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Geoeffective twisted flux ropes in the solar wind near Earth

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Solar magnetized structures can be destabilized, and consequently ejected into the extended solar corona (i.e., the heliosphere), where typically can be identified as interplanetary flux ropes (FRs). These structures (twisted flux tubes) transport through the solar wind huge amounts of mass, energy, magnetic flux and helicity. Thet also affect the transport of energetic particles in the interplanetary medium. The global and detailed configuration of FRs in the interplanetary medium can be estimated from numerical and theoretical models, complemented with spacecraft in situ observations. FRs contain different plasma and magnetic field properties, compared with those of the ambient solar wind, which can strongly perturb the geo-space. These transients are the most geo-effective heliospheric objects, with major consequences on new technologies and on live in space. Different physical mechanisms occur during their evolution, and thus determine the level of their impact on the terrestrial space environment. These mechanisms include expansion, erosion, dynamics of fluctuations and turbulence, accretion of magnetic field, and drag. The identification of the composing sub-structures, their global 3D shape, as well as how the plasma and magnetic field are typically distributed inside them, are crucial to understand these interplanetary objects. In this presentation I will provide a general review of the main aspects of FRs affecting their properties during the evolution in the solar wind from the Sun to the Earth, which significantly affect their geoeffectiveness.

KEYWORDS: Space Weather – Solar Wind – Interplanetary Flux Ropes

Argentina

Ionospheric Modeling Using Machine Learning Towards Space Weather Operational Service

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Machine Learning techniques have increasingly been used in the space weather community during the last years with promising results, in particular, to perform nowcasting and forecasting of different space weather subdomains. An important and widely used ionospheric parameter is the Total Electron Content (TEC) of the ionosphere, especially because of the ubiquity of GNSS from which TEC is derived. In this work, we present three different deep-learning techniques to forecast 24-hour global TEC using GIM maps as the input and Kp index as an external variable (for the space weather forcing). We address several strategies for feature engineering and selection, the advantages and disadvantages of each model, and software development and deployment considerations from a data science perspective towards a pre-operative prototype. We discuss also the role of different indexes according to the geomagnetic regions (e.g. Dst, AE, AU, etc), IMF and solar wind parameters, and solar activity proxies, for feature selection and for different time scales. We discuss also future works including new ML techniques and regional ionospheric forecasting.

KEYWORDS: Deep learning – Space Weather – ionospheric forecasting

Austria

SWAP: An initiative to network researchers and stakeholders in space weather in Austria

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The term "space weather" summarizes phenomena in the solar system that primarily originate from the sun. The Earth and its magnetic field interact continuously with space weather, usually without consequence. However, there are also extreme conditions in space weather (known as solar storms) that can affect modern technologies. The most well-known consequences include disturbances of navigation systems (e.g. GNSS), problems in power supply operation, as well as the loss of radio communication.

The SWAP (Space Weather: The Austrian Platform) project deals with the diffusion of space weather expertise to potential users and the public at a national level. Funded as part of the Austrian Space Applications Programme (FFG), the project is carried out by a consortium of eight partners in space weather research and application. Our aims are to (1) connect national expertise in the field, (2) establish a national space weather platform, and (3) plot a road map for the future development of the space weather sector in Austria.

In this presentation we will provide an overview on our progress in developing a national platform. A newly established website serves as a single point of entry into the topic of space weather. We use this platform as a launchpad to contact potential stakeholders and provide a resource for national expertise and infrastructure, with the intent to extend awareness of space weather events and their potential consequences. Using a space weather “atlas”, the website ties together national expertise with current space weather forecasts. A direct line of contact to the relevant experts is provided in case of extreme events. We have identified various stakeholders including regional warning centres, power grid operators, groups relying on GPS and radio signals, and the press, among others.

As in any science outreach initiative, there are many challenges involved when contacting stakeholders, depicting space weather topics to the general public, and in consolidating current expertise. This project can be a useful test case for similar initiatives in other countries.

KEYWORDS: Space weather, national network

Austria

The magnetospheric weather: origin and consequences

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The Earth's magnetosphere is formed as a consequence of the interaction between the solar wind and the Earth's magnetic field. Magnetic reconnection, which is a fundament plasma process where magnetic energy is transferred into particle energy accompanied by a topology change of the magnetic field, is the main process how the solar wind energy enters into the magnetosphere. Thereby stored energy in the magnetotail is explosively released resulting drastic acceleration of plasma and precipitation of particles into the ionosphere producing aurora. In the context of space weather these magnetospheric processes are directly coupled to geomagnetic activity as well as near-Earth high energy particle environments that is of key importance.

In this talk selected key magnetospheric processes relevant to the space weather will be highlighted. These include dayside magnetospheric boundary processes, particle acceleration and magnetosphere–ionosphere interaction associated with mesoscale magnetospheric drivers. Furthermore, advances and future plans in the magnetospheric observations will be discussed that is expected for a breakthrough in our understanding and modeling of the complex magnetospheric space weather phenomena.

KEYWORDS: Magnetosphere, magnetic reconnection, aurora

Austria

Operational Space Weather Services at University of Graz

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Improving space weather forecast is a topic of high timeliness. The current solar cycle 25 is increasing in its activity strongly, and we may face the next maximum rather soon for that we expect increased disturbances from solar events. The strongest space weather effects are caused by coronal mass ejections (CMEs) and compression regions from stream interaction regions (SIRs). In total we aim to simulate the occurrence of SIRs and propagation behavior of CMEs more reliably. Hence, we need to better understand the outflow from the Sun and how it structures interplanetary space in that the CMEs are embedded in. In that respect, the Heliospheric Physics Research Group from University of Graz, Austria, studies in a complementary approach in various projects coronal holes, solar wind streams, and CME events. From the richness of research results produced by national and international teams, several operational services have been developed. The “ESWF” (empirical solar wind forecast) using the relation between coronal hole sizes and solar wind speed at 1au, “STEREO+CH” a coronal hole based persistence solar wind forecast model, the “ESWF24” an data assimilation solar wind model, and “DBEM” the drag-based CME propagation model in its basic and ensemble version. For satellite operators we recently developed “SODA” a forecast of the neutral density enhancement in the thermosphere and satellite orbit decays. All the services currently run within the Space Safety Programme of ESA (https://swe.ssa.esa.int/) under the Expert Service Centers of Heliospheric and Ionospheric Weather.

KEYWORDS: Solar wind, coronal mass ejections, forecast, research to operation

Belgium

Forecasting Space Weather from Coronal Mass Ejections: Modeling and Observational Challenges

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Coronal mass ejections (CMEs) are primary sources of adverse space weather in the inner heliosphere. These large-scale transients, characterized by intense and highly twisted magnetic field bundles, often drive fast-forward interplanetary shocks and turbulent sheaths, which can dramatically compress planetary magnetospheres through their intense dynamic pressures. Depending on their orientation, the intense magnetic fields present within CMEs can also trigger major magnetic reconnection events with magnetospheric plasmas, causing severe magnetic storms and facilitating the penetration of energetic particles from the solar wind to the innermost layers of a planetary magnetosphere. Particularly the interaction of CMEs with other interplanetary structures and other CMEs can drastically alter their global and local properties during propagation, complicating the forecasting of CME in situ properties and space weather impact at Earth and other locations in the heliosphere.

Providing accurate predictions of the CME impact at Earth and other target locations with sufficient lead time is of prime interest to our society, and relies on two paramount pillars: the development of sophisticated but computationally-efficient numerical models for CMEs and the surrounding solar wind; and the availability of space missions monitoring the solar and interplanetary environment and allowing near-real-time characterization of the CME geometric, kinematic, and magnetic parameters required to initialize numerical models. Additionally, advances in the fundamental understanding of the physical phenomena altering CME structures during their journey through the heliosphere are critical to improve current forecasting capabilities of space weather events triggered by CMEs.

In this talk, I will review the main numerical approaches employed for the modeling of CMEs and their propagation through the inner heliosphere, and I will discuss how the synergy with remote-sensing and in situ CME observations from multiple spacecraft enables the achievement of more accurate and reliable predictions at various locations in the heliosphere.

KEYWORDS: coronal mass ejections – solar wind – space weather

Burkina Faso

Effect of turbulence of high-speed solar winds upstream of the Earth's magnetosphere: Case of the outer minima of solar cycles 20, 21, 22, 23 and 24

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Sun is a magnetic body in motion among the 200 billion that our galaxy counts. It continuously emits into interplanetary space, various electromagnetic radiations (UV, X-rays, etc.) and very energetic particles (solar winds, ICMEs, etc.). Due to the progress of space exploration and the rapid growth of the information society, our socio-economic system supported by highly developed infrastructures such as communication systems, artificial satellites, electrical and aviation networks, may become more vulnerable to space weather variability. Electric fields induced in the ground by these variabilities can also cause damage to these infrastructures. All these solar disturbances have economic consequences whose cost can only be properly assessed by a precise knowledge of the climatic variability of the Earth's radiative environment, which has led to the emergence of a new science: space weather. Space weather is concerned with the solar wind, a stream of energetic particles consisting mainly of protons and electrons. During its journey in interplanetary space, solar wind becomes more accelerated during the outer minima (descending phase) of the solar cycles and can therefore influence all of humanity and its technology. In this paper, we evaluate the contribution of sufficiently High-Speed Solar Winds (HSSW) to the averages of the geomagnetic indices Aa during the outer minima of the last five complete solar cycles (solar cycle 20 to 24). For this purpose, 1UA data of solar wind, Aa geomagnetic index and interplanetary frozen electric/magnetic fields were extracted from the OMNIWeb (https://omniweb.gsfc.nasa.gov/) and ISGI (https://isgi.unistra.fr/data_download.php) web browsers. These data comprising tens of thousands of points, are carefully examined to identify HSSW currents (velocities $\geqslant$ 450 km/s averaged over a day and Aa $\geqslant$ 20nT) removing all excursions due to poorly identified events or interacting with interplanetary coronal matter ejections (ICMEs). Only those cases where the solar parameters By (ICME y-component), Bz (ICME z-component), V (solar wind speed), Ey (frozen electric field: Ey = -V x Bz), and Aa (geomagnetic indices) available simultaneously in solar magnetospheric (GSM) geocentric coordinates, were taken into account. Analysis of energetic solar plasma particles has shown that strong geomagnetic field variations can occur even in the absence of large solar disturbances (interplanetary coronal mass ejections ICMEs for example). In all our analyses, we used the daytime coupling function of the magnetosphere presented by Wang et al. (2014), which aims to quantify the overall daytime reconnection rate, and then the empirical formula developed by Milan et al. (2012) to determine the magnetic flux conversion rate from a closed to an open daytime topology. In this work, the value of the dayside reconnection rate was normalized to its average value of the entire analysis period. Thus, for all state variables selected in this study, the normalized reconnection rate remains most significant for the 1994 outer minima which had recorded significant extreme solar activities. While the normalized reconnection rate was estimated to be ~21% of the total variance of the magnetospheric variables, the upstream of the Earth's magnetospheric cavity was perturbed 80% of the time with large recorded energies. As a result, the magnetosphere becomes denser (i.e., more drag), which is a problem for satellites. Thus, during the outer minimum, the coupled solar wind-

magnetosphere system follows scale-invariant dynamics and is in a state far from equilibrium with more than 97% of HSSW imposed in the range 300-850 km/s.

KEYWORDS: solar winds, magnetosphere, reconnection rate

Canada

Ionospheric space weather

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Understanding and preparing for space weather events is critical for our technology innovations that operate in the near-earth space environment and/or rely on trans-ionospheric and skywave signal propagation. Safety-critical radio-based applications include satellite-based positioning, navigation, and timing (PNT), HF radar, and VHF communications. For example, Global Navigation Satellite System (GNSS) chipsets now deliver sub-decimetre-level precise positioning for billions of PNT devices worldwide, with rapidly growing downstream markets for autonomous location-based services driving ever more rigorous safety and integrity standards. With many countries pursuing space weather strategies for national safety and security, there is a need for growing global coordination of modelling approaches and observational infrastructure. Here we discuss the most significant ionospheric disturbances and parameterization via data-driven modelling approaches, and provide some recommendations for leveraging new observing capabilities.

Fundamental to this work is an ionospheric data assimilation framework that specifies three-dimensional temporally evolving electron density distributions over regional and global spatial scales. Input observations include integrated total electron content (TEC) for multi-frequency GNSS signal combinations from ground- and space-based receivers, electron density profiles (e.g. radio occultations and ionosondes), and in situ (e.g. Swarm plasma) observations. Bottomside resolution is achieved through emerging HF-based systems: this includes inversion of imaging riometer measurements and assimilation of oblique ionograms. Features such as polar patches, storm-enhanced density, and the equatorial anomaly are resolved in a global unifying context with space weather benchmarks estimated to inform monitoring and mitigation approaches. Adapting methods from the Wide Area Augmentation System (WAAS) for integrity assurance, which includes capturing ionospheric threats in under-sampled regions, we propagate ionosphere states and uncertainties into user domains. To assess model performance, predictions of key metrics were generated for a three-year period and compared with more than 200,000 truth observations. The framework was validated across all performance requirements.

We provide examples of space weather events from our Transition Region Explorer (TREx) network, a national investment in over 40 new sophisticated optical, magnetic and radio instruments across Canada. Combined with our modelling tools, we leverage this facility for geospace remote sensing and characterizing the near-earth space environment. Ground-based infrastructure includes all-sky cameras (near-infrared, blueline, and true colour RGB), imaging and multi-frequency riometers, spectrographs, multi-constellation GNSS TEC/scintillation receivers, and specialized front-end RF samplers to provide scientific observations and assess the safety-critical failure modes resulting from space weather. Commercial GNSS receivers are co-located at key sites for real world testing of PNT operations. Together this complement forms a national scale testbed for model development and verification, as well as basic research into the space environment, remote sensing techniques, space situational awareness and impacts on technology.

These investigations provide insight into the most impactful and meaningful observations from existing and emerging space- and ground-based observing systems, and identify gaps and opportunities in ionospheric modelling. We offer perspective on the deployment of emerging instrument technologies, coordination of multi-instrument multi-scale observing networks, and the benefits of strategic collaborations for characterizing ionospheric space weather.

KEYWORDS: space weather, ionosphere, modelling

China

Data and application of space weather payloads onboard of BDS satellites

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Space weather events often affect the normal operation of satellites from all kinds of Global Navigation Satellite System (GNSS) in different orbits. Therefore, in recent years, navigation satellite in various systems often carries payload packages for space environment detection. In this presentation, the payload packages for space environment detection onboard of Beidou-3 satellites is briefly introduced. And then I will talk a little bit more about the Omnidirectional Ion Detector, which is developed by the Space Payload Research Group of the University of Science and Technology of China. Finally, based on data analysis, the impact of space weather events on satellite will be discussed in details.

KEYWORDS: Space Weather Payloads; GNSS; BDS Satellites

Croatia

An open-access massive data set for research on geomagnetic field effects on GPS/GNSS ionospheric delay

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GPS/GNSS is a fundamental technology and a cornerstone of a modern civilisation [3]. Mitigation of space weather, geomagnetic and ionospheric effects on GPS/GNSS Positioning, Navigation, and Timing (PNT) service provision is essential, since those render profound effects causing the GPS/GNSS PNT quality degradation [1, 2]. Researchers in the field often lack experimental data to work with while developing and testing GPS/GNSS ionospheric delay correction models as alternatives to those offered as standard (Klobuchar, NeQuick) [1, 8]. Recent developments argue in favour of utilisation of correction models that utilise awareness of space weather conditions in immediate vicinity of a GPS/GNSS receiver [1, 2, 8]. Here we report the arrangement of an open-access massive data set collected in sub-equatorial region, in support of research in the positioning environment-aware self-adaptive GPS/GNSS ionospheric delay correction model development [4, 5]. We assembled a massive data set comprising: (i) Total Electron Content (TEC) observations, derived from dual-frequency GPS pseudorange observations taken at International GNSS Network (IGS) reference station Darwin, NT, and (ii) components of geomagnetic field density (Bx, By, Bz), collected at the INTERMAGNET reference station Kakadu, NT. Data are assembled using a tailored software developed in the R environment for statistical computing. It extends the time span of a whole year 2014, thus covering the full range and occurrence rate of various geomagnetic events impacting GPS/GNSS PNT. Structured as a single CSV file of 28.5 MB, the data set comprises 522 298 individual instances (observations taken at the same time). The assembled data set is provided in the open access manner at the internet-based research repository figshare [5], as a service to international research community.

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KEYWORDS: GPS/GNSS ionospheric delay; geomagnetic conditions; massive data set

Egypt

Prediction of the Ionospheric irregularities over Egypt using GNSS observations and Deep Learning

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Irregularities in the Earth's Ionosphere layer threaten satellites, navigation, and communication. Understanding and mitigating risks to satellites and communication systems requires research into space weather dynamics and activities. Egypt increasingly prioritizes space and satellite technology. For space missions to be sustainable, the irregularities of Earth's ionosphere must be precisely modeled and predicted. Vertical Total Electron Content (VTEC) is one of the physical quantities that can be estimated using GNSS data. It's commonly used to develop ionospheric TEC prediction models. Many global TEC prediction models have been developed and tested; however, Egypt's data paucity makes these models inaccurate over this region.

In this project, we utilized GNSS data from some Ground stations in Egypt. In addition, satellite measurements were used in areas where ground data was unavailable. Using VTEC estimated from ground and space-based data, a Hybrid deep neural network (DNN) model was trained to forecast ionospheric VTEC variations over Egypt during quiet and disturbed periods. Solar and geomagnetic indices such as F10.7-index, Kp-index, and Dst-index were used as inputs with the VTEC in the DNN model. The new Hybrid DNN model can predict the VTEC values with acceptable accuracy during different activity phases regarding geomagnetism.

KEYWORDS: Space Weather – Ionosphere – Deep Learning

Ethiopia

Ionospheric response to the 23–31 August 2018 geomagnetic storm in the Europe-African longitude sector using multi-instrument observations

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This study presents ionospheric responses of the mid and low-latitude region in the Europe-African longitude sector (along 30◦ ± 10◦E) to the intense geomagnetic storm of 23-31 August 2018 (SYM-Hmin = -207nT) using the Global Ionospheric Map (GIM) and Global Positioning System (GPS) receivers data, the satellite data (SWARM), Defense Meteorological Satellite Program (DMSP), Global Ultraviolet Imager on board the Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics (GUVI/TIMED), and Prompt Penetration Equatorial Electric Field model (PPEFM). The percentage deviation in total electron content (TEC) denoted by ΔTEC (%) was used to observe the ionospheric storm effects. The rate of change of TEC index (ROTI) derived from GPS-TEC and the rate of change of plasma density index (RODI) obtained from SWARM satellites were utilized to quantify the occurrence of ionospheric irregularities. Results obtained from GPS receivers and GIM data revealed a large increase in TEC (positive ionospheric storm effect) in the equatorial and low-latitude region of Africa, and a decrease in TEC (negative ionospheric storm effect) over the mid-latitude region of Europe and Africa during the storm recovery phase. The decrease in $[O]/[N_2]$ ratio is the possible cause for the observed negative ionospheric storm effect. Hemispheric asymmetry was noticed over Europe-African longitude sector during the storm main and recovery phases. The occurrence of ionospheric irregularities over the low-latitude region of Africa in the pre-midnight and post-midnight was suppressed (ROTI < 0.4 TECU/min). This could be related to the local time at which the minimum SYM-H occurred which corresponded to daytime over Europe-African longitude sector. This, on the other hand, may not support the development of conducive environment for the generation of ionospheric irregularities. However, significant fluctuation in the plasma density was noticed by the SWARM-C on 23, 25, 30, and 31 August 2018 over equatorial and low-latitude region of Africa during the post-midnight period.

KEYWORDS: Geomagnetic storm, Ionospheric storm effect Ionospheric irregularity

Finland

Solar Energetic Particle events and their importance for Space Weather

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Our Sun produces explosive phenomena, in which elementary particles such as electrons and ions can be accelerated to high energies. These Solar Energetic Particles (SEPs) can reach relativistic energies and contribute to space weather. The two main acceleration sites considered to produce SEPs are magnetic reconnection regions in the solar atmosphere, associated with solar flares, and shocks in front of fast Coronal Mass Ejections (CMEs).

The measurements by interplanetary spacecraft are key to understanding space-weather phenomena. Reliable forecasting tools to protect the systems at Earth are, however, not yet in place because of our lack of understanding of the physical processes that generate these events. Until recently we have suffered from a limited number and locations of observing spacecraft and insufficient instrumentation, but now we finally possess an expanded fleet of interplanetary S/C with NASA's Parker Solar Probe and ESA's BepiColombo and Solar Orbiter spacecraft. These provide not only unprecedented data products but also more numerous observations including measurements at short distances from the Sun and constantly varying S/C constellations. This opens completely new avenues in identifying and understanding the mechanisms that generate solar energetic particles.

This talk will provide an overview of the space-weather impact of SEPs, their main acceleration processes as well as their transport through the interplanetary medium. Differences between electrons and protons will be highlighted as well as remaining open questions in our understanding of the generation of SEP events.

KEYWORDS: solar energetic particles – particle acceleration – particle transport

France

Scientific and monitoring objectives of the international meridian circles project

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Earth's ecosystems and human activities are threatened by a broad spectrum of hazards of major importance for the safety of ground infrastructures, space systems and space flight: solar activity, earthquakes, atmospheric and climatic disturbances, secular changes in the geomagnetic field, fluctuations of the global electric circuit, and the current global warming of our atmosphere that re-shapes terrestrial climates. Monitoring and understanding these major hazards to better predict and mitigate their effects is one of the greatest scientific and operational challenges of the 21st century. Though diverse, these hazards share one feature in common: they all leave their characteristic imprints on a critical layer of the Earth's environment sometimes called the ionosphere, middle and upper atmosphere (IMUA), or the Lower Thermosphere and Ionosphere (LTI).

Indeed, this narrow region of the upper atmosphere is the critical interface between the neutral atmosphere of our planet and its plasma envelope, where disturbances induced from above by the Solar-Terrestrial coupling chain overlap with disturbances propagating from below, generated by Solid Earth and tropospheric/stratospheric weather and climate. The objective of the International Meridian Circle Program (IMCP), a major international program initially proposed by the Chinese Academy of Sciences (Liu et al., 2021), is to deploy, integrate and operate a global network of research and monitoring instruments that will use the IMUA as a screen on which to detect this broad spectrum of disturbances, to disentangle them and to use the resulting information for a continuous monitoring of natural and anthropic hazards.

In this presentation, we will show that the optimal geometry of the IMCP global observation system is one that will be able to cover the (main) latitude and (secondary) longitude variations of monitored phenomena. This requirement leads to deploy instruments in priority along two great meridian circles in quadrature: the first 120°E-60°W great meridian circle, running above East Asia, Australia and the Americas, will cover the dominant geographic and geomagnetic latitude variations. Its deployment is facilitated by its large coverage of continental areas. It should be complemented by a second Great Circle along the 30°E-150°W great meridian circle, running along north and central Europe, Africa, the central Pacific and Alaska, which will allow us to capture longitude variations. Operating together, the two great circles will have the unique capacity of monitoring land-ocean contrasts in the working of the Earth system.

Given the required worldwide coverage provided by the two great circles, participation of all nations interested in contributing to the deployment, scientific data analysis and monitoring services enabled by the IMCP project will be instrumental to achieve its objectives for the benefit of all of humankind. Support to the project by the United Nations in the framework of its International Space Weather Initiative is therefore highly desirable and of the utmost importance.

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KEYWORDS: Space Weather, Natural Hazards, Solar-Terrestrial connections

France

CDPP's web-based tools for solar-terrestrial physics and space weather

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CDPP is the French data centre for space plasma physics. It consists of a developing and growing set of web-based facilities that allow any user to retrieve data from spacecraft and probes across the Solar Sys-tem, as well as a set of ground-based instruments observing the geospace. It also provides outputs from numerical heliospheric models. We shall demonstrate, through a case study, the capabilities of the follow-ing CDDP's web services: the Propagation Tool that propagates any solar disturbance throughout the Solar System; 3DView, which is a 3D visualisation software for satellite orbits and data; AMDA, which is a ver-satile web tool for handling data, data mining, and displaying data selected from a comprehensive cata-logue; and the Space Weather Tool that predicts the impact of a solar event on the geospace. In the ex-ample presented, we shall identify a coronal mass ejection (CME) at the Sun, follow its propagation to the Earth, and study its consequences on Earth's magnetosphere and upper atmosphere. These web-based tools prove very useful to carry out research and prefigure an operational space weather service; they are suitable to hands-on activities during training sessions or summer schools. In fact, they are regularly used at the space weather schools organised in French-speaking Africa and sponsored by ISWI.

KEYWORDS: data; modelling; forecast

Germany

Findings on the October Effect in VLF Measurements

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Very Low Frequency (VLF) radio signals provide a unique possibility of continuously monitoring the lower ionosphere and their dynamics since these signals are reflected at the ionospheric D region between 60-90 km. Recent investigations have shown a very sharp decrease in signal amplitude at the beginning of October which deviates from the actual symmetric course of solar zenith angle variation over the year. The effect is developed differently depending on latitude, longitude and frequency, as we will present. In investigation for the cause of this phenomenon, first comparisons suggest a close correlation with the sudden reversal from easterly to westerly zonal flow, the asymmetric peak in semidiurnal solar tide S2, and the progression of the lower mesospheric temperature. Independent of the solar zenith angle mostly in high latitudes, a strong warming of the lower mesosphere during fall can be observed, confirming dominating atmospheric inner dynamics. Further studies are ongoing.

KEYWORDS: Very Low Frequency (VLF), D region, October effect

Germany

Ionospheric effects on the performance of GAGAN satellites for aircraft precision approach

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The GNSS working group at NASO thrives to facilitate the GNSS capacity-building program and is collaborating with a group of undergraduate and graduate students from various engineering universities to generate competent manpower. An in-kind technical project support from DLR GfR mbH, Germany, was provided during the previous UNOOSA meeting (Orbital Space Mission Call for Interest) in 2017. Also a technical support for Nepalese aviation activities was acknowledged within the UNOOSA GNSS workshop in Nepal in 2016. Since then three projects in GNSS and aircraft navigations have been conducted at NASO to bridge the knowledge between universities and industries. One of the projects focused on the study of ionospheric impacts on the availability of GPS Aided Augmentation Systems (GAGAN) in its coverage area. In particular, for the approach and landing phases, the vertically guided procedures using the GAGAN is a proven procedure that can substantially modernize Nepalese airspace. As the variation of the space weather has a regular impact on the availability of the GAGAN services in its coverage zone, the project is characterizing the GAGAN performances for the year 2022 and 2023 when the solar activities are increasing and heading towards the maximum of Solar Cycle 25. The coverage of the sensor stations for GAGAN ionospheric estimation will evolve in the future but at the moment, it is possible to support only the APV-I aircraft approach on nominal days. During the high Kp index ionospheric events, the performance for APV-I fluctuates within the coverage zone. A comparison with existing SBAS systems is done to understand the robustness of the system to high ionospheric activities, correlated mostly to the Kp index. The project is a first of a kind in Nepal as the existing literature do not provide any evidence of GAGAN performance analysis for aircraft approach and landing procedures. This has been the case despite the technical assessments on the Nepalese aviation sector by international companies who have regularly stressed a need for GNSS centric air navigation services and relevant skilled GNSS manpower in the CNS/ATM sector. The project at NASO is contributing to meet such needs.

KEYWORDS: GAGAN, APV-I and Kp index

Ghana

Ionospheric Irregularities observed over African Equatorial and Low Latitude Region

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Using data collected by Geographical Navigation Satellite System (GNSS) dual frequency receivers network, Total Electron Content were generated to study ionospheric plasma irregularities over equatorial and low latitude region that are triggered during geomagnetically disturbed and quiet time. During these days we observed irregularities in the ionospheric level purported to affect the signals of navigation and positioning accuracies due to the delay of the signals. Geomagnetically disturbed time irregularities are attributed to the influence of the storms while the quiet time irregulates are attributed to the atmospheric gravity waves and other forcing from the neutral atmosphere. We also realized that some fluctuations were generated mostly during the storm time and their recovery phases similar to the traveling ionospheric disturbances. The present work serves as a strong foundation to unearth the mystery of ionospheric fluctuation that are generated during geomagnetically disturbed period, recovery phase as well as the quiet time.

KEYWORDS: ionospheric, geomagnetically, equatorial, fluctuations

Greece

Coronal flux ropes and space weather

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Practically all coronal mass ejection (CME) models predict that CMEs contain magnetic flux ropes after eruption. The flux rope may be an integral part of the pre-eruptive configuration or it may form during the eruption. The search for evidence of pre-eruptive flux ropes in the low corona is usually done through proxies which include thread orientation in filaments, soft X-ray sigmoids, nonlinear force-free field extrapolations of photospheric vector magnetograms, and coherent hot channels or hot blobs that are identified as hot flux ropes. We review pertinent multi-spectral low corona observations of flux ropes with emphasis on what high-cadence, high spatial resolution observations obtained with the Atmospheric Imaging Assembly (AIA) aboard the Solar Dynamics Observatory (SDO) can tell us about the existence and timing of hot flux ropes. The space weather potential of erupting flux ropes will also briefly reviewed.

KEYWORDS: Sun: coronal mass ejections – Sun: flares

India

Effects of the relative dynamics of ionospheric irregularities and GPS satellites on receiver tracking loop performance

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Transionospheric satellite signals being exposed to medium introduced perturbations, performance of satellite signal-based navigation and communication systems can be significantly compromised during periods of ionospheric scintillation, sometimes leading to complete signal outage. Such phenomena can be of regular occurrence over low-latitude and equatorial stations, owing to the strong irregularity dynamics associated with these regions [Bandyopadhayay et al., Electronics Letters, 1997; DasGupta et al., Radio Sci., 2004]. However, in addition to the effects of drifting irregularity structures, motion of satellites can also impose further impact on signal perturbation outcomes. In this study, efforts have been made to investigate the effect of GPS satellite geometry, on tracking loop performance of ground-based receivers, during periods of ionospheric scintillations. Observations are being reported from station Calcutta (22.58°N, 88.38°E geographic; magnetic dip 34.54°), located near the northern crest of Equatorial Ionization Anomaly (EIA).

A transionospheric satellite signal having dominant velocity component in the eastward direction, may resonate with irregularities drifting from west to east, giving rise to longer duration of signal outage and lower rate of signal fading [DasGupta et al., Radio Sci., 2006; Kintner et al., Radio Sci., 2001; Kintner et al., Radio Sci., 2004]. Based on this, in this study, eastward component of satellite velocity at IPP (Ionospheric Pierce Point) are measured and correlated with duration of loss-of-lock and rate of signal fading.

Data analyzed in this study is recorded during three different solar activity period (March 2014, March 2015 and March 2022), using a dual frequency GPS receiver and a multifrequency GNSS receiver where raw amplitude and carrier phase data is recorded at a sampling rate of 50Hz.

Results of this study indicate ~75-78% between duration of signal outage and eastward component of satellite velocity at IPP, for all three period of observation. Signal fading rate for fading <-10dB, is found to decrease with increasing satellite velocity. Median value of the cumulative distribution percentage for fading rate is found to correspond with satellite velocity of 16.69m/s, 31.76m/s and 19.14m/s respectively during March 2014, March 2015 and March 2022. Hence, direction of satellite velocity at IPP is recognized to be dominant source of signal outage, even during periods of weak to moderate scintillation.

KEYWORDS: Ionosphere, Irregularity, loss-of-lock

India

Ionospheric response of intense geomagnetic storms over Indian low latitude region

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The results presented in this paper are obtained from low-latitude ionospheric total electron content (TEC) variation during the chosen intense geomagnetic storm events happening during the solar cycle 24. For this, we have used the TEC data from four different low latitude stations: Varanasi (Geographic latitude 25°, 19’ N, longitude 82°, 59’ E), Lucknow (Geographic latitude 26°, 50’ N, longitude 80°, 55’ E), Bangalore (Geographic latitude 12°, 58’ N, longitude 77°, 35’ E), and Hyderabad (Geographic latitude 17°, 23’ N, longitude 78°, 27’ E). Various solar and geomagnetic parameters related to the geomagnetic storm have been analyzed to examine the consequences of geomagnetic storms on vertical total electron content. The storm-induced TEC changes at chosen stations have been discussed in terms of local time, storm wind effect, neutral wind, composition changes and variation in the dawn–dusk component of the interplanetary electric field (IEF Ey).

KEYWORDS: Geomagnetic storm; Total electron content; Global positioning system

India

Observations of X- ray and EUV fluxes during X-class solar flares and response of upper ionosphere during in 23rd and 24th solar cycle

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The majority of studies investigating the impact of solar flares on the upper ionosphere, where ionization is caused by EUV photons, have relied on X-ray measurements from the SOLRAD and GOES satellites. To validate these studies, we compare simultaneous observations of GOES X-ray fluxes and SOHO EUV fluxes for 10 X-class solar flares that occurred during the beginning and peak phases of 23rd and 24th sunspot cycle. We found that the peak intensities of X-ray and EUV fluxes for these flares exhibit a weak correlation, and this weak correlation persists when analyzing a larger datasets of flares that occurred during these sunspot cycles. However, the correlation improves significantly when considering the central meridian distance (CMD) of the flare location. We find that the peak enhancement in Total electron content (TEC) shows a strong correlation with the peak enhancement in EUV flux, while the correlation with X-ray flux remains poor.

KEYWORDS: X-ray, EUV, Solar Flare

Indonesia

Space Weather Studies in Indonesia

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The President of Republic of Indonesia in 2017 issued Regulation number 45 concerning the Master Plan for Space Activities in 2016-2040. The master plan focuses on, among others, the development and improvement of space implementation capabilities in space science. Indonesia with its national space agency which established since 1963 has an authorized capital that continues to be developed. This paper will describe the policy, vision, and program of space weather in Indonesia.

KEYWORDS: Indonesia, policy, space weather

Italy

The role of the ionosphere in the space weather

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The European Space Agency (ESA) defines Space Weather as “the environmental conditions in Earth’s magnetosphere, ionosphere and thermosphere due to the Sun and the solar wind that can influence the functioning and reliability of space borne and ground-based systems and services or endanger property or human health”. Thus, the ionosphere plays a very important role in space weather impact because the different conditions of the ionized upper atmosphere under geospace disturbed state result in a variety of disturbances on radio waves reliant technologies. Among them, the most important effects are those affecting the HF communication and the GNSS navigation and positioning systems. This contribution would like to provide an overview of the current international efforts addressed to advance the scientific understanding and to support service providers and end-users against ionospheric threats triggered by severe space weather conditions. The overview would like to provide useful information to scientific community to extend (or planned) existing (or future) initiatives, to students and early career scientists to consider capacity building opportunities, and to space weather interested stakeholders to facilitate the networking among scientific and industrial counterparts.

KEYWORDS: ionospheric weather, GNSS, capacity building

Italy

The INGV interdepartmental project “tropomag”: possible effects of geomagnetic storms on the troposphere

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TROPOMAG is an institutional project of the Environment Department of Italian National Institute of Geophysics and Volcanology (INGV), aimed to investigate the connection between Space Weather, Meteorological Weather and Climate, with a multidisciplinary and multi-instrument approach.

In particular, TROPOMAG investigates the effects of changes of the Earth's magnetic field on the atmosphere and weather conditions. The idea is to verify preliminary studies, according to which there could be increases in rainfall and atmospheric pressure anomalies during the occurrence of geomagnetic storms. Considering that the storms are frequent and intense at high levels of solar activity, due to the frequent occurrence of Coronal Mass Ejections (CMEs) and Interplanetary CMEs, and that they undergo a semi-annual variation, with equinoctial maxima and solstice minima, the confirmation of a possible relationship between tropospheric disturbances and changes in the Earth's magnetic field could contribute to a better quantification of natural sources of atmospheric variability.

The meteorological variability induced by the geomagnetic field variability, with particular reference to geomagnetic storms, can be thought of as an accelerated time scale model of what could be the mutual interactions between the time-varying climate and geomagnetic field on longer time scales.

We decided to investigate active volcanic areas, and in particular Etna, Stromboli, Vulcano and Vesuvio; we included in the concept of “active” also those volcanic systems able to sustain a significant flux of energy/matter, from the lithosphere to the atmosphere, with hydrothermal activity. This choice is based on the consideration that volcanoes generate thermal anomalies and input in the atmosphere solid and gaseous particles, which create a vertical corridor connecting different atmospheric levels.

The dynamics of these fluxes and of the Earth’s electromagnetic field can influence the water vapor content of the atmospheric column, due to the electrically charged nature of many of these particles (polar molecules or ions) and to the electrostatic field generated by the volcanic particulates. This process creates an electromagnetic bridge between the low, neutral troposphere and the high, electrically charged ionosphere. It is worth noting that some of these volcanoes, as Etna and Vesuvio, are located inside wide conurbations, allowing us to evaluate the possible role of anthropization in driving the studied processes, e.g the ascensional atmospheric flow linked to the “urban island” effect, sustaining the vertical transport of particulate produced by fossil fuel combustion.

The water vapor variability will be analyzed by using a dense permanent GNSS network over a long time period, so that possible relations with the variability of geomagnetic field and solar activity can be investigated.

Finally, a preliminary study to investigate the so-called co-volcanic ionospheric disturbances (CVID) is performed, thanks to the dense GNSS receiver network managed by INGV.

For accomplishing these goals, a strongly multidisciplinary approach is used, based on applied geophysical methodologies, as the analysis of the geomagnetically driven ionospheric and tropospheric components of the GNSS signal, geomagnetic field data, geomagnetically induced currents (GICs) circulation, anomalies of ground level atmospheric pressure and other parameters acquired in the ground-based monitoring networks of the studied volcanoes.

Objectives of this project include scientific outreach activity, which focuses on the need, for the Society in general, and for modern School in particular, to embrace a holistic Earth system Science approach, in order to provide an effective tool to focus on climate change and its consequences.

KEYWORDS: Atmospheric pressure; GNSS; ionosphere

Italy

Empirical climatological electron density models adaptation to REPRESENT IONOSPHERE Weather

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Modelling the regular variations of the Earth's ionosphere has been done with general success by first principles models as well as by empirical models. Empirical models though have been recognized to accurately represent the ionosphere states at a low computational cost.

Through the combination of data from ground and space-based sources and different techniques that involved data assimilation/ ingestion it has been possible to adapt empirical models that represent the climate of the ionosphere to be able to better match observations during geomagnetic disturbed conditions.

A brief overview is presented with the inclusion of some recent efforts and demonstrative tests made to describe the ionospheric weather states during Space Weather events using known empirical models and data-based techniques.

KEYWORDS: ionospheric models, data assimilation, space weather

Italy

Interdisciplinary Space Weather Research: a Road to Follow

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The importance of the interdisciplinary and systemic approach to research in Space Weather and Ionosphere (as a discipline connected to it) is now quite accepted in the scientific community. However, the meaning of such an approach and its differences with the multidisciplinary one is not totally clear to many of the researchers and organizations concerned. In this paper an attempt is made to elucidate this concept applied to the multiple disciplines that should be integrated in Space Weather (and Ionosphere) research. The first topic to be discussed will regard characteristics of complex systems in general and of the solar-terrestrial environment system in particular, being this the domain of space Weather and Ionosphere studies. About these the large number of disciplines and subdisciplines involved and their limitations to treat the very complexes and non-linear problems of the physical system involved will be briefly discussed. Differences between Knowledge-to-Applications (K2A) and Applications-to-Knowledge (A2K) approaches will be discussed for Space Weather and Ionosphere studies and their relevance for human society on Earth. The importance of using the very large amount of experimental data available through what is now called Data Science and new methods and techniques like those offered by Machine Learning will be considered, giving examples of such contributions to Space Weather and Ionosphere research.

KEYWORDS: Space Weather, Ionosphere, Interdisciplinarity

Ivory Coast

Estimating the daytime vertical E×B drift velocities in the F-region of the equatorial ionosphere using the IEEY and AMBER magnetic data in West Africa

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In this paper the daytime vertical $\vec{\mathbf{E}} \times \vec{\mathbf{B}}$ drift velocity in the F-region of the equatorial ionosphere was estimated from the magnetic effect of the equatorial electrojet (EEJ) in the West African longitude sector. In this purpose, the geomagnetic data recorded during the International Equatorial Electrojet Year (IEEY) from 1993 to 1994 and that provided in 2013 by the African Meridian B-field Education and Research (AMBER) network were used. For the IEEY project, data from Sikasso (11.34° N, 5.71° W, 0.12°diplat), Tombouctou (16.73° N, 3° W, 6.76 diplat) and Lamto (6.23° N, 5.02° W, -6.27 diplat) were considered. For the AMBER project data from Conakry (10.5°N, 13.71°W, -2.69°diplat) and Abidjan (4.60° N, 6.64° W, -8.54° dip) were considered. The vertical drift velocity was inferred from the EEJ contribution (ΔH) in the geomagnetic field horizontal component. The estimated noontime seasonal averages are respectively V_d= 10.95 m/s and V_d= 9.46 m/s for March and September equinoxes; V_d= 8.75 m/s and V_d= 8.27 m/s for December and June solstices. The daytime vertical drift velocity was found to be larger in equinoxes than in solstices. These values are in agreement with the results of previous studies in the same longitude sector.

KEYWORDS: Equatorial Electojet, Equatorial ionosphere, daytime vertical drift

Japan

Low-cost GNSS receiver system for space weather

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Space weather has several impacts on GNSS signals. The major impact is due to Earth's ionosphere layer. The signals are slowed down due to ionospheric effect. Ionospheric effect may cause GNSS position errors from few meters to several tens of meters. It also causes cycle-slips in phase measurements that degrades RTK performance. Space weather related parameters such as TEC (Total Electron Content) and scintillation parameters (S4: Amplitude Scintillation and Sigma-phi: Phase Scintillation) can be computed by measuring ionospheric effects on GNSS signals.

High-end commercial GNSS receivers are used for TEC and Scintillation measurements. Several GNSS receiver manufacturers have also released low-cost GNSS receivers with multi-frequency capabilities for high-accuracy. Besides, some GNSS chip manufacturers have also released dual frequency (L1/L5) GNSS chipsets for mobile phones to provide higher position accuracy.

In this paper, we present our studies related with low-cost GNSS receiver systems that are capable for TEC and scintillation computation. The studies also include how to do system integration for low-cost GNSS receiver systems with COTS components. If it is possible to use low-cost GNSS receiver systems, this will further enhance our capacity building activities in the field of space weather applications. This also requires development and modification of software that will be capable to use data from low-cost GNSS receiver system. We will also explore currently available software to compute TEC and scintillation.

KEYWORDS: Space Weather, TEC, Scintillation

Kazakhstan

Behavior of Galactic Cosmic Rays before and during High-Energy Magnetospheric Electron Flux Enhancements

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Changes in the intensity of galactic cosmic rays on Earth and beyond the boundary of the magnetosphere occur earlier than an increase in the flux of high-energy magnetospheric electrons with energy >2 MeV in the geostationary orbit, so the behavior of galactic cosmic rays before and during electron flux enhancements can provide valuable information about the processes occurring in near-Earth space at this time. The density and vector anisotropy of galactic cosmic rays for 453 events of high-energy magnetospheric electron flux enhancements over the period 1996-2020 were calculated by the Global Survey Method (GSM). Some examples of these events, which are characteristic of different classes of solar sources, are considered. The behavior of the density and vector anisotropy of galactic cosmic rays before and during electron flux enhancements in events connected with the arrival to Earth of high-speed streams from coronal holes, coronal mass ejections associated with solar flares or disappeared solar filaments is revealed.

KEYWORDS: magnetospheric electrons, galactic cosmic rays

Kenya

Update on Space Weather Infrastructure and Capacity Building in Africa

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Space weather science has been a growing field in Africa since 2007, the International Helio-physical Year (IHY2007). This growth in infrastructure and human capital development has been accompanied by deployment of ground-based observing infrastructure, most of which was donated by foreign institutions or installed and operated by foreign establishments. However, due to a number of factors, some of the space weather monitoring facilities are either non-operational, partially operational and either operational but do not transmit data to other stakeholders. In this paper we explore, the gaps in ground-based space weather observing infrastructure in many African countries as well as the human capital development issues, situations which hampers data acquisition necessary for space weather research, hence limiting possible development of space weather products and services that could help address socio-economic challenges.

KEYWORDS: space weather; infrastructure , human capital development

Malaysia

Assessment of local derived ionospheric model in baseline ambiguity resolution

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The ionospheric conditions highly affect the positioning and navigation accuracy of the Global Positioning System (GPS), especially in the Malaysian region, which is located over the equator. Utilizing a network of GPS over the region, the local ionospheric model has been derived for solving the baseline ambiguity. In doing so, selected GPS stations from the network have been used to form baselines that consist of short, medium, long, and very long baselines. Then, during the process of solving baseline ambiguity, rather than using the global ionospheric models, the locally derived ionospheric model has been applied. The assessment consists of the percentage improvement in ambiguity resolution, baseline vector differences, and station coordinate repeatability.

KEYWORDS: Global Positioning System (GPS), Ambiguity Resolution, Local Ionospheric Model, GPS Baseline

Malaysia

Analysis of Solar Radio Bursts detected by a single station Callisto Spectrometer for space weather study at Space Technology Complex, Banting, Malaysia

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This paper summarizes the results of an analysis of solar radio bursts detected by the Compound Astronomical Low-cost Low-frequency Instrument for Spectroscopy and Transportable Observatory (CALLISTO) spectrometer hosted by Malaysian Space Agency at Space Technology Complex (STC), Banting. Analyzed data were detected during the first year (October 2021 until 31 December 2022) of the new configuration. A total of 123 solar radio bursts (SRBs) were detected by the CALLISTO station located in Banting, Selangor, according to the e-CALLISTO website. Among them, 11 are type IIs, 104 are type IIIs, 2 are type IVs and 6 type Vs. It is found that 15% of type III bursts and 17% of type V bursts are associated with impulsive solar flares. Meanwhile, 63% of type II bursts, 30% of type IIIs and 17% of type V are related with Coronal Mass Ejections (CMEs). Furthermore, all of the analyzed type IV bursts, 37% of type II, 19% type III and 33% of type V are associated with solar flares and CMEs. From this study, we can confirm that detection and analysis of solar radio bursts (SRBs) from ground observation can be used to diagnose the space weather phenomena that may serve as the advance warning of the related severe space weather hazards.

KEYWORDS: Solar Radio Bursts (SRB), Solar Flare, Coronal Mass Ejection (CME)

Morocco

Space Weather in Morocco

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The purpose of this talk is to present the main achievements realized in the space weather field in Morocco. It started within the framework of the International Space Weather Initiative (ISWI) program after an ISWI delegation visit to Morocco. The RENOIR (Remote Equatorial Nighttime Observatory of Ionospheric Region) experiment was then deployed in Morocco on November 2013 at the Oukaïmeden Astronomical Observatory of Cady Ayyad University (31.206◦ N, 7.866◦ W; 22.84◦ N magnetic). The RENOIR experiment consists of a Fabry-Perot (FPI) interferometer and a wide-angle viewing camera, tracking the 630 nm nighttime airglow in order to measure the thermospheric winds and temperature and detect the ionspheric irregularities. The RENOIR experiment allows for the establishment of the climatology of the thermospheric winds and temperature over North Africa for the first time. The seasonality and the solar cycle dependence of the thermospheric winds and temperature were well defined. The different scenarios to the thermospheric response to geomagnetic storms were established. It appears that atmospheric tides and gravity waves in quiet time conditions shapes the day-to-day variability of the thermosphere. However, during geometrically disturbed conditions, mid-latitudes traveling atmospheric disturbances like circulation is predominant and trans-equatorial atmospheric disturbances are common. Furthermore, the RENOIR experiment is part of a network of identical equipments in different parts of the globe. This allows for the quantification of the longitudinal and latitudinal dependence of the thermospheric winds in quiet and disturbed times.

In addition to the RENOIR experiment, Five GPS stations exist in Morocco. The ionospheric Total Electron Content (TEC) is a key parameter not only to characterize the ionosphere but also to drive its coupling with the thermosphere. The climatology, seasonality of the TEC in quiet and disturbed conditions has been achieved.

Comparison of the FPI data to empirical and physics-based models; HWM14, NRLMSIS-00, TIE-GCM and GITM, has been done along with the use of SWARM satellite ionospheric data.

KEYWORDS: Thermosphere, Ionosphere, FPI interferometer

Nepal

Ionospheric Plasma Anomaly Using GPS TEC Measurements Over Nepal

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Ionospheric concentration can be measured as the total electron content (TEC) i.e. the total number of electrons present per square meter along a path between a radio transmitter from a satellite and a receiver. The TEC data for this study are acquired from the UNAVCO GPS network, which is widely distributed across Nepal. The ionospheric TEC fluctuation is primarily influenced by the terrestrial, geomagnetic, and solar activities. This talk covers such ionospheric variabilities using the GPS TEC measurements over Nepal. The TEC data from 53 GPS stations from Nepal are extracted for the long period (19 years) from 2000 to 2019 to study the trend of the ionospheric variability over Nepal with the comparison study with other ionospheric models. We have also developed the Artificial Neural Network (ANN) models to predict the ionospheric behavior over Nepal. In order to investigate the ionospheric responses with geomagnetic activities, the TEC are cross-correlated with various geomagnetic indices such as interplanetary magnetic field (Bz), disturbance storm time index (Dst), and auroral electrojet index (AE) during the superstorms events obtained from the ACE satellite observations. Similarly, to examine the eclipse-triggered consequences on TEC in response to the annular solar eclipse, the TEC variability is investigated at different solar eclipse events. Moreover, the presentation will also attempt to find the ionospheric anomalies using the TEC data before and after the great Gorkha Earthquake in Nepal (28.23°N, 84.73°E) with magnitude 7.8 on April 25, 2015.

KEYWORDS: Total electron content, Ionospheric anomaly, Superstorms

Nigeria

Investigation of Ionospheric Response to Geomagnetic Storms over a Low-Latitude Station, Ile-Ife, Nigeria

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Due to several complexities associated with the equatorial ionosphere, and the significant role which the total electron content (TEC) variability plays in GPS signal transmission, there is the need to monitor irregularities in TEC during storm events. The GPS SCINDA receiver data at Ile-Ife, Nigeria was analysed with a view to characterizing the ionospheric response to geomagnetic storms on 9th March and 1st October, 2012. Presently, positive storm effects, peaks in TEC which were associated with prompt penetration of electric fields and changes in neutral gas composition were observed for the storms. The maximum percentage deviation in TEC of about 120% and 45% were observed for 9 March and 1 October 2012 respectively. An obvious negative percentage TEC deviation subsequent to sudden storm commencement (SSC) was observed and besides a geomagnetic storm does not necessarily suggest a high S4. The present results show that magnetic storm events at low latitude regions may have adverse effect on navigation and communication systems

KEYWORDS: Geomagnetic storm, total electron content, percentage deviation

Nigeria

On the coupling between the equatorial electrojet and the solar quiet daily variation Sq current using ground observation

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Equatorial electrojet indices obtained from ground based magnetometers at 6 representative stations across the magnetic equatorial belt for the year 2009 (mean annual sunspot number Rz = 3.1) were treated to nonlinear time series analysis technique to ascertain the longitudinal dependence of the chaos/complexities associated with the phenomena. The selected stations were along the magnetic equator in the South American (Huancayo, dip latitude -1.80°), African (Ilorin, dip latitude -1.82°; Addis Ababa, dip latitude – 0.18°), and Philippine (Langkawi, dip latitude -2.32°; Davao, dip latitude -1.02°; Yap, dip latitude -1.49°) sectors. The non-linear quantifiers engaged in this work include: Recurrence rate, determinism, diagonal line length, entropy, laminarity, Tsallis entropy, Lyapunov exponent and correlation dimension. Ordinarily the EEJ was found to undergo variability from one longitudinal representative station to another, with the strongest EEJ of about 192.5 nT at the South American axis at Huancayo. The degree of complexity in the EEJ was found to vary qualitatively from one sector to another. Probable physical mechanisms responsible for longitudinal variability of EEJ strength and its complexities were highlighted

KEYWORDS: Equatorial electrojet, Ionosphere, Coupling

Pakistan

Longitudinal Dependence of Ionospheric Irregularities to Maximum Ring Current and PPEF sensed by GNSS and Magnetometers during the Storm of 4 November 2021

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In this study, we employ multi-instrumental data to investigate the behavior of equatorial and low latitude ionosphere during the geomagnetic storm of November 3-6, 2021. We used Total Electron Content (TEC) data obtained from Global Positioning System (GPS) receiver stations located in the equatorial and low latitudes of the Asian, African, and American sectors. It is found that the storm-time ionization level varies significantly in the trough and crest of the equatorial ionization anomaly (EIA) region over the three longitudes. The rate of TEC change index (ROTI) shows the ionospheric plasma bubble irregularities during the storm. Strong ionospheric irregularities were observed over the American sector, prior to the storm showing the impact of the High-Speed Solar Wind Stream (HSSWS). Usually, the main phase of the geomagnetic storm triggers the equatorial plasma bubble irregularities and the recovery phase suppresses the occurrence of these irregularities. However, in this study, we observed inhibition of the plasma irregularities over the three sectors during the main phase of the storm. We suspect this may be due to the injection of the Penetration Electric Fields (PEFs) which occur between local midnight and around noon during the main phase. The PEFs restrict the diffusion of plasma and therefore, suppress the occurrence of plasma irregularities during the main phase. During the recovery phase, ionospheric irregularities occurred at local midnight in the American sector on November 5 and 6. In the African sector, the occurrence of irregularities can be seen before midnight on November 5 and 6.

However, the Asian sector does not exhibit noticeable ionospheric irregularities during the storm. The longitudinal variation in the generation of plasma irregularities can be associated with the local time at maximum negative excursion of the SYM-H index and the electric field. We conclude that the development of ionospheric irregularities can be influenced by factors such as local time occurrence of maximum ring current, prompt PEF, disturbance wind dynamo electric field, and shielding electric field.

KEYWORDS: Penetration Electric Field, Plasma Irregularities, ROTI index

Peru

First Steps towards developing a Nowcasting Algorithm for Amplitude Scintillations in Peru

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Nowadays, GNSS systems play an essential role in different sectors of the economy. Therefore it is of vital importance to know the phenomena that can affect the proper functioning of these systems in order to take action to mitigate these effects. For this reason, several investigations have been carried out to analyze the impact of space weather on these systems. In that sense, the Jicamarca Radio Observatory (JRO) has studied several equatorial space weather phenomena.

The central phenomenon studied for this work has been the influence of amplitude ionospheric scintillations (S4) in errors in position approximation made by GNSS receivers. The data was obtained from different GNSS receiving stations of the Low-Latitude Ionospheric Sensor Network (LISN) during the descending period of the last solar cycle (24). However, we used most of the data for our analysis of the Huancayo station.

JRO implemented machine learning models to explore if the space weather phenomena can be correlated with the errors in the approximation of position observed in the GNSS receivers. To generate the database, we used geomagnetic activity, and solar activity, among other space weather parameters taken from OmniWeb and the value of ionospheric amplitude (S4) scintillations taken from the Novatel GPS of the Huancayo station belonging to the LISN network.

A convolutional neural network was also generated, and it takes those geophysical space weather parameters to predict the value of ionospheric amplitude scintillations in different time windows. Although currently, the model uses as input space weather variables obtained from Omniweb, such as the geomagnetic index Kp, storm index DST, and Solar Flux F10.7, among others. The final idea of the work is to generate a network that can generate nowcasting of the possible impact on GNSS receivers, using as inputs local instruments such as GPS (Position, S4, TEC), the magnetometers (H), and ionosondes (hf' or type of ESF) of the LISN network and other networks near the equatorial zone, in this way, it could be taken into account even the direction in which the irregularities that affect these systems travel.

KEYWORDS: GNSS systems, space weather, ionospheric scintillations

Poland

Assessing the Interrelationship between Intense Geomagnetic Storms and Power Grid Disruptions In Poland

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Our research focuses on investigating strong geomagnetic storms that occurred during the solar cycle 24. These kind of storms appeared not so often, and typically were accompanying by a southward-directed heliospheric magnetic field Bz. Through the use of different machine learning techniques such as self-organizing maps, we have demonstrated that an increase in the number of transmission line failures, potentially caused by solar activity, was observed during and immediately after strong geomagnetic storms. In addition, we analyzed the evolution of transmission line failures between 2010 and 2014 and observed a linear increase in their frequency, which may be associated with solar activity. To further investigate this connection, we compared these findings with the geoelectric field computed for the region of Poland, utilizing a 1-D layered conductivity Earth model.

KEYWORDS: geomagnetic storm, geomagnetically induced currents

Poland

LOFAR radio-telescope as a novel instrument for ionosphere monitoring

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Low Frequency Array (LOFAR) is a novel paneuropean interferometer. Currently, the International LOFAR Telescope (ILT) network consists of 54 stations. 24 core stations and 14 remote stations are located in the Netherlands; in addition, 16 international stations are spread across Europe: 6 in Germany, 3 in Poland and individual stations in UK, Ireland, Latvia, France, Sweden, Italy and Bulgaria. LOFAR operates at the frequency band of 10-230 MHz: the lower limit of such a frequency range approaches the ionospheric plasma frequency even at middle latitudes. Thus, LOFAR is sensitive to propagation signatures originated from ionospheric structures to a high degree. This creates a unique opportunity to monitor ionospheric structures with higher sensitivity than traditional instruments. In turn, a greater understanding of ionospheric structures occurring over multiple scales contributes to a better modelling of the ionospheric impact onto typical radio astronomy observations. A typical LOFAR observation of ionospheric structures is based on scintillation induced on radio waves: the amount of scintillation induced by ionospheric irregularities typically decreases with the radio wave frequency and therefore reaches higher values at lower frequencies. A methodology to infer and characterise ionospheric structures through LOFAR scintillation measurement is illustrated by means of observations that were collected by the Polish LOFAR stations located in Bałdy, Borówiec and Łazy. Preliminary results suggest that observations of LOFAR VHF scintillation can be utilised to detect plasma structures forming in the mid-latitude ionosphere. This contribution illustrates various case studies and discusses on the sensitivity of LOFAR ionospheric observations.

KEYWORDS: Ionosphere, LOFAR, IGS

Russian Federation

An Empirical Model for Estimating ICMEs Speeds, Delays and expected geomagnetic activity

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We have reviewed and analyzed 364 coronal mass ejections (CMEs) associated with solar flares and registered with the SOHO/LASCO coronagraph, which interplanetary counterparts (ICMEs) were observed in near-Earth space for the period from 1995 to 2021. The whole catalogue of events with different CME/ICME parameters is available online at http://spaceweather.izmiran.ru/papers/2023/ICME_catalogue.pdf. It has been shown that for the researched events ICME transit speed and delay depend on the initial speed of the corresponding CME, the longitude of the associated solar flare and the ambient solar wind velocity. It is also established that the ICME transit speed in the studied 364 events is closely related to the maximum speed observed on Earth (cc=0.89) and correlates well with the level of the geomagnetic activity characterized by Ap-index (cc=0.71).

We can use data on these events to determine the expected transit speed and time, and geomagnetic activity of a new event averaging the available information in the vicinity of the point under study. In this case, the contribution of neighboring points is taken into account so that the nearest points have the largest weights.

A model has been created that takes into account the ambient solar wind velocity and the solar data that accompany the generation of CMEs: initial speed and heliolongitude of the source. It is possible now to estimate ICME transit speed and delay, as well as the maximum speed of the corresponding interplanetary disturbance in near-Earth space and expected geomagnetic activity. The mean absolute error for ICMEs delay is 11.5 hours, so the use of our model is quite justified.

The results obtained are applicable in forecasting a state of space weather and are already used in daily practise of IZMIRAN Space Weather Prediction Center.

KEYWORDS: space weather, ICME speed, geomagnetic activity

Rwanda

Overview of Type II SRBs through analysis of associated solar and near earth space weather features during ascending phase of SC 25

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Type II solar radio bursts are signatures of particle acceleration caused by shock waves in the solar atmosphere and interplanetary space. Being electromagnetic radiation that travel at the speed of light, they can serve as ground observed data to provide early notice of incoming solar storm disturbances. An observational overview of 31 Type II bursts which occurred in the period between May 2021 to December 2022 is made. We analyzed associated parameters such as bandwidth, drift rates, starting frequency to evaluate their dynamical parameters such as the shock and Alfeve´n speeds to estimate the Alfeve´n Mach number as well as the coronal magnetic eld strength using Rankine-Hugoniot relation. We also evaluated accompanying space weather implication in terms of ionospheric total electron content (TEC) enhancement. At heliocentric distance $\sim 1-2\,R_\odot$, the shock and the Alfeve´n speeds are in the range 504 - 1301 kms−1 and 368 - 837 kms−1, respectively. At the same heliocentric distance, the Alfeve´n Mach number is of order of $1.2 \leqslant MA \leqslant 1.8$ and the magnetic eld strength of ∼7.8 G to 0.7 G. The study nds that 15/31 type II radio bursts are associated with immediate space weather impacts because they are associated with either radio blackouts or a polar cap absorption events, that are the signature of solar proton enhancement and solar energetic particle events. There is ionospheric disturbances during the radio blackouts or polar cap absorption events as revealed by the prominent TEC enhancements. The ndings from this study indicates that through analysis of type II SRBs observed from the ground and their physical features characteristics, it is possible to monitor well current progress of solar cycle 25 and predict the intensity of associated space weather phenomena.

KEYWORDS: Solar activity, Solar Radio Bursts, Space weather

Serbia

Serbian space weather research activities

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Strong variation of solar activity and accompanied space weather phenomena can affect Earth's environment and our civilization. Cosmic rays, originated from outside of the Solar system are also sensitive to properties of interplanetary medium and violent energetic events originated from the Sun that can additionally modulate cosmic rays. Here, a correlation between various space weather indices and energetic particles flux measured in-situ at L1 and measured ground–level cosmic ray muon flux is investigated. Found connection between proton flux fluence spectra and selected parameters of associated Interplanetary coronal mass ejections and variation of primary cosmic rays can improve analysis of how violent energetic events, with irregular sporadic occurrence, affect space weather and induce primary cosmic ray variations but also affect Earth's magnetosphere and upper atmosphere. These events can produce Forbush decreases, a transient decrease in the observed galactic cosmic ray intensity that can be detected by ground-based cosmic ray detectors. Ground-based muon detectors are sensitive to higher energies of primary cosmic rays than the network of standard devices like neutron monitors and can expand the range of energy of monitored cosmic rays. Plans for a worldwide network of ground muon detectors are discussed as well as plans and goals of space weather related Serbian CUBESAT project. The goal of CUBESAT project, still in the initial phase, is to study solar activity from LEO and to correlate acquired data with VLF measurements of the ionosphere and CR measurements conducted at the Institute of Physics. These projects will have strong educational and outreach components because of the necessity to develop research capacity in study of the integrated Sun-Earth system.

KEYWORDS: solar energetic particles; secondary cosmic ray muon flux; ground-based and satellite observations

Slovakia

Variations in the rotational speed of the solar corona (2011–2022)

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The contribution summarizes the results of determining the rotational speed of the solar corona in the period of 2011– 2022.

The authors published already the method of input data selection and the results for the period of 2011 - 2018 in Sol. Phys. 294 (2019). This extended analysis takes into account temporal variations in the speed of rotation of the solar corona in the period of 2011 – 2022 depending on (a) the heliographic latitude in the range of (–65°, +65°) and (b) on the level of solar activity.

KEYWORDS: Sun: differential rotation, Sun: solar activity

Sudan

Effect of Ionosphere on GNSS

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Study the sources of ionospheric variability or “weather” which originate from solar and geomagnetic activity and meteorological influences under some phenomena that occur due to suddenly increase in X-ray and EUV fluxes during solar flares events and causes extra ionization of the D, E and F regions of the earth’s ionosphere in the sun lite hemisphere within short intervals of time and suddenly increase the total electron content (SITEC). strongly dependent on the solar zenith angle. Moreover, the strong coupling of the ionosphere to the dense regions below and the solar-driven magnetosphere above make it the most variable component of the atmosphere. Motivation of studding the effect of ionosphere in order to improve techniques to predict ionospheric weather that effects on Global Navigation Satellites Systems and I will suggest to use GNSS data for basic research in future plan.

KEYWORDS: Ionospheric effect in GNSS, Sun-Earth environment and Geomagnetic Perturbation Matrices

Switzerland

CALLISTO instrument and the e-CALLISTO network

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A low-cost solar radio spectrometer, e-CALLISTO, is presented. It is a frequency-agile receiver based on cheap, commercially available consumer electronics. Its major characteristic is the low price for hardware and software, and the short assembly time, two or more orders of magnitude below existing spectrometers. The instrument is sensitive at the physical limit and extremely stable. The native frequency range is 45 MHz up to 870 MHz, and the width of individual channels is 300 kHz. A total of up to 800 measurements can be made per second. The output of the spectrometer is stored in FIT-files, one per 15 minutes of observation. All files from all observatory sites are archived at a central data-server in Switzerland and everyone has full access to all data back to 2002. The spectrometer is well suited for solar low-frequency radio observations pertinent for space weather research, radio monitoring and outreach. 210 instruments of the type were constructed until now and put into operation at ~100 sites, distributed over the whole planet. Several copies of CALLISTO are intended to put into operation in view of ISWI. Antenna setup and results of recent observations made at different stations will be presented and discussed.

KEYWORDS: Radio Spectrometer CALLISTO

Thailand

Equatorial Plasma Bubble (EPB) Observations at low latitude regions of ASEAN

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Equatorial Plasma Bubbles (EPBs) are phenomena characterized by a depletion of ionospheric plasma density surrounded by relatively higher-density regions. They originate at the bottom side of the ionosphere along the magnetic equator during nighttime. EPBs typically stretch to low and mid-latitude regions, and have significant impacts on various technologies such as satellite navigation, communications, power grids, and avionics.

The Excellence Center on GNSS and Space Weather at King Mongkut's Institute of Technology Ladkrabang (KMITL), Thailand develops an observation system to detect and track EPBs using Global Navigation Satellite System (GNSS) data from multiple receiver stations located near the magnetic equator and low latitude in Thailand, Laos. The GNSS receiver stations installed at National University of Laos (NUOL), Laos, and Cambodia Academy of Digital Technology (CADT), Cambodia are as the part of ASEAN IVO projects (http://www.nict.go.jp/en/asean_ivo/index.html), and financially supported by NICT (http://www.nict.go.jp/en/index.html). Using GNSS data, we generate 2D-maps of Total Electron Content (TEC) and Rate of TEC Index (ROTI), covering the low latitude region from N 0° to N 25° and E 95° to E 110° in terms of latitude and longitude. The dynamics of EPBs are studied with ROTI keogram and radar images collected from a very high frequency (VHF) radar system at Chumphon station, Thailand. Additionally, GNSS scintillation index S4 plots from selected stations are observed to evaluate the impact of EPBs on GNSS positioning and navigation system.

This EPB observation system plays a vital role in the field of space weather. We expect that timely detection and tracking of EPBs for ASEAN's low-latitude regions are crucial for mitigating their adverse effects on various technologies.

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KEYWORDS: Equatorial plasma bubbles (EPBs); Global navigation satellite system (GNSS), Total Electron Content (TEC)

Thailand

Effects of Equatorial Plasma Bubbles on RTK Positioning at Low-Latitude Stations in Thailand

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Equatorial plasma bubbles (EPB) is local ionospheric irregularity which occurs at low latitudes region . The y cause uneven variation of TEC and , as a result, degrade the performances of the positioning system including kinematic positioning . Real time kinematic (RTK) positioning offers centimeter level positioning, which is widespread in today's technology (He et al., 2014). The RTK technology requires one or more base stations to broadcast error correction to the rover stations (users). Rovers determine their positions using algorithms that incorporate ambiguity resolution and differential correction. In (Jacobsen et al., 2012), the researchers noticed that the positioning errors increase exponentially with increasing ROTI and the standard deviation of errors increases from less than 10 cm to 3 m during the disturbed period since the RTK positioning system cannot provide the fixed solution. In (Jacobsen et al., 2014), the researchers also found that there is a strong positive correlation between the ROTI and PPP errors since the 3D positioning errors increase exponentially with ROTI based on observation data of 2012 in high latitude regions ranging from 57˚ to 79˚ North.

In this study, we analyze the effects of ionospheric disturbances on the GPS kinematic positioning technique with different baseline lengths between the base and rover station near the Suvarnabhumi Airport, Bangkok Thailand. Three station pairs are used to study the various baseline length of 4 km, 12 km, and 21 km respectively. At each baseline length, we analyze the positioning errors base d on 1 second observation data of disturbed days determined by ROTI.

For example, on DOY 296, 2022, the percentages of fixed and float solutions are 90.8 and 9.2 percent for the 4 km short baseline, 68.5 and 31.5 percent for the 12km medium baseline, and 46.6 and 53.4 percent for the 21km long baseline, respectively. We observed that the positioning errors significantly increase during the disturbed hours from cm level to m level accuracy. The horizontal and vertical errors of all baseline lengths are high during the disturbed period; the errors are even higher at longer baseline lengths due to lower percentages of the fixed solutions. We notice that most of the high positioning errors occur at the equinox and high positioning errors are caused by local ionospheric events rather than global activities and the global geomagnetic activity (Kp) does not have much effect on local ionospheric conditions (ROTI) in this region.

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KEYWORDS: Equatorial plasma bubbles (EPB); RTK; Ionosphere

Türkiye

A Novel Ionospheric Diagram for understanding Ionospheric Characteristics and Behaviour

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The ionosphere is a highly dynamic and complex region of Earth's upper atmosphere, where plasma interacts with electromagnetic radiation, magnetic fields, and other physical processes. Comprehending the attributes and actions of the ionosphere is crucial for multiple applications, such as radio communication, navigation, and space weather forecasting. This study has a novel theoretical diagram of the ionosphere that presenting a standardized structure for grasping the physical mechanisms characteristics of this region.

The diagram includes ten lines in the middle that represent the variation of the Poynting vector as a function of altitude, which offers a quantitative measure of the energy flow in the ionosphere. Their slopes are proportional to the Kp index, which represents the level of geomagnetic activity. On the left y-axis, there are several vertical lines representing different ionospheric layers, such as the D, E, F1, F2, and F layers, as well as various phenomena like aurora and plasma bubbles. The length of these vertical lines is calculated as a function of F10.7 and the Solar Zenith Angle, and the value of the layer or phenomenon of interest on the line is determined according to their values at the time of examination. The diagram also encompasses three logarithmic secondary y-axes denoting electron density, electron temperature, and the electron-to-ion temperature ratio, computed via Chapman functions. By drawing lines from the layer/phenomena lines and intersecting them with the interested altitude point of the middle lines at the selected Kp index, various characteristics such as electron density and temperature can be determined for questioned layer/phenomena. As a result, the values of various ionospheric characteristics may be shown at different altitudes and under different solar and geomagnetic conditions.

The proposed theoretical representation of the ionosphere introduced in this investigation delivers a valuable tool for visualizing and understanding the energy flow and connected physical processes within the ionosphere. As it is purely theoretical and not restricted to any specific location or observation, scientists studying the ionosphere in any locality can utilize it, providing a standardized method to visualize and comprehend the ionosphere's properties and behaviour. It could function as a universal reference instrument for comparing and interpreting observational data, enabling scientists investigating the ionosphere in various locations and under different solar and geomagnetic conditions to better understand and interpret the complex physical processes occurring in the ionosphere. With ongoing research and development, this representation holds the potential to substantially enhance our understanding of the ionosphere and its effects on Earth and space-based technologies. It could facilitate efficient and effective ionospheric study, leading to new discoveries and advancements in fields such as plasma physics, geophysics, space physics, and space weather.

KEYWORDS: Space Weather, Ionosphere

Uganda

Validation of Ionospheric Irregularities observed by the COSMIC satellites over the low latitude African region

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This study validated the ionospheric irregularities observed by the Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC) satellites. The validation was done using the scintillation intensity index (S4) data measured by the Scintillation Network and Decision Aid (SCINDA) receiver which operated at Nairobi University (geog lon 36.8o E, geog lat 1.3oS, dip lat -24.1o), Kenya up to the beginning of the year 2012. Therefore, the data of the year 2011 which was the ascending phase of solar cycle 24 was used. The data analyzed were for quiet (Kp < 3) geomagnetic conditions. A simple geo-location of the COSMIC S4 data associated with a link between the COSMIC and Global Positioning System (GPS) satellites was proposed at the tangent point with height between E and F regions of the ionosphere. The COSMIC S4 data whose geo-locations fall in the vicinity of Nairobi were compared with the S4 data measured by the SCINDA receiver. The coefficient of determination which represents the percentage of the variation in COSMIC S4 data associated with the variation in SCINDA S4 was 51 %. Both data sets depict that scintillation occurs mostly in the seasons of March and September equinoxes compared to June and December solstices. However, there was a weak positive correlation (r = 0.3) between COSMIC and SCINDA S4 data.

KEYWORDS: Ionosphere, Ionospheric irregularities, scintillations

United States of America

ISWI Data Coordination & Usage

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The International Space Weather Initiative (ISWI) is a program of international cooperation to advance the space weather science by a combination of instrument deployment, analysis and interpretation of space weather data from the deployed instruments, in conjunction with space data, and to communicate the results to the public and students. To enable open data access and effective use of ISWI data by the international community, careful and deliberate coordination and collaborations between data providers are essential. This presentation will consider the challenges confronting users in accessing and using ISWI instrument data and how those challenges might be mitigated in the future.

KEYWORDS: ISWI data distribution, access, and citation

United States of America

The Sun and Space Weather

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The Sun affects Earth's space environment when it encounters mass and electromagnetic emissions from the Sun. Earth-affecting solar disturbances are flares, coronal mass ejections (CMEs), and corotating interaction regions (CIRs). Flares and CMEs are closely related and often the result of energy release from closed magnetic field regions such as sunspot regions. Flares on the frontside of the Sun change the level of ionization in the ionosphere with significant effect on radio wave propagation that affect GNSS. Flare emissions in radio wave lengths can submerge radar and satellite signals that affect operations. High-speed solar wind can flow from coronal holes on the Sun, which are also from regions of elevated magnetic field strength, but the magnetic fields have open topology. Both CIRs and CMEs can cause geomagnetic storms when they impinge on the magnetosphere with a southward field component. About 10% of CMEs are fast and wide and hence drive magnetohydrodynamic shocks, which accelerate protons to very high energies. Particles in the magnetosphere are also accelerated to high energies during such storms. Particle precipitation into the ionosphere from the magnetosphere and directly from the Sun also change the ionospheric conductivity. Disturbances such as gravity waves propagating into the atmosphere can couple with the ionosphere resulting in ionospheric disturbances and irregularities. This talk provides an overview of the solar sources of space weather and their geospace consequences.

KEYWORDS: Space weather, Geospace Impact, Solar Source

United States of America

Understanding Space Weather and the Effects on Technology

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Space weather can adversely impact the operations of critical infrastructure such as high-voltage electric power transmission grids, navigation, and communication systems. Coronal mass ejections arriving at Earth can trigger geomagnetic disturbances, which produced strong changes in the near-Earth space environment. However, our understanding of the coupled solar wind-magnetosphere-ionosphere dynamics is still a major challenge. This presentation will highlight some of my past and on-going space weather investigation, and how these investigations are used to address societal needs. Particularly, I will focus on geomagnetically induced currents, which occur at the end of the space weather chain.

KEYWORDS: Space Weather, geomagnetically induced currents, technology

Zambia

Variability of the African equatorial ionization anomaly (EIA) crests during Major Storms in the year 2012

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The study investigated the variability of the magnitude and position of the Equatorial Ionization Anomaly crests over the African sector during major magnetic storm periods in 2012. Total electron content data obtained from a chain of global positioning system receivers in both hemispheres around 28°E longitude covered the year 2012 was used in the analysis. As a measure of solar activity, the solar extreme ultraviolet proxy index was used. It was found that the crests expanded poleward during the main phase of the magnetic storm. Additionally, the position of the crests was found to be asymmetric with respect to the magnetic equator. Both crests moved poleward during equinoxes and collapsed towards the equator during winter and summer The results highlight the complexity of the ionospheric variability in the region that lays between the low and mid latitudes region- the “transition” region. Equinox moths recorded the greatest crest magnitude followed than the winter and summer months over both hemispheres during the main phase of the magnetic storms.

KEYWORDS: Equatorial Ionization Anomaly, African Sector, Ionospheric Variability