to be carried out in the power grid in Nairobi over a solar cycle if measuring gadgets are installed in order to obtain a more comprehensive account of geomagnetic disturbances on the power system in Nairobi and Kenya at large. From the foregoing, it follows that the power grid in Nairobi, Kenya might have been affected by GICs and so mitigation measures need to be put in place to prevent future power outages and transformer breakdowns arising from the effects of GICs, especially during solar maxima when geomagnetic storms are expected to be more intense.

KEYWORDS: Earth Surface Potential, Geomagnetically Induced Currents

Latvia

Microwave observations of the Sun with VIRAC RT-32 Radio Telescope

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Nowadays microwave observations of the Sun remains one of significant trends in the solar radio astronomy and solar physics. Observations and analysis of spectra of the solar microwave emission proposes an unique possibility for direct measurements and studies of the spatial distribution of plasma parameters and magnetic field inductions in the upper chromosphere and the lower corona by known methods.

Ventspils International Radio Astronomy Center (VIRAC), Latvia, performs routine microwave spectral polarimetric observations of the Sun since 2013. Today spectral polarimetric observations of the Sun were implemented by VIRAC RT-32 radio telescope equipped with multi-channel (12 frequency channels) spectral polarimeter in 2.1-7.5 cm wavelength range and both circular polarizations simultaneously in a “single dish” mode. Final results of solar observations were expected as a set of Stokes I and V 2D maps of calibrated brightness temperatures of the microwave emission with a limited spatial resolution for each of frequency channels.

The presentation concerns on physics, technical and data processing issues of solar microwave observations performed with VIRAC RT-32 radio telescope. Some solar physics tasks which could be solved with these observations are discussed as well.

KEYWORDS: solar physics, solar radio astronomy, solar microwave emission

Malaysia

A statistical analysis of geomagnetic storms and their effect on Earth atmosphere currents

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This study presents geomagnetic storm statistics for 24 solar cycles from 2009 to 2019 while looking at the effects of currents flowing on Earth using selected events. Our analysis characterized the geomagnetic storm using the Dst index for the entire year of the solar cycle 24. This work observes the (GIC) and (EEJ) currents changes based on observational data at different latitudes. The geomagnetic stations detect GIC existence at high and medium latitudes. At the same time, variation in EEJ current is observed using data collected from stations located in the geomagnetic equatorial region. This study identified several variations at the geomagnetic phases, even in the same geomagnetic storm type, such as long, rapid, and complex recovery during the moderate storm. In addition, our analysis observed that the GIC occurs in high latitude geomagnetic areas. This GIC events occur if the AE index reaches around 500 nT for a long time and the maximum value reaches 1000 nT. Furthermore, for the equatorial areas, the EEJ current is disturbed during geomagnetic storms. This EEJ current also seems related to the AE index and GIC, indicating the current chain from high latitude to the equator region.

KEYWORDS: Geomagnetic storm, EEJ, GIC

Malaysia

Analysis of geomagnetic disturbances for earthquake precursor detection

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The application of electromagnetic signals in earthquake study has been demonstrated by previous researchers through the monitoring of geomagnetic variations. The previous studies have revealed inconsistencies in implementing the diurnal variation ratio (DVR) approach and the results were also found to be limited in specific events. This study sought to enhance the reliability of earthquake forecasting by implementing two different variants of DVR methods in investigating the magnetic responses prior to earthquakes (EQ). Through the SuperMAG database, 1-min sampling (low-fidelity) period of global geomagnetic daily variations data recorded by global magnetometer stations between year 2000 - 2020 with magnitude above 5.0 were downloaded and analyzed. Two approaches of DVR, namely DVR using threshold value (Method 1) and DVR using the comparison with 1-year background geomagnetic data (Method 2) has been employed to determine the most feasible method in finding the earthquake precursor. It is found that Method 1 approach yields results with precursors present significantly more than Method 2. The anomalous behaviors exhibited by each earthquake event in geomagnetic diurnal ratio variations were concluded to be detected in all components prior to the earthquakes. The anomalies were found to be detected earlier through Method 1 than in Method 2. All geomagnetic N, E, and Z components showed anomalous behavior during the quiet days but with temporal lags between the components. To further investigate the seismo-ionospheric effect in the Z-component, a multi-observation approach using different kinds of sensors such as GPS for total electron content (TEC) will be conducted.

KEYWORDS: Geomagnetic diurnal variation, earthquake precursor, SuperMAG database

Mexico

Public policies and civil protection in space weather

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The objective of this presentation is to show the mandate of the general civil protection law regarding astronomical phenomena and to contribute to the development of public policies for the prevention of disasters due to space weather events.

Likewise, it is to show the advances in public policy actions for civil protection in space weather that have been developed in Mexico in the last three years.

The achievements of this public policy in Mexico include the formation of a working group, education and outreach, national space weather programmes, the creation of a service and a national laboratory, the formation of a network of instruments with space weather applications, the publication of the first global space weather studies in Mexico using own data, and civil protection actions to contribute to the development of public policies that contribute to the development of civil protection in space weather.

KEYWORDS: Public policy, civil protection law and education and outreach

Morocco

The contribution of CRASTE-LF to capacity building in space science and technology in Africa

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The African Regional Centre for Space Science and Technology Education-in French Language (CRASTE-LF) was established in Morocco on 23 October 1998 under the initiative of the UN Office for Outer Space Affairs (UNOOSA) programme in fulfilment of the UN General Assembly Resolution 45/72 of 11 November 1990 and 50/27 of 6 December 1995. The CRASTE-LF is based at the Mohammadia School of Engineers of the Mohammed V University of Rabat in Morocco. It was initially founded by 11 Member States, and subsequently joined by 2 others African countries in 2002 and 2004.

The CRASTE-LF is mandated to build capacities in space technology in the francophone African region. Its objectives are to increase knowledge in space sciences and technologies by organizing postgraduate and/or activities: short courses, seminars, workshops and conferences at regional level; improve the technical competence of experts, teachers and decision-makers and to keep them informed about technical progress; assist the countries of the region in the development of endogen capacities in space tools; strengthen local and regional capacities; promote cooperation between the developed countries and member states as well as among these states; and develop expertise in space sciences and technology.

Since 2000, the CRASTE-LF has regularly organized post-graduate training in space science and technology in 4 options: Remote Sensing and GIS, Meteorology by Satellite and Global Climate, Satellite Telecommunications and Satellite Navigation Systems (GNSS).

To date, the CRASTE-LF has organized 33 post-graduate training sessions for 483 trainees from 22 countries, and 45 international and regional activities to benefit to more than 3200 trainees from 61 countries, in 12 French-speaking African countries. These activities covered a wide range of topics related to Space Sciences and Technology, such as spatial information and sustainable development, climate change, disaster management and emergency management in Africa, GNSS etc.

KEYWORDS: CRASTE-LF, Capacity Building, GNSS

Nepal

Total Electron Content estimation and comparison using multi-GNSS constellations at Pashchimanchal Campus

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From the past few years, the number of applications has been increasing for Global Navigation Satellite System, which consists GPS of Americans, Russians GLONASS, GALILEO of Europeans and Chinese BeiDou. Apart from GNSS, the regional navigation systems; QZSS of Japanese and NavIC of Indians were also developed. One of the major applications of GNSS is to study the ionosphere propagation medium behavior by estimating TEC, Scintillations and Faraday rotation of electromagnetic waves. The main objective of this research paper is to estimate and compare TEC by using signals of multiple GNSS constellations over the receiver located at Pashchimanchal Campus, Pokhara (28°15'18.3"N, 83°58'35.1"E), Nepal. For this an experimental setup was established with multi frequency GNSS receiver and TEC of ionosphere estimated using the data raging from July 5, 2022 to August 3, 2022 i.e day186 to day 215 of year 2022. By analyzing the results, the maximum anomalies in TEC of the range upto (600 TECu) found along the GLONASS constellation signal path while the minimum value of TEC of the range (60 TeCu) was found in both GPS and Galelio Satellite Constellation. Further the results confirmed that the data of multiple constellations can be used to study the ionosphere medium.

KEYWORDS: GNSS, Ionosphere, Total Electron Content(TEC)

Nigeria

On the evolution of dynamical complexities in space environment over four solar cycles

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The paper presented the results of the investigation of the dynamical complexities of the space environment using the hourly Dst values obtained from the World Data Center for Geomagnetism, Kyoto, over four solar cycles (1964–2008) using nonlinear methods: sample entropy, Lyapunov exponents, correlation dimension, recurrence quantification analysis, and multifractal detrended fluctuation. The space environment was observed to be chaotic based on Lyapunov exponents obtained. The order of increasing complexity in the solar cycles based on recurrence rate (RR) values is Cycle 21 < 22 < 23 < 20. Similar patterns and trend were observed in the correlation dimension values for the different solar cycles. The peak of each solar cycle is associated with high chaoticity. In all the analysis considered, high values of sample entropy, Lyapunov exponent, correlation dimension, correspond to increasing chaoticity. However, lower value of RR signifies more chaotic activity. The solar cycle 20 with the greatest values of mean sunspot number (651.62) and standard deviation of sunspot number (1,656.90) has the greatest chaoticity. The chaoticity in the magnetosphere increases with increasing geomagnetic activity as captured by Dst index. Similar trends were not observed in BZ and solar wind dynamic pressure which showed that the observed chaoticity is due to internal variations. The multifractal spectrum of Dst at all solar cycles considered revealed that the chaotic activities in the magnetosphere are not influenced by the local fluctuations in the region

KEYWORDS: Space environment, chaos, magnetosphere

Pakistan

Plasma irregularities over low-mid latitudes during instense geomagnetic storms of solar cycle 24

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We use ground-based (GNSS and magnetometers) and spaceborne (GUVI, SWARM) instruments data to study the ionospheric response over equatorial-low and middle latitudes to the intense geomagnetic storms that occurred during the solar cycle 24. The Global Navigation Satellite System (GNSS) receivers data is used to compute the Total electron content (TEC) variations during the storm period. The intensity of ionospheric irregularities can be exhibited from the rate of change of TEC index (ROTI) variations. The ROTI index is used to characterize the scintillation of the electromagnetic signal due to plasma irregularities and equatorial plasma bubbles (EPB). ROTI index in the equatorial, low-latitude, and middle latitudes is used to identify the spatial-temporal variation of scintillation during geomagnetically active period. The magnetometers data is used to estimate the storm time variations in the horizontal component of the magnetic field and the disturbances in the ionospheric E region electric currents (Diono). The variations of the horizontal component (H) of the magnetic fields are used to evaluate the disturbances in the ionosphere due to the equatorial electrojet (EEJ) which represents an intense electric current flowing along the dip-equator in the day-side ionospheric Eregion. The simultaneous analysis of the Diono and EEJ strengths help in identifying the pre-reversal effect (PRE) condition that play strong role in the development of equatorial plasma bubbles (EPBs).

KEYWORDS: Geomagnetic storms, Ionosphere, Plasma Bubbles

Pakistan

Detection, analysis and forecasting of sunspot groups (active regions) using advanced machine learning

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The study of the Sun has revealed fundamental physical puzzles that have resisted understanding for generations of astronomers. Solar flares can damage satellites used for commercial communications, global positioning, intelligence gathering, and weather forecasting and directly affect the ionosphere and radio communications at the Earth, and also release energetic particles into space. Predicting the impacts of the Sun on Earth's climate and on "space weather" in the near-Earth environment is vital in understanding the solar dynamics. Therefore, to understand and predict 'space weather' and the effect of solar activity on the Earth, an understanding of both sunspots and solar flares is required. The continuing development of ground and space-based observatories brings astronomy to the Big Data era hence the need of new computational tools even more. Deep learning & artificial neutral networks are active research areas in machine learning and pattern recognition that offer excellent opportunities.

The proposed presentation will focus on an on-going project focusing on developing a machine learning based time series forecasting algorithm that will not only allow us to forecast and validate the future sunspots/active regions but also aid in studying useful physical properties such as sunspot areas and its evolution on the solar disc from the image. For the project, data collection stage consists of collecting data in the form of images from various data sources such as NASA's Solar Dynamics Observatory (SDO) Data archive, Virtual Solar Observatory (VSO), Heliophysics Event Knowledgebase (HEK), Joint Science Operations Center (JSOC) Database and AIA Synoptic Data Server. The dataset is included data from Solar Cycle 24 that started in 2009 and ended in late 2020. Only NASA's SDO collects 1 TB of data per day using its science instruments that makes handling this massive amount of data a challenge. The dataset also contains images taken in different wavelengths depending upon the instruments used. For such Big Data to handle, state-of-the-art big data computing tools and practices along with advanced machine learning and AI algorithms are required.

This project offers unique opportunities like understanding and predicting the impacts of the Sun on Earth's climate, understanding the role of solar evolution in the evolution of life in planetary systems, astronomy education & research opportunities, national & international level collaborations and communication & navigation systems' studies.

KEYWORDS: Sunspots, Big Data Computation, Machine Learnings

Poland

Current performance of IGS ionospheric products and future improvements

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The Ionosphere Working group started the routine generation of the combine Ionosphere Vertical Total Electron Content (TEC) maps in June 1998. This has been the main activity so far performed by the eight IGS Ionosphere Associate Analysis Centers (IAACs): CODE/Switzerland, ESOC/Germany), JPL/ U.S.A, UPC/Spain, CAS/China, WHU/China, NRCan/Canada and OPTIMAP/Germany. Independent computation of rapid and final VTEC maps is used by the each analysis centers: Each IAAC computes the rapid and final TEC maps independently and with different approaches. Their GIMs are used by the UWM/Poland, since 2007, to generate the IGS combined GIMs. Since 2015 UWM/Poland generate also IGS TEC fluctuations maps.

Key accomplishments:

a) First attempts to the IGS real-time ionospheric services have been made and first results have been obtained:
Within works carried out under the development of the real-time global ionospheric maps (RT-GIMs) the computation methods of RT-GIMs from four individual IGS ionosphere centers were assessed and a new version of IGS combined RT-GIM was introduced.
The assessment of the RT-GIMs was carried out in two approaches: above the ocean the RT-GIM-derived VTEC values were compared with observation from the Jason-3 mission. Above the Continental part, dSTEC values were calculated from RT-GIMs and then compared with direct GPS-dSTEC observations. The quality of most IGS RT-GIMs is close to postprocessed GIMs.
The real-time weighting technique for the generation of IGS combined RT-GIM performs well when it is compared with Jason-3 VTEC and dSTEC-GPS assessment. The real-time weights of RT-GIMs are defined as the normalized inverse of the squared rms of RT-dSTEC errors and represent the accuracy of RT-GIMs in the RT-dSTEC assessment. For each RT-GIM, the number of daily winning epochs is computed by counting the number of epochs within the day when the one RT-GIM is better than the other RT-GIMs.

b) IGS ROTI Maps: current status and its extension towards low latitudes and Southern Hemisphere:
The IGS diurnal ROTI maps ionospheric product was developed to characterize ionospheric irregularities occurrence over the Northern hemisphere and has been available for the community since 2014. Currently, the diurnal ROTI maps database hosted by NASA CDDIS covers the period from 2010 to now.
Apart from actual ROTI maps product production, we work on the extension of ROTI maps to cover not only the Northern hemisphere but also the area of the Southern hemisphere and equatorial/low latitude region. Such extended ROTI maps are important for ionospheric

irregularities climatology research and ionospheric responses to space weather. We present recent development toward the new ROTI maps product and the updated data format. To evaluate extended the ROTI maps performance, we analyzed the ability to represent key features of ionospheric irregularity occurrence over the Southern hemisphere and low latitudes. For auroral and midlatitudes, we present the cross-comparison of ROTI-derived irregularities patterns over the Northern and Southern hemispheres. For low latitudes, we examined the sensitivity of the resulted ROTI maps to detect plasma irregularities associated with equatorial plasma bubbles development for low, middle, and high solar activity periods.

KEYWORDS: Ionosphere, IGS, Space Weather

Russian Federation

Evidence of impact of earthquakes on geomagnetic and ionospheric activity during spotless sun

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We investigate the geomagnetic and ionospheric effects of seismic activity during 1810 Sun spotless days (SSL) from 1994 to 2020. Newly developed 1h geomagnetic index Hpo and the ionospheric Weq index are used for the comparisons with the daily peak earthquake Mw. The ionosphere Weq index is derived at the EQ epicenter from JPL GIM-TEC map. Superposed epoch analysis is used with the zero epoch time t0 taken at EQ. It is found that the magnitude of Hpo(t0) is always less that the both peaks of Hpo(preEQ) and Hpo(afterEQ). Similar effect is observed with the peak of the absolute values of |W(preEQ)| and |W(afterEQ)| the both exceeding |Weq|. The seismic activity tends to increase towards the solar minimum when SSLs occur. Our results provide evidence that EQ-related geomagnetic and ionospheric activities experience decline of intensity at the time of EQ during SSL.

KEYWORDS: Earthquake; geomagnetic activity; ionospheric disturbance; spotless Sun

Russian Federation

Spectral transfer of magnetic helicity in short-correlated plasma turbulence

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Modern studies of the solar small-scale magnetic field suggest that helicity in the convective shell can play a significant role both in the global solar dynamo cycle and in the frequency of flare phenomena. However, there is no clear understanding of how magnetic and hydrodynamic helicities accumulate in a turbulent plasma flow, how they are transported along the spectrum, and what maintains the helicity balance. According to recent research Kazantsev-type dynamo models show that in short-time-correlated turbulence the magnetic helicity grows on small scales, followed by its sign separation. In this report, we investigate this issue using the shell approach: we demonstrate the growth of small-scale helicity in complex shell MHD models, compare the generation with the results of the Kazantsev approach, and qualitatively study the transfer of growing helicity along the spectrum towards large-scale turbulence. To do this, by parallelizing the process, we numerically implement and statistically analyze the processes that describe the transport of energies and helicity when a seed magnetic field is added to the initially stabilized hydrodynamic Kolmogorov spectrum. In this case, both the linear mode of generation, which is compared with the linear Weinstein-Kichatinov model, and the nonlinear mode of process stabilized due to the reverse influence of the magnetic field on the velocity field are investigated. This work was supported by the BASIS Foundation grant no. 21-1-3-63-1.

KEYWORDS: solar dynamo cycle, mhd shell approach, Kazantsev model.

Senegal

Estimating zonal Ekman transport along coastal Senegal during passage of hurricane Fred, 30–31 August 2015

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We examine the role of zonal Ekman transport along the coast of Senegal on 30 August 2015 when the tropical disturbance associated with Tropical Cyclone Fred was located to the west of Senegal, causing considerable coastal damage in southern Senegal–Gambia domain (south of Dakar, Senegal). Ten-meter winds from three Weather Research and Forecast model simulations were used to estimate zonal Ekman transport, when the maximum values were found on 30 August. These simulations are in agreement with limited coastal observations showing increasing southerly wind speeds during 30 August but overestimated relative to the three coastal stations. The strong meridional winds translate into increased zonal Ekman transport to the coast of Senegal on 30 August and are likely responsible for some coastal flooding. Ekman transport along the coast contributes significantly to the water-level variations during swell events. The use of a coupled ocean model will improve the estimates of Ekman transport along the Guinea-Senegalese coast. The observed damage suggests that artificial and natural barriers (mangroves) should be strengthened to protect coastal communities in Senegal.

KEYWORDS: tropical cyclone; Weather Research and Forecast model, Coastal flooding

Serbia

Heliospheric and atmospheric parameters affecting cosmic rays flux measured at Belgrade muon station

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Belgrade Muon station monitor secondary cosmic ray flux for two decades. It is a part of The Low-background Laboratory for Nuclear Physics (LBLNP) at the Institute of Physics, Belgrade, Serbia. Measurements are done simultaneously at ground level and at shallow-underground level which is suitable for studies of energy dependence of cosmic-ray variations. Overview of laboratory's activity and research is given. Progress in several different research topics studied, ranging from correction of secondary cosmic rays flux on atmospheric parameters using multivariate analysis, upgrade of instrumental setup and determining concentration of in situ cosmogenic radionuclides based on simulation, to studying correlation between solar wind parameters and measured muon flux during transient or quasi-periodic cosmic-ray variations like Forbush decreases. Also a planned future collaboration is discussed with goal of developing and using worldwide network of novel, low-cost and portable detectors for cosmic ray muon and neutron flux measurements and its application in studying heliospheric and environmental parameters.

KEYWORDS: cosmic rays, measured flux, ground and underground station

Sudan

The effects of ionospheric disturbance's on GNSS signals during solar cycle 24

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Ionospheric Space Weather effects cause disturbances in the ionosphere layer, such as ionospheric scintillation, which can adversely degrade the performance of radio systems operating for communication, space-based navigation, and remote sensing. Thus, navigation signals transmitted by Global Navigation Satellite Systems (GNSS), such as the Global Positioning System (GPS) or the European system Galileo, traveling through the ionosphere are delayed, refracted, and diffracted by the highly variable ionospheric plasma due to high solar activity. This will be occurring when the signals cross regions of high electron density irregularities and lead to significant errors in the phase and amplitude of the signals. Since the performance parameters, such as accuracy, availability, continuity, and integrity of GNSS signals are crucial in the safety of life and precise positioning applications, detection, monitoring and prediction of ionospheric effects are important for mitigating the impact. In this paper we evaluate the ionospheric disturbance and its potential effects on GNSS signals, using the disturbance time storm (Dst), solar radio flux F10.7 and ionospheric scintillation index (S4), as well as daily mean ionospheric Total Electron Content (TEC) maps during high solar activity and correlate them with GNSS data correspond to the scintillation time using simulation software.

KEYWORDS: Space weather; Ionospheric disturbances; Ionospheric scintillation; Global navigation

Sudan

Studying the ionosphere using Ionosonde observations' data: Some plans of space weather observations in Sudan

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In this work we will introduce a proposal in which we shall carryout analyses of Ionosonde data to study understanding the possible local mechanisms of producing sporadic E layer above the Ionosonde station. One of the major roles that an Ionosonde station can play, if being installed in the country, is that its data may be used to contribute in the global maps of the total electron content (TEC) of the ionosphere. Furthermore, it is obvious that in the country recently there've been many efforts exerted towards enhancing capacity building in space weather science, research and data products and that is via looking for attracting more space weather devices installations within the country. Our study shall be improved and further studies in the future shall be conducted using these ionosonde data.

KEYWORDS: Ionosonde Device, Ionosphere and Total Electron Contents (TEC)

Türkiye

Temporal and periodic variations of the solar flare index during the last four solar cycles and their association with selected geomagnetic activity parameters

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We studied the temporal and periodic variations of the monthly solar flare index (FI) and selected geomagnetic activity parameters (Ap, Dst, Scalar B, and aa) measured during Solar Cycles 21-24 (from January 1, 1975 to December 31, 2020) and report the following findings: 1) all data sets except the FI peak values gradually decreased since 1992, while the FI peak values began their gradual decrease in 1982; 2) all data sets show double or multiple peaks during the maximum phase of solar cycles; 3) the FI shows meaningful correlations with the investigated geomagnetic activity parameters; 4) the 11-year sunspot cycle periodicity and as well as periodicities lower than 3.9 months were observed in all data sets without exception; 5) the FI time series exhibits a unique period of 4.8-5.2 months that is not present in all other indices, while geomagnetic aa, Ap, and Dst indices show a unique 6-6.1 months periodicity that does not appear in the scalar B and FI; 6) cross wavelet transform (XWT) spectrums between FI and other parameters generally show phase mixing at the short (2-8 months) period range, while all parameters used in this study were found to be in phase and highly correlated with the 11-year solar activity period. All these results show that the FI variations are one of the main driver of the geomagnetic activity.

KEYWORDS: Solar Flares, Solar Cycle, Geomagnetic activity

Uganda

using B-splines to model Total Electron Content derived from radio occultation measurements by cosmic satellites over African region

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This study developed a model of Total Electron Content (TEC) over the African region. The TEC data were obtained from radio occultation measurements done by the Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC) satellites. Data during geomagnetically quiet time (Kp < 3 and Dst > -20 nT) for the years 2008 - 2011, and 2013 – 2017 were binned according to local time, seasons, solar flux level, geographic longitude and latitude. B splines were fitted to the binned data to obtain model coefficients. The model was validated using actual COSMIC TEC data of the years 2012 and 2018. The validation exercise revealed that, approximation of observed TEC data by our model produces root mean squared error of 5.02 TECU. Moreover, the modeled TEC data correlated highly with the observed TEC data (r = 0.93). Due to the extensive input data and the applied modeling technique, we were able to reproduce the well-known TEC features such as local time, seasonal, solar activity cycle, and spatial variations over the African region. Further validation of our model using TEC measured by ionosonde stations over South Africa at Hermanus, Grahamstown and Louisville revealed r values > 0.92 and RMSE < 5.56 TECU. These validation results imply that our model can estimate fairly well TEC that would be measured by ionosondes over locations which do not have the instrument. Another importance of this study is the fact that it has shown the potential of using basis spline functions for modeling ionospheric parameters such as TEC over the entire African region.

KEYWORDS: modeling, total electron content, radio occultation measurments

United Kingdom

Operational forecasting of ground effects using the Gorgon MHD Model

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In response to the threat of space weather to modern infrastructure there has been a concerted worldwide effort to develop space weather forecasting capabilities. Within this development there is an emphasis for operational models to produce accurate and actionable estimates for end-users. Global magnetohydrodynamic (MHD) simulations are a powerful tool for achieving this aim, explicitly modelling the near-Earth current system dynamics faster than real-time. Besides general situational awareness, driving such simulations with either in-situ or predicted solar wind data has the potential for increased forecasting lead-times, and ultimately allows for effective implementation of end-user mitigation strategies. An example this approach is that of Gorgon, a global magnetospheric MHD model developed at Imperial College London.

Various model optimisations are needed to perform global magnetospheric simulations in real-time, with additional post-processing required to convert outputs into ground geomagnetic field estimates and other actionable end-user outputs. Here we discuss the various current operational deployments of Gorgon and its post-processing suite. In the UK context this takes the form of work within the SWIMMR Activities in Ground Effects (SAGE) consortium, which aims to deliver forecasting products to the UK Met Office with a specific focus on end-users affected by geomagnetically induced currents. At a more regional level, there is the ESA Global MHD Modelling project, in collaboration with the University of Bergen, and integration into ESA's Virtual Space Weather Modelling Centre (VSWMC). Both these projects feed into regional forecasting and application within the ESA Space Weather Service Network.

We further present details and results of the current operational Gorgon outputs using real-time upstream solar wind. The various key optimisations of the model are discussed, including multiple ground geomagnetic field estimation techniques and specialised grid configurations. Besides general magnetospheric and field-line visualisation, operational outputs such as local geomagnetic field estimates, regional and global geomagnetic indices, Joule heating, magnetopause stand-off distance and high-latitude potential and field-aligned current mapping are included and compared to measured data. We then conclude with an overview of future application and development.

KEYWORDS: forecasting, simulations, real-time

United Kingdom

Diagnostics of the pre-flare and Pre-eruption Magnetic field in the solar corona

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Powerful energy releases occurring in the corona of the Sun, such as flares and coronal mass ejections, as the main drivers of extreme events of space weather. The key source of the released energy is the non-potential ("free") magnetic field accumulated and stored in coronal active regions. The robust forecasting of space weather events requires reliable information about the coronal magnetic field, which could not be obtained directly. A promising technique for the indirect diagnostics of the coronal field is magnetohydrodynamic (MHD) seismology, which utilises coronal MHD waves and oscillations. Especially relevant are kink oscillations of coronal plasma loops, which are confidently detected in active regions with modern high-resolution spaceborne extreme ultra-violet (EUV) imagers. Kink oscillations are observed as harmonic transverse displacements of coronal loops from the equilibrium, and are interpreted as standing magnetoacoustic eigenmodes of the loops. The oscillation period is found to depend linearly on the length of the oscillating loop, with the gradient of this dependency being determined by the Alfvén speeds inside and outside the loop. The Alfvén speeds are, in turn, determined by the magnetic field. Thus, observational detection of kink oscillation periods and estimation of the loop lengths provide us with unique information about the absolute value of the field. In combination with the extrapolation of the coronal field by photospheric magnetic sources, seismological diagnostics allows for estimating free magnetic energy available for flares and eruptions. Decayless kink oscillations appear in the quiet Sun periods of time, are standing kink oscillations too, and are interpreted as kink self-oscillations. This regime of kink oscillations allows for the diagnostics of the magnetic field in pre-flare active regions. We demonstrate the robustness and reliability of such diagnostics with the use of data obtained with the Atmospheric Imaging Assembly on the Solar Dynamics Observatory (SDO/AIA) and the EUV Imager on the Solar Orbiter (SolO/EUI). Seismological diagnostics of the coronal magnetic field should be included in space weather forecasting models of the new generation.

KEYWORDS: Solar corona; Magnetohydrodynamic waves, Magnetohydrodynamic seismology

United States of America

Design and assembly of a COTS CubeSat for space weather applications

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The strategic use of small CubeSats for exploration and the proactive development of small-satellite capabilities and miniaturized sensors have increased the past few years. With these developments, it is imperative to train future scientists and engineers for the space workforce. Towards this goal, we developed a program that is aimed at providing students with hands-on experience in the development of space technology. The curriculum trains students to experience a CubeSat Mission from its design, assembly, and operations. Students are trained in an interdisciplinary setting where they work with both scientists and engineers in a laboratory, in which they experience interacting with a CubeSat Flatsat for preliminary assembly, integration, & testing (AI&T) final assembly and CubeSat launch. CubeSat designs are guided by NASA's Engineering Design Model, one used by NASA engineers when solving problems, and are assembled with commercial-off-the-shelf (COTS) components. The semester long curriculum is enhanced by an optional paid 10-week summer internship at NASA or one of our university partners. We will discuss the program, resources (human and facilities), time, funding, as well as the challenges, including working remotely during the COVID-19 pandemic on a hardware project. This low-cost and replicable student-led project can serve as a model for other universities interested in engaging undergraduate and high school students in all aspects of a COTS CubeSat mission, with a future goal of launching into space.

KEYWORDS: CubeSat, Space Weather, undergraduate students

United States of America

The Sun as the primary source of space weather

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The frequency of spacecraft anomalies typically peak in a few days after the onset of a solar energetic particle (SEP) event at Earth and the storm sudden commencement (SSC). In both cases, energetic protons and electrons in the space environment interact with spacecraft components resulting degradation and/or loss. The SEPs are accelerated by shocks driven by coronal mass ejections (CMEs). CMEs arriving at Earth cause geomagnetic storms that result in particle energization inside the magnetosphere. Both SEPs and magnetospheric particles precipitate in the polar atmosphere resulting in changes in atmospheric chemistry including Atmospheric heating following geomagnetic storms leads to the expansion of the upper atmosphere resulting in additional drag on satellites in low Earth orbits. The two underlying phenomena, viz., SEP events and geomagnetic storms

KEYWORDS: Solar Mass Emission; Geomagnetic Storms; Solar Energetic Particles

United States of America

Development of a whole atmosphere model with a non-hydrostatic dynamical core

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The need for ground-to-exosphere General Circulation Models (GCMs) were specified for the first time by Roble in 2000. These models, commonly known as the whole atmosphere models, are needed for a more accurate study of the relevant physical and chemical interactions, climate change, climate response to solar variability, space weather, and the interpretation of global observations. Two decades following the work of Roble, whole atmosphere modeling has developed into an active and fast-growing area of research.

Currently, there is a strong push for representation of the lower atmosphere in space weather models, since there is increasing appreciation of the driving from below. For accurate simulation of the region between the Sun and the Earth, the impacts from the lower atmosphere need to be taken into account in addition to the atmospheric impacts from the solar output and magnetosphere. This is extremely influential in the future development of the whole atmosphere models which will find increasing number of geospace applications. This focus stems from our society becoming more and more dependent on advanced technology which can be vulnerable to space weather.

The Whole Atmosphere Community Climate Model with thermosphere and ionosphere extension (WACCM-X), developed by the High Altitude Observatory (HAO) at the National Center for Atmospheric Research (NCAR), extends from the Earth surface to the exobase (~600 km). However, the dynamical cores used in current WACCM-X configurations (both finite volume, FV, and spectral element, SE) are based on the hydrostatic assumption. As part of the NCAR System for Integrated Modeling of the Atmosphere (SIMA) project, we have recently developed and tested the Specified Chemistry Whole Atmosphere Community Climate Model (SC-WACCM) with the non-hydrostatic Model for Prediction Across Scales-Atmosphere (MPAS-A) dynamical core. This is the preliminary step towards the final goal of using MPAS-A as a dynamical core for WACCM-X.

The mean zonal wind and temperature climatology from SC-WACCM/MPAS-A is compared with the results from SC-WACCM using finite volume and spectral elements dynamical cores. Gravity wave forcing (GWF) is a key driver of the wind and temperature structure in the middle atmosphere. Hence, GWF from these simulations are also compared. Comparison of non-hydrostatic and hydrostatic dynamical cores will allow the assessment of the nonhydrostatic effects on various spatial and temporal scales.

KEYWORDS: Whole atmosphere models, Non-hydrostatic dynamical core, Gravity wave forcing

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Protecting the Planet from Space Threats

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The Space Weather related activity serves as one of first steps in implementing a broader program of measures designed to protect our Planet from dangers the Space poses. This talk invites for a discussion of futuristic scenarios to deal with potential threats including the extremes of Space Weather and the low probability, but of high consequences, events like celestial superflares, asteroid impacts and so on.

KEYWORDS: Space weather, Celestial bodies, Celestial superflares