United Nations
Office for Outer Space Affairs

United Nations/Philippines Workshop on the Applications of Global Navigation Satellite Systems

Jointly organized by
The United Nations Office for Outer Space Affairs and
The National Mapping and Resource Information Authority

Co-organized and co-sponsored by
The International Committee on Global Navigation Satellite Systems and
The Philippine Space Agency

22 – 26 April 2024
Manila, Philippines

Book of abstracts

As of 17 April 2024

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Algeria

Current status and assessment performance of Algerian Augmentation System AL-SBAS based on Alcomsat-1

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The Algerian Space Agency launched in December 2017 an SBAS payload equipped with L1 and L5 transponder channels on board of the Alcomsat-1 geostationary (24°8) satellite. Algeria is taking short, medium and long-term actions to ensure that the Algerian Satellite Based Augmentation System (AL-SBAS) complies with the MOPS (Minimum Operational Performance Standards, RTCA DO-229) and the ICAO Standards and Recommended Practices. This makes it interoperable with other SBAS and ensures a seamless transition aircraft flying into and out of other SBAS service areas. The system aims to provide SBAS services not only for aviation users but also for other general users, such as maritime navigation, surveying, transportation and railways, etc.

The AL-SBAS correction and integrity messages are calculated by the Data-Processing Center (DPC) using GPS satellite data collected from a terrestrial network of eighteen Reference Stations (AL-CORS), geographically distributed over the entire Algeria country. Additionally, the DPC use data from selected reference stations from the IGS network to enhance the accuracy of the calculations. The AL-SBAS transmit these messages through Alcomsat-1 using Pseudo Random Noise (PRN) code 148 on the L1 band. At present, the service area of the AL-SBAS system is limited to Algeria as declared to the International Telecommunication Union (ITU); the test transmission of AL-SBAS with PRN 148 was started in July 20, 2020.

Currently, the SBAS system is in the development phase, undergoing continuous improvement and enhancements to achieve full certification and operational status as a fully functional SBAS.

Since 2021, a series of tests were conducted to assess the AL-SBAS performance, the tests were carried out using real data. The experiments test with the application of AL-SBAS corrections showed the system's ability to improve GPS positioning accuracy. The preliminary tests have yielded very interesting results, with precision comparable to the EGNOS system in its service area, which is operational since October 1st 2009. These test results indicate that the AL-SBAS system is able to provide effective corrections, which enable improved accuracy compared with GPS alone. These promising preliminary results open the possibility for a better exploitation of the AL-SBAS system in the future. Additional efforts should be made to improve positioning accuracy and ensure data integrity. It is therefore possible that further work will be required to make the AL-SBAS system operational.

As a perspective, we encourage the cooperation with EGNOS and the African air navigation services to accelerate the SBAS services deployment and provision to meet requirements of the aviation and extend the coverage of the AL-SBAS system.

KEYWORDS: AL-SBAS, GPS, EGNOS, Accuracy, Integrity.

Armenia

GPS-based 2D Map Creation using Drones Swarm

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Accurate and up-to-date aerial imagery is essential for a range of applications, including mapping, agriculture, surveillance, and environmental monitoring. Many countries are independently developing their own systems to process data acquired from their satellites and various aircraft. The Republic of Armenia (RA) already possesses its artificial satellite and has plans to expand in the upcoming years. Additionally, various organizations, including the Russian-Armenian University, are actively involved in the development of diverse aerial devices for collecting aerial images. Given all the mentioned facts, the development of a system for processing and analyzing aerial images is an important and significant problem.

This project introduces an innovative system that employs swarms of drones for comprehensive land monitoring and data collection. The first step in this system is the storage of collected data, encompassing precise details about the time and location of each capture, in a database. The core of the system is an algorithm designed for processing this data, which includes stitching together drone-captured images using GPS data to create expansive panoramas. The system then conducts rectification to correct image geometry and georeferencing to align these images with standard world maps. The culmination of this process is the integration of these corrected images onto the maps, coordinated by GPS data and Ground Control Points (GCPs), resulting in detailed and continuously updated 2D maps.

A key feature of this system is its capability to continually update the maps. This allows for various types of analyses, such as tracking the changes in a specific territory over time, demonstrating its utility in diverse fields.

KEYWORDS: Drone Swarms; aerial imagery; geographic data analysis; GPS mapping.

Austria

GNSS Application in Nepal

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Nepal, a mountainous, landlocked, and developing country, has recognized the transformative potential of Global Navigation Satellite Systems (GNSS) but faces challenges due to limited prior work in this area. Nepal's unique geographical features present both challenges and opportunities for GNSS applications. Nepal has been using GNSS for various purposes including Geodetic survey, like Ground Control Point (GNS) established by GNSS method to prepare and update the topographical base maps of the country, in natural calamities and environment, e.g. Satellite Gravity Mission Gravity Recovery and Climate Experiment (GRACE) observations have been used to quantify the change in mass because of monsoon precipitation, Himalaya ice loss, and change in ground water storage, in Air Route Planning e.g. Nepal completed WGS-84 (World Geodetic System-84) survey of the runway thresholds, critical positions of runway and navigation aids of TIA and all domestic airports in operation in 1999 and re-verification in 2010, in border control management e.g. Nepal has planned to equip the eight thousand border boundary pillars along Indo-Nepal border to be equipped with positioning system using Nepal-India Boundary Global Navigation Satellite System (NIB GNSS). Although having used GNSS in various areas, Nepal stands at the crossroads of potential and limitations. Nepal's commitment to capacity building signals a proactive approach to address knowledge gaps and harness the transformative power of GNSS applications. However, the journey is incomplete without robust regional and international cooperation. Collaborative initiatives are necessary for sharing expertise, resources, and infrastructure, ultimately propelling Nepal towards a future where GNSS becomes an integral driver of socio-economic progress in this mountainous and landlocked nation. As Nepal opens its doors to collaborative partnerships, it requests the global community to contribute to a shared vision of unlocking the heights through GNSS advancements in this dynamic and promising landscape.

KEYWORDS: Nepal, Capacity Building, International Cooperation.

Bangladesh

Exploring Cadaster mapping by GNSS technology to control time and costs, the possibility of sustainable development in Land Management

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A Land Administration System (LAS) with its cadastral component is the infrastructure that facilitates the implementation of land policies to attain sustainable development. Therefore, the availability of a digital, up-to-date and easily accessible cadastral map with database has become a primary requirement for undertaking efficient land administration and/or spatial planning decisions for any country.

GNSS & GIS technology has the potential to serve the land management decision making process significantly better than conventional methods. Several researches suggest that its investment in GNSS and GIS technology and use of the Digital Cadastral Maps and Database as the primary geographical reference fabric will realize this potential and result in significant benefits to individual users and long term benefits to the nation as a whole.

In this paper, the authors demonstrate a method for constructing a seamless digital cadastral database based on colonial cadastral maps (Mouza maps, Sketch maps) using GNSS, GIS and Remote Sensing image interpretation techniques and photogrammetry for an area of about 600 acres in 3 pilot areas in Amtali Upazila, Borguna district, Jamalpur Sadar Upazila and Mohonpur Upazila, Rajshahi.

50 cm Aerial Orthophoto (Captured by Survey of Bangladesh,2010), 30 cm Worldview-3 (pan-sharpened, December 2016) satellite Orthophoto and Unmanned Aerial Vehicle (UAV) captured Orthophoto (5 cm) data were used for this feasibility study purpose in combination with limited on-site survey which includes GNSS/RTK, Electronic Total Station (ETS) and traditional measuring tape. Comparative analysis of accuracy and cost for different methods were determined for decision making which one will be adopted in future.

The proposed approach could be considered as an alternative to a complete cadastral resurvey, geo register and archive historical sketch mouza maps in a cost and time effective way including exploring numerous future and underlying prospects. It is important to mention here that the quality of these colonial maps is quite high and can be proven as a basis for spatial planning though the common ideas is very much negative in sense of geo-spatial location, dimensional accuracy, edge matching etc.

A cadastral resurvey may be required in the future where there is an urgent need for higher accuracy, but the approach would be time consuming and potentially bring unrest in villages and urban neighborhoods. Hence, an alternative is, therefore, to respect the contents of the existing maps and records combined with a quality upgrade: make the existing records and maps up-to-date as a basis for a spatial planning.

KEYWORDS: GNSS, Georeferencing, Cadastral.

China

Application of BDS for Safety Communication and Search and Rescue

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As a Global Navigation Satellite System (GNSS), BeiDou Navigation Satellite System (BDS) provides both radionavigation satellite service and mobile satellite service. In November 2022, BeiDou Message Service System, a functional component of BDS, was recognized by the International Maritime Organization for use in the Global Maritime Distress and Safety System (GMDSS). Meanwhile, BDS Medium-Earth-Orbit Search and Rescue (MEOSAR) satellites were included into the space segment of the International Cospas-Sarsat Programme. This presentation mainly provides updates on the work progress of BDS application under the framework of international organizations. In addition, the usage of BDS for safety communications and SAR in the transport industry is introduced in details, with a view to facilitating regional and international cooperation on BDS application.

KEYWORDS: BDS, GMDSS, SAR

Croatia

Probability-of-occurrence model for GNSS PNT utilisation risk assessment facilitates GNSS application developments in the fields of aviation and maritime

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The Probability-of-Occurrence (PoO) model is proposed for the GNSS application-related risk assessment of GNSS Positioning, Navigation, and Timing (PNT) service utilisation. The presentation outlines the PoO model development, based on statistical analysis of the long-term GNSS position estimation errors data set, and presents the approach in its interpretation and utilisation in definition of Quality of Service (QoS) of a targeted GNSS-based application. Its development and interpretation is demonstrated in a case of risk assessment of single-frequency commercial-grade GNSS PNT degradation caused by ionospheric effects. The interpretation of developed PoO model is demonstrated for scenarios of GNSS applications in aviation and maritime. The PoO GNSS risk utilisation model is a generic tool for the GNSS-based application QoS determination. Its utilisation contributes to a wider GNSS adoption, and facilitates GNSS-based applications QoS quantification. Additionally, the PoO model utilisation offers prospects for rising GNSS resilience against adversarial ambient effects on GNSS PNT performance. Finally, the PoO model bridges the gap between the GNSS PNT performance specifications, given by GNSS operators, and requirements for PNT performance, set by GNSS-based applications developers, operators, and users. The research presented contributes to UN SDG 9: Industry, Innovation and Infrastructure, and SDG 3: Good health and well-being. The presentation addresses the following Session topics of the United Nations/Philippines Workshop on the Applications of Global Navigation Satellite Systems: (i) Session 2, GNSS-based applications, The use of GNSS for aviation, including integration of satellite navigation technology into air traffic management and airport surface navigation and guidance; (ii) Session 2, GNSS-based applications, Navigation systems operation in marine environment, including waterway navigation, harbour entrance/approach, marine archaeology, fishing, and recreation; and (iii) Session 4, GNSS data processing, Understanding GNSS data types, GNSS errors, coordinate systems and applications.

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KEYWORDS: risk assessment of GNSS utilisation, GNSS PNT performance, Probability-of-Occurrence (PoO) model.

Egypt

Designing, Implementing and Testing a Low-Power GPS Rx Subsystem for LEO Satellites

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The GPS Subsystem stands as a pivotal component within satellite systems, playing a crucial role in determining satellite position and velocity—essential factors for optimal satellite functionality. This project focuses on the development of a low-power, high-accuracy GPS Subsystem for LEO Satellites. Rigorous testing, including vibration and temperature testing in the Agency's AIT facility, ensures the subsystem's resilience to space environment conditions. Functional assessments were conducted using LabVIEW-based CTE implementation and Signal Simulator testing under various scenarios. The resulting subsystem is poised for integration into future agency missions.

KEYWORDS: GPS - LEO – LabView.

Estonia

Estonian GNSS permanent station network ESTPOS as EUREF densification

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Estonian GNSS (Global Navigation Satellite Systems) permanent station network (ESTPOS) serves the basis of the Estonian geodetic system and provides new high quality coordinate solution for the continuously operating refence stations (CORS). Presentation gives an overview of the computation process and future insights for Estonian geodetic system.

For the computation of the ESTPOS CORS the methodology developed by Nordic Geodetic Commission (NKG) GNSS Analysis Centre (GNSS-AC) was used. Computation is based on daily RINEX files. Bernese GNSS Software version 5.2 was used to compile weekly SINEX solutions. In order to obtain multi-year solution, CATREF programme was used, as the result final coordinates and velocities of ESTPOS CORS stations were obtained. Final coordinates were given in International Terrestrial Reference Frame 2014 (ITRF2014) and were also transformed to European Terrestrial Reference Frame 1989 (ETRF89), using web-based tools available from European GNSS Network (EPN) Central Bureau (CB) webpage. The corresponding computation and analysis were submitted to Reference Frame Sub Commission for Europe (EUREF) Governing Board and was accepted as EUREF densification for Estonia, corresponding to EUREF Class A accuracy (i.e., coordinates with 1 cm precision and velocities with 1 mm/yr precision at all epochs).

KEYWORDS: ESTPOS, GNSS, EUREF

India

Compact, Low-Cost GNSS Hardware: Potentials in Precise Positioning, Ionospheric Probing, Time Transfer and Application Development

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GNSS now is used for myriads of applications- in positioning, atmospheric research and timing with extreme precision and confidence. To cater to the needs of the applications, various positioning techniques and methods have evolved together with notable changes in the hardware aspects. Commercial introduction of the compact, low-cost, single frequency (CLS) and dual frequency (CLD) GNSS modules offered advantages in terms of cost, size, power requirements, multi-GNSS signal tracking capability and provision for raw GNSS data collection. These modules quickly penetrated the location-based application market of GNSS. This work presents the results of systematic, repeated, and diverse studies on the suitability of compact, low-cost GNSS modules for GNSS research and real-time applications.

In the case of positioning, CLS and CLD GNSS modules operating concurrently with geodetic grade GNSS receivers show similar performances. In GPS-only single point positioning (SPP) both the hardware types provide better than 3 m 2DRMS in 2-dimension (2d); in 3-dimension (3d), the CLD module performs like the geodetic receiver with SEP values around 1.7 m; the CLD performance is slightly inferior. Exciting results have been found in Real Time Kinematic (RTK) operation using a uBlox M8T CLS module together with a commercial patch antenna as the Rover and a geodetic grade Base station. In GPS+Galileo+QZSS hybrid operation, up to the single baseline distance of 288 km, better than 40cm 2DRMS values are obtained. Use of only one Base for a long baseline and low-cost compact module as the Rover proves the scope for overall cost reduction of the RTK infrastructure for real-time applications. CLD modules perform better than the CLS modules as RTK rovers. For Precise Point Positioning (PPP), two CLD modules offer below 5 × 5 mm horizontal accuracy which is similar or better results compared to their geodetic.

Together with the widely used positioning applications, the CLD modules show extremely good capability for ionospheric research. Total Electron Content (TEC) measured using the data from a uBLOX F9P receiver shows a good match (correlation coefficient, r = 0.97) with the values calculated using the same data from a Javad Triumph LS geodetic receiver. During the periods of low to intense ionospheric scintillations, concurrent observation using a uBlox F9P CLD module and a Leica GR50 geodetic receiver again shows a good match (r= 0.99) between the amplitude scintillation index (S4) for GPS and BDS signals using CLD module and geodetic receiver. The fade rate and decorrelation time values also match well. These results show the potential of the compact GNSS modules for developing a network of autonomous, multi-probe ionospheric monitoring infrastructure over a distributed geographical region to study small-scale events in a cost-efficient manner, typically in cost-constrained situations.

Time Transfer- the other important application of GNSS may also be done using these compact modules using the provision of hardware 1pps output. Typically for India, using NavIC modules for such applications would help in cost-efficient time transfer applications.

The efficacy of the GNSS modules is utilized in real-time application developments like in agriculture, resource and situation monitoring, asset tracking has been successfully implemented.

With the clear advantages of cost, compactness, ease of use and power efficiency, performance studies of the compact GNSS modules show that they are good candidates for the popularization of GNSS through best exploiting the potential of GNSS for all GNSS stakeholders, especially for the developing countries. The presentation will showcase the results of the studies in detail.

KEYWORDS: GNSS Compact Modules, PNT, Ionospheric Research.

India

A Comprehensive Analysis of Android Smartphones GNSS Positioning and Signal Strength in Indoor and Outdoor Environments

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The increasing popularity of GNSS smartphone positioning systems, owing to their cost-effectiveness, has sparked considerable interest. However, achieving high-accuracy smartphone positioning presents challenges such as noisy GNSS data, environmental influences, and varying GNSS sensor configurations. A very few research articles discussed single-point positioning (SPP) quality based on single- /dual-frequency smartphone code observations. In view of this, there is a need to examine and compare the quality of GNSS observations from Android smartphones for substantial insights and outcomes. In this research work, the smartphones namely 'Poco M3' and 'Moto G52' with dual-frequency chipsets (Snapdragon 662 and 680, respectively) and the 'Huawei Nova 3e' with single-frequency chipset (Honor Kirin710) are employed. Here, the real-time GNSS data was acquired on August 23, 2023 (DOY-235) in both indoor and outdoor environments. The primary objective of this study is to assess the accuracy and reliability of single-frequency measurements in contrast to dual-frequency measurements. Furthermore, this work also aims to evaluate the comparative analysis of dual-frequency Android smartphones. Here, signal-to-noise ratio (SNR) and position solutions are considered to determine the quality of Android GNSS measurements. The positional solutions are estimated with weighted least squares (WLS) and kalman filtering (KF) techniques and the positioning error is assessed in terms of horizontal and vertical directional errors at 50% and 95% probabilities. In both environments, the obtained results illustrate the impact of smartphone chipsets corresponding to number of position solutions and the acquisition of satellite signals. It is noticed that the "Huawei Nova 3e" smartphone exhibits lower satellite signal strength compared to dual-frequency smartphones. Moreover, it experienced unexpected observational drifts and insufficient positon solutions in indoor conditions. Here, the single-frequency signal strength is approximately 5–6 dB-Hz lower than that of the dual-frequency signals at outdoors. In case of the comparative assessment of dual-frequency smartphones, the 'Moto G52' achieves better horizontal and vertical accuracy of about 3m and 6m at indoors and 1m and 2m at outdoors, respectively, when compared to the 'Poco M3'. Here, the 'Poco M3' device has an SNR range of about 15 to 38 dB-Hz. In contrast, the 'Moto G52' device has SNR values are mostly concentrated between 25 and 40 dB-Hz. Notably, dual-frequency smartphones exhibit a promising signal strength compared to single-frequency device. During the observation period, the GPS and GLONASS signals exhibit a better SNR range (27 dB-Hz to 36 dB-Hz) across all observed devices in both indoor and outdoor conditions. These findings contribute to a better understanding of the flexibility of Android GNSS signals and significance of dual-frequency devices in signal-degraded environments.

KEYWORDS: Android GNSS measurements, SNR,WLS, and KF.

Indonesia

Accuracy assessment of high-end and low-cost GNSS receivers using MADOCA PPP

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The performance of GNSS receivers is the primary concern in meeting the industry needs, mainly their accuracy. GNSS receivers available in the market offer alternatives, including price ranges. This study compares GNSS receivers' accuracy when categorized into high-end and low-cost. Trimble NetR9, MSJ MJ-3008-GM4-QZS, U-Blox F9P, and Septentrio Mosaic CLAS were investigated daily for eight MADOCA PPP data logging days. Though convergence time was observed, the 2D RMS was closely analyzed. The 2D RMS value indicated that Trimble NetR9 and U-Blox F9P were mainly stable. Septentrio Mosaic CLAS, as a low-cost receiver, performed with good accuracy despite the unstable performance and high convergence time. Thus, this study stresses that the low-cost GNSS receiver is reliable when precise accuracy is concerned. This finding is an essential reference for GNSS receiver innovation and development, even more so for the users.

KEYWORDS: GNSS; High-end receiver; Low-cost receiver; MADOCA PPP.

Indonesia

GNSS Applications and Prospects in Indonesia: Academic Perspective

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Satellite-based surveying and monitoring techniques, including the Global Navigation Satellite System (GNSS) application, are rising trends in current industry. GNSS has been applied from macro to micro levels by multi stakeholders. Technology innovations has intensely used in many primary sectors in Indonesia, as the strategic tool for problem solving as well as policy and decision making. However, the GNSS applications has not been widely implemented in technology utilization in Indonesia. Indonesia experiences ranges of urgent needs of real time and precise technologies; such as natural disasters, smart cities, transportations, marine, agriculture, infrastructure construction and security and defense. This situation is not only urgent needs but also the great prospects for applications and development of GNSS in Indonesia. There are many factors involved for Indonesia to transform to this stage, including the knowledge and awareness of local and national authority. Therefore, comprehensive review of current GNSS applications and prospects in Indonesia from the academic point of view is presented in this study.

KEYWORDS: GNSS Applications; Prospects; Indonesia.

Japan

Pilot Experiment of MADOCA-PPP for base point installation in a remote islands of the Philippines

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Since relative positioning with existing reference points is not possible on remote islands or areas without CORS (Continuously Operating Reference Stations) nearby, establishing a new base point using GNSS requires long-term SPP (Single Point Positioning) observations or long baseline analysis. Particularly on remote islands in the ocean, long baseline analysis is often not possible. SPP's accuracy is also limited by various error sources such as atmospheric delays, satellite clock errors, and multipath errors.

Applying PPP (Precise Point Positioning) in such cases can be expected to significantly reduce the time to install a base point and improve the accuracy of the coordinates. PPP utilizes precise satellite orbit and clock data which corrects for signal errors present in SPP, leading to a more reliable position.

A technical guideline (draft) was developed based on the statistical methods for the operation of MADOCA-PPP (Multi-GNSS Advanced Orbit and Clock Augmentation) that was the free service of the QZSS (Quasi-Zenith Satellite System), and established a base point using MADOCA-PPP on the actual remote islands in the Philippines. QZSS is a regional satellite navigation system operated by Japan and it is primarily deployed to enhance the availability and accuracy of GNSS signals in the Asia-Oceania region, particularly in areas where GNSS signals are obstructed by buildings or natural features.

The application of PPP, and specifically MADOCA-PPP, represents a significant advancement in the field of geospatial science. It offers a practical solution for establishing reliable and accurate reference points in remote areas, thereby enhancing the capabilities of mapping, surveying, and navigation in these challenging environments. The continued development and adoption of MADOCA-PPP will likely play a crucial role in the future of global geospatial infrastructure. The authors hope that the use of MADOCA-PPP will increase based on the guidelines in the future.

KEYWORDS: MADOCA-PPP, QZSS, CORS

Kyrgyzstan

Impacts of space weather on aviation

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The World Meteorological Organization (WMO) defines space weather to be, “The physical and phenomenological state of the natural space environment, including the Sun and the interplanetary and planetary environments.”

Space weather events such as solar radiation storms, geomagnetic storms, ionospheric storms and solar flares are considered for international air navigation. These forecasts enable operators the opportunity to be situationally aware and to formulate alternative plans in case the impending conditions be of a magnitude and a type that could disrupt normal flight operations.

Space weather impacts may include degraded performance of navigation and surveillance that rely on GNSS.

For example, during ionospheric storms, GNSS amplitude and phase may each be affected making the signals of one or more satellites in view impossible to track. This loss-of-lock may result in reduced accuracy of positioning of an aircraft in flight or, at worst case, a denial of GNSS service.

In rare cases, bursts of radio emission during solar flares are strong enough to have effects on GNSS receivers. This is strictly a dayside impact and is mainly noted by non-aviation GNSS receivers employing high-precision techniques. Since aircraft use more robust GNSS applications for navigation, it is highly unlikely this impact would ever be registered in aviation.

There are four global space weather centers (SWXCs) in the world. SWXCs issue the space weather advisory when impacts to HF communications, communications via satellite, GNSS-based navigation and surveillance systems, or heightened radiation occurs.

KEYWORDS: Space, Weather, Aviation.

Lao People's Democratic Republic

Satellite Communications in Lao PDR

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Lao PDR is the only landlocked country in Southeast Asia covering a total of 236,800 square kilometers. Nearly three-quarters of Lao PDR is covered in mountains and forested hills where normal terrestrial communications facilities are difficult to be deployed. Satellite Communication plays an important role in promoting the social development of Lao PDR and improving Lao people's living standard. Lao PDR attaches great importance to the LAOSAT-1 satellite project.

The Lao Satellite Project is a great strategic choice of the Lao government for the enhancement of overall national strength, technological capabilities, and further socioeconomic development to ensure that Lao people have equal opportunity to be able to receive television and education channels as well as more importantly allow for the wide and immediate dissemination of critical and safety of life information to not only Lao population but also to those of neighboring countries. It will be a breakthrough for the first time for Laos for peaceful use of outer space, narrowing the technological distance and to eliminate the digital division in our country's communications field, we are com-mitted to a variety of ways to promote the development of the Lao satellite communications industry.

And LAOSAT-1 satellite was launched on 21st November 2015. It deploys 22 transponders including C band and Ku band frequency.

As a developing country, however, Lao PDR has less experience in the satellite industry and lacks of satellite communication professionals who are familiar with the Satellite technical and Radio Regulation provisions, and the LAOSAT-1 is this country's first satellite, and we are learning more from the International Satellite Organization and the ITU expertise.

In 2021, our Ministry changed its name by combining the Ministry of Post and Telecommunications and the Ministry of Science and Technology, currently, one of the important works is GNSS.

We use GPS for positioning, Mapping, Air Traffic Navigation, Land Management, Vehicle Safety Protection, Vehicle Traffic Navigation, etc.

Many organizations used GNSS in Lao PDR, and they are developing by co-operating with start-up from many companies, organizations and other countries. So, this is very challenging work for us to learn the technical and regulations of GNSS from advanced countries and International Organizations to become the central of GNSS management Digitalization in Laos.

KEYWORDS: Satellite Communications, Digitalization, Radiolocation.

Malaysia

Enhancing Precision Navigation in Peninsular Malaysia: A Comparative Analysis of Satellite-Based DGPS and Commercial SBAS Services

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Global Navigation Satellite System (GNSS)-based augmentation systems play a crucial role in ensuring the accuracy, integrity, and availability of navigation signals across various sectors. This research focuses on assessing precision navigation in Peninsular Malaysia by comparing the performance of Satellite-Based (Communication Satellite) Differential GPS (DGPS) and Commercial Satellite-Based Augmentation System (SBAS) Services to enhance GPS navigation accuracy. Data were collected using a geodetic-grade receiver mounted on a vehicle along the east coast of the Malaysian peninsula (covering Kuantan, Pekan, Mersing, and UTM Johor). The study aims to evaluate the advantages and limitations of these augmentation services, providing insights essential for decision-makers in transportation, agriculture, surveying, and related sectors. The significance of this study lies in its potential to enhance navigation efficiency and effectiveness in the region, contributing to socio-economic development and national technological advancement planning. The outcomes include a comparative analysis of the augmentation services, identifying strengths and weaknesses, and offering recommendations for optimizing GNSS-based navigation systems in response to Peninsular Malaysia's unique geographical and environmental conditions. This research aims to facilitate the progress of precision navigation in the country, serving as a valuable resource for future research, development, policymaking, and implementation to support critical applications.

KEYWORDS: GNSS, DGPS, SBAS.

Mongolia

Geodetic Network of Mongolia

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Mongolia is quiet big country in terms of mapping and to solve geodetic issues, which should fit for 6 six degrees zones from 45 up to 50.

Mongolian height network established in 1936-1954 by Russian red army, which connected to Russian height network by 6 lines. Height network's total length is 14000 km with 46 lines and 13 polygons, which consist of more than 2500 points.

1st class gravity network with 31 points in 21 aimag centers established in 1982-1985. Relative gravity measurement done and connected to Russian gravity network by airborne gravity measurement in 1980s.

2nd class gravity network established in 1988-1989 with 103 points in soum centers.

Mongolian geoid height model developed using satellite, airborne and ground gravity measurement. Airborne gravity measurement carried out in 2004-2005. Geoid model's accuracy is 16 cm for whole country, 2-5 cm in capital city.

There are two types of horizontal network established in Mongolia since 1940-s: Triangulation network and GPS primary network, which is known as Monref 97.

Mongolian triangulation network was established Russian red army in 1936-1961. Datum point is Pulkovo 1942. There are more than 20000 triangulation network points in Mongolia.

GPS primary network of Mongolia Monref97 was established in 1997-1998 and adjusted in 2000 by Bernese software. Monref97 network consists of 34 points, which are 1st class Gravity and 2nd class triangulation network points.

Densification of Monref 97 network was carried out in 2002-2013 and consists of 3760 points and used for cadastral and topographic mapping.

GNSS CORS established since 2000. There are 65 permanent stations: 43 stations owned by General authority for land administration geodesy and cartography \General authority\, others by Mongolian academy of science, Local government organizations and private companies.

43 CORS stations coordinates, which are running by General authority calculated in ITRF2008 coordinate system.

Mongolian Government Decree Number 25 from 2009 says to use WGS84 coordinate system, the Baltic sea level height system and UTM projection for surveying and mapping.

1st class leveling network established in 2014-2023 with Length 4300 km, which has 7 lines and 2 polygons with 520 points. GNSS measurement, gravity measurement and leveling measurement carried out on leveling network points.

Mongolian geodetic network origin point was installed in Arkhangai aimag center in 2019. GNSS, leveling network connected to the origin point.

There are more than 1500 GNSS networks points installed in Mongolia.

Database of geodetic network points created and are distributing through Internet since 2019.

The Government of Mongolia approved Resolution No. 267 in 2022 to use ITRF2020 coordinate system, Baltic Sea level height system, and UTM projection in surveying and mapping.

The GNSS-CORS data is adjusted in the ITRF2020 coordinate system and their velocity value is calculated in 2023.

KEYWORDS: coordinate system, origin point, GNSS-CORS.

Mongolia

GNSS Application based on citizen science in Mongolia

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Mongolia is landlocked country between Russia and China, the total territory area is 1,564,000 square kilometers with average elevation 1,300 m from Baltic Sea level. Space technology in Mongolia has a long story from 1965 which was involved INTERCOSMOS program, old Soviet Union Space program, and its included 1st telecommunication satellite data receiving station 'ORBIT' and meteorological satellite data receiving station in 1970. Moreover, Mongolians are comparing the 1st cosmonaut of Mongolia, Dr. J. Gurragchaa, and he is the 2nd Asian in the space. The 5 years, ago, Mongolian 1st CubeSat, MAZAALAI, launched under JAXA nano- satellite program.

Surveying and establishing geodetic networks in such a large and varying country is of course very demoing and time-consuming, especially, with traditional geodetic methods as triangulation and levelling. In the past, the Mongolian triangulation, gravity and leveling networks were based on Soviet Union, meaning the old Pulkovo-42 reference system, Krassovsky reference ellipsoid and height system was Baltic Sea level. The introduction of GPS and GNSS techniques for geodetic measurements at the 1990s set new requirements on the reference systems and did at the same time give new possibilities for the establishment of new reference systems. Moreover, in the 2009, Mongolian Government Resolution No.25 noted the coordinate system: WGS 84 (ITRF 2000 epoch 1997.8 /MonRef 97/), the height system: Baltic Sea level, the projection: UTM. Consequently, in the 2014, Agency for Land Administration, Geodesy and Cartography's resolution No. A/112 and A/261 is defined ITRF2008 epoch 2005.0 • Mongolian Geoid Model (MONGEOID 2012/2014). Currently, in Mongolia is totally working 54 CORS, and five of them is connected in the APREF and one, ULAB, is connected to IGS network.

In 2014, Mongolian Geospatial Association (MGA) is established in Ulaanbaatar, and the main aim of the association is a Mongolian non-profit organization dedicated to promoting geospatial information management, remote sensing, GNSS and surveyor, thought sharing information and professional knowledge, cooperation and international understanding and goodwill impact the Mongolian geo-spatial information users, researchers and experts. The MGA has served over 100 members to deliver and to share cutting-edge technology and approaches about geo-informatics by Mongolian language. Since 2018, we were involving International GNSS Monitoring and Assessment" (iGMA) project, Asia-Pacific Space Cooperation Organization (APSCO) and the project was established two monitoring stations in Mongolia, Ulaanbaatar, which a capital city and Ulaangom, which is in the western Mongolia, Uvs province. Moreover, MGA hosted United Nations/Mongolia Workshop on the Applications of Global Navigation Satellite Systems (in Virtual Format), Ulaanbaatar, Mongolia, 25 - 29 October 2021 with UNOOSA. Furthermore, we, MGA, are interesting to host School on Space Weather (SW) and Global Navigation Satellite Systems (GNSS) in the Mongolia with UNOOSA and other stakeholders.

KEYWORDS: space, GNSS, network, activities, monitoring, network.

Nepal

Research Activities on GNSS Lab at Pashchimanchal Campus, Tribhuvan University, Pokhara, Nepal

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Pashchimanchal Campus, Tribhuvan university has conducted Bachelor Degree in Geomatics Engineering and Master of Science in Geospatial Engineering for the demand of Geospatial engineering human resources in Nepal. The Center for Space Science and Geomatics Studies (CSSGS), Pashchimanchal Campus, Tribhuvan University has established GNSS lab and a first priority has given to the capacity building, data distribution and second priority is for research application in the field of GNSS. The main aim of CSSGS is to focus for center of excellence in the field of Global Navigation Satellite Systems (GNSS) research and provide services to universities students and government of Nepal. CSSGS has focus in collaborative training, research and students' research activities. CSSGS has been providing GNSS training with collaboration with the support of ICG, Center for Spatial Information Science (CSIS), The University of Tokyo and University Grants Commission, Nepal for the students and government employee since last three year. CSSGS has established one CORS station for the GNSS application data generation. Students are doing their research project and thesis research on Application of GNSS from the data acquire from CORS. Establishment of other CORS stations throughout the Gandaki Province are continuing process to generate data for the further research. CSSGS has conducted GNSS based research activities and master students research in the divers' theme of application of GNSS. CSSGS welcome to international universities and institute for the collaborative research activities.

KEYWORDS: Global Navigation Satellite System (GNSS), CORS, Space Science.

Pakistan

Study of Equinoctial Asymmetry in Total Electron Content (TEC) for the Two Extremes of Solar Cycle 24

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Over the past decades, studies regarding ionospheric variation have been modelled, toward seasonal and semi-annual variations, along with summer-to-winter and solstice-to-equinox differences using the critical frequency of the F2 layer (foF2), peak electron density (NmF2), and total electron content (TEC) data. We anticipate the same as pointed out by previous studies that at several stations, TEC values in March-April are usually larger than the TEC values in September-October equinoxes. Also, during low solar activity, EA is mainly a low-latitude phenomenon. It is also anticipated that solar EUV is found to be major factor which not only controls the ionization of the ionosphere but also has direct or indirect effect on other mechanism responsible for EA. The present study aims to analyze, using both model (IRI, NeQuick) and observational evidence ionospheric EA, in Total electron content (TEC); for the two extremes (solar minimum and solar maximum) of the solar cycle 24 over the regions ranges from 25° - 60° N geog. latitude, during quiet geomagnetic conditions (Ap < 6) to point out the liable mechanisms responsible for this asymmetry. Furthermore, the findings of this study can be used to improve ionospheric models and is essential in advancing our knowledge of the ionosphere's behavior and its interactions with the Sun.

KEYWORDS: Equinoctial Asymmetry, Solar minimum, Total Electron Content, Low Latitude.

Pakistan

Development of Sustainable Cities using Pak-SBAS

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SUPARCO is developing Pakistan Space Based Augmentation System (Pak-SBAS) for improving the accuracy and reliability of existing Positioning, Navigation, and Timing (PNT) service in Pakistan. The system is planned to be launched by year 2024 for enabling Public and Authorized Services in Pakistan. Public Service will provide integrity based enhanced sub-meter level accuracy for Safety of Life (SoL) applications whereas, Authorized service will provide decimeter level accuracy based on Precise Point Positioning (PPP) technology to Non-Safety of Life (Non-SoL) applications. Pak-SBAS is the first SBAS System utilizing BeiDou PPP-B2b signal in Pakistan. The system will receive data from International GNSS stations (IGS) to enable the Authorized service (Level-I) with convergence time of 30 min. At later stage, the convergence time will be reduced to 1 min.

Primarily, Pak-SBAS service is intended for Performance Based Navigation (PBN) in the aviation sector, in accordance with the International Civil Aviation Organization (ICAO) Standard & Recommended Practices (SARPs). However, the Pak-SBAS Authorized service can be utilized in the socio-economic contributing sectors such as transportation, urban planning & infrastructure development, precision agriculture and deformation monitoring etc., to achieve UN Sustainable Development Goals (SDG).

In recent years, Urban Planning and Infrastructure development has become a critical sector in Pakistan due to on-going population growth and rapid urbanization. Government is facing numerous challenges in urban planning, transportation, infrastructure development and management. Considering these challenges, Pakistan Vision 2025, also envisages in developing urban areas into sustainable, eco-friendly cities through effective urban planning and efficient local mobility infrastructure (mass transit systems) using modern technologies. However, there is a limited GNSS infrastructure available in Pakistan which can meet the requirements of urban development. Pak-SBAS services hold immense potential to enhance efficiency, safety, and productivity in urban planning, management and infrastructure development. The subject presentation will present the utilization of Pak-SBAS services in urban planning, infrastructure development and monitoring: These services can be used for land demarcation to define property boundaries, parcel shapes, and plot location. Large-scale topographic maps can also be prepared for site planning and designing. Pak-SBAS services can be used in the various construction activities such as the establishment of utilities, development of critical infrastructure and monitoring of structural deformation faced by bridges & buildings etc. These services can also play a significant role in the advancement of modern transportation systems. Detailed maps of road networks and infrastructure can contribute to effective transportation planning, management and smart mobility.

SUPARCO is diligently working on implementation of Pak-SBAS to address the challenges in the fields of transportation, urban planning & infrastructure development, agriculture, disaster management & relief sectors etc. SUPARCO looks forward to the cooperation of the GNSS Community and Industry to adopt advanced GNSS technology services and applications in Pakistan.

KEYWORDS: GNSS Applications, SBAS system, Precise Point Positioning (PPP) Service.

Philippines

On the use of ERA5 Reanalysis data for Precipitable Water Vapor Estimation using Philippine GNSS CORS stations

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Precipitable water vapor (PWV) is the amount of water vapor found within a vertical strip of atmosphere that has the potential to condense into rain or snow. Due to its correlation with precipitation, forecasting PWV has the ability to improve weather predictions and aid in developing more accurate climate models. While standard methods to acquire PWV exist, such as through radiosondes (RS), they tend to be expensive, have low temporal resolution, and are limited in spatial coverage. Moreover, estimating PWV solely using GNSS data relies on the availability of collocated synoptic stations that measure surface meteorological parameters. This, however, is not always possible, especially as the Philippines has limited available GNSS stations. Hence, this study explores the use of meteorological data from the ERA5 model alongside GNSS Zenith Total Delay (ZTD) data from the Philippine Active Geodetic Network (PAGeNet) in order to compute for PWV in different locations within the country. Data from PPPC station (9°46'22.8"N 118°44'24.0"E) from the year 2015 was used in order to determine the performance of ERA5 surface meteorology in estimating PWV. Preliminary results from this study indicate a strong correlation (R = 0.9585) between PWV estimated using the proposed method and RS-PWV. In comparison with the standard way of estimating GNSS-PWV using surface meteorology and RS-PWV, where R = 0.9627, it can be concluded that the proposed method has the potential of being an alternative method of estimating GNSS-PWV. It is recommended that further studies explore the use of other GNSS stations from other locations as well as increasing the years investigated.

KEYWORDS: PWV, ERA5, GNSS

Philippines

GNSS Motions Associated with eight Recent Earthquakes in the Philippines

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Eight significant earthquakes that occurred in Luzon and in Mindanao from 2019 to 2022, namely the 2019 Cotabato earthquake series (M6.3 on 16 October 2019; M6.6 and M6.1 on 29 October 2019; and M6.5 on 31 October 2019), the 2020 and 2023 Masbate earthquakes (M6.6 on 18 August 2020 and M6.0 on 16 February 2023), and the 2022 July and October Northwestern Luzon earthquakes (M7.0 on 27 July 2022 and M6.4 on 25 October 2022) were analyzed using the data collected from continuous and campaign Global Navigation Satellite System (GNSS) measurements. The data were processed using the Bernese GNSS software to determine the positions, interseismic surficial velocities, and co-seismic displacements.

Measurements from a GPS campaign survey conducted three days after the 31 October 2019 M6.5 Cotabato earthquake showed cumulative co-seismic displacements of 335.40 mm for the four events. The direction of the displacements of the two GNSS stations closest to the epicenters indicates a largely right-lateral strike-slip motion.

On the other hand, subsequent analysis on the August 2020 M6.6 Masbate earthquake showed that the largest horizontal displacement is 447.5 mm, with azimuthal direction towards N137.61°. The total co-seismic displacement was measured at least 620 mm along the fault, consistent with the approximate horizontal displacement measured by the PHIVOLCS Quick Response Team (QRT) members. The direction of the vectors for the GNSS points in Masbate displayed left-lateral motions, consistent with the motion of the Philippine Fault. Similarly, data from the GNSS survey following the 16 February 2023 M6.0 Masbate earthquake also indicated predominantly parallel displacements to the Philippine Fault. The total co-seismic displacement during the 2023 earthquake is at least 200 mm. Both earthquakes showed indications of elastic rebound, with most of the points west of the fault moving in a southeasterly direction.

Dislocation modeling based on GNSS data collected from 1997 to 2005 in Masbate indicated a recurrence interval of 20-80 years for significant earthquakes in the region. The last substantial event occurred only 17 years ago. Enhanced modeling techniques suggest that GNSS could play a valuable role in assessing seismic hazards.

GNSS data calculations associated with the Northwestern Luzon earthquakes, M7.0 on July 27, 2022, and M6.4 on October 25, 2022, showed cumulative co-seismic displacements near the Abra River Fault and Vigao-Aggao Fault of 235 mm and 29 mm, respectively.

Further analysis of interseismic data from Cotabato province between 2009 and 2018 revealed surficial horizontal velocities ranging from 49.10 mm/yr to 62.53 mm/yr with azimuths from N270° to

N297°, calculated with respect to the Eurasian Plate. Conversely, the interseismic horizontal velocities in Masbate were calculated varying from 23.39 mm/yr to 55.79 mm/yr and have azimuths from N291.63° to N310.56°. Over a 22-year period in Northwestern Luzon, GPS measurements yielded velocities ranging from 72.72 mm/yr to 85.87 mm with azimuths from N284° to N288°.

KEYWORDS: GPS, earthquakes, co-seismic displacements

Philippines

Data Collection from Mobile Phones Using Open Data Kit (ODKCollect) for field validation of satellite-derived data products

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Satellite images are reliable earth observation data that can be processed to produce maps used in various applications including environmental monitoring, disaster risk reduction and management, research and development, and policymaking. To ensure acceptable data quality and accuracy of these maps, field surveys are necessary to validate the results. However, field validation of spatial data often encompasses large areas making it impractical to validate with limited manpower. In this case, site data collection using mobile phones can help hasten the process. ODKCollect is a mobile application which uses Open Data Kit (ODK), a platform for open-source tools to acquire and manage data, that creates digital survey forms and supports a variety of question-and-answer formats. We employ ODKCollect to prepare survey forms and make use of the mobile phone's location services to geotag survey information for straightforward mapping applications of satellite-derived data like land cover maps and water quality monitoring maps. However, ODKCollect needs improvements in circumstances where higher positional accuracies are needed since it only uses the GNSS device built into the mobile phone used. To address these challenges, the use of handheld/low-cost GPS/GNSS receivers was used. Through the Philippine Space Agency Integrated Network for Space-Enabled Actions towards Sustainability (PINAS), this field validation method is shared to equip the sectors, including state universities and colleges, local government units, and national government agencies, in effectively utilizing space data. Feedback from the users suggests that ODKCollect is an effective geospatial tool which enables easy field data collection. ODKCollect also works even with intermittent internet connection, which may further help in studies and surveys in remote areas or in disaster response management.

KEYWORDS: Open Data Kit (ODK), Satellite data, field validation

Philippines

Global Navigation Satellite System (GNSS) Co-located Tide Stations: Purpose and Prospects in the Philippines

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Global Navigation Satellite System (GNSS) co-located tide station is another practical way to determine the vertical land motion (VLM), among other factors, contributing to an apparent sea level rise. By separating the VLM signals from the GNSS receiver one can determine the absolute sea level and in the long term the rate of the sea level rise sans the ground subsidence or uplift. Likewise, combining measurements from GNSS receivers with traditional tide gauge sensors can improve the redundancy, reliability, and efficiency of tide observations. Also with this setup, a significant advancement in tidal observations with the potential to revolutionize traditional methods and opportunities for other applications can be unlocked. However, challenges such as signal interference, infrastructure requirements, and data processing complexities need to be addressed to fully realize their potential. Nevertheless, these challenges can somehow result positively, by optimizing the primary purpose of the GNSS co-located tide stations. Yet again, the fairly new Global Navigation Satellite System Interferometric Reflectometry (GNSS-IR) technology can contribute to the value the GNSS technology has to offer. The GNSS-IR is a technique that uses signals from GNSS satellites reflected off surfaces, such as the ocean surface, to make measurements. When applied to tide gauge measurements, GNSS-IR can provide valuable information about sea surface height variations, complementing traditional tide gauge measurements.

Tide gauges directly measure the water level relative to a fixed point on land. This measurement includes variations in sea level due to tides, currents, surface wind-induced waves, and other factors. However, tide gauges can be affected by local factors such as vertical land motion, which can introduce errors in the measurements. GNSS-IR technique uses the reflections of GNSS signals (called multi-path signals) off surfaces like the ocean to indirectly measure sea surface height changes. By analyzing the phase changes of the multi-path signals, GNSS-IR can provide high-resolution measurements of sea surface height changes with centimeter-level accuracy. By combining GNSS-IR measurements with tide gauge measurements, researchers can obtain a more comprehensive understanding of sea level variations. GNSS IR can help correct errors in tide gauge measurements caused by factors like vertical land motion, providing more accurate sea level trend monitoring.

The purpose and prospects of GNSS co-located tide stations are promising, offering opportunities for cost-effective, scalable tide monitoring networks with improved spatial coverage and data quality. This technology backdrop will serve as an impetus to a downstream project proposal by the Philippines to fully benefit the continuously evolving GNSS technology.

KEYWORDS: Co-located tide stations, GNSS-IR, VLM, Philippines

Philippines

Effects of major solar flares on ionospheric plasma density over southeast Asian region using GNSS

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Solar flares (SFs) can generate ionizing radiation in immense amounts that affect Earth's atmosphere. The short timescale radiation in the X-ray and EUV regimes is examined during major SFs on solar cycles (SC) 24 and 25. An X6.9 erupted on 09 August 2011 (SC24), whereas an X2.25 and M9.7 occurred on 20 and 21 April 2022 (SC25). During these SF occurrences, the Philippines was on Earth's sunlit side. Geomagnetic conditions during these SFs were also quiet as reflected in the Dst, Kp, and Hp measurements. Moreover, effects on the ionospheric electron density are observed using the total electron content (TEC). Two GNSS receiver stations in the Philippines were used for TEC calculations. Data were obtained from PIMO (14.6357196°N, 121.0777322°E) and PTGG (14.5354022°N, 121.04126541°E) for the August and April SFs, respectively. Visible changes in the difference relative STEC are manifest during the X6.9 and M9.7. The EUV enhancement observed in the 121.6nm wavelength was evident during the X6.9. Despite the X2.25 being stronger than the M9.7, the EUV radiation enhanced more for the M-class, which was observed in the 117.5nm wavelength. This shows that the contribution of the EUV radiation to this ionospheric response in the E and F ionospheric regions is more immense than that of the X-ray. EUV increases during the X6.9 also registered to be larger than during the M9.7. The subsequent effects of which are reflected in the electron density changes. These enhancements are then quantified using the difference between the TEC and its fitted data.

KEYWORDS: space weather, ionosphere, GNSS

Philippines

Observation of Electron Density Variations in the Ionosphere associated by the Tonga Volcano Eruption in 2022 over the Philippines using GNSS

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Volcanic events can trigger severe disturbances that reach into the atmosphere above the epicenter and produce periodic waves in both charged and neutral particles. A strong eruption with a volcanic explosivity index (VEI) 5 can cause long-period ionospheric fluctuations in the atmosphere. Travelling ionospheric disturbances (TIDs) are plasma density fluctuations that propagate as waves through the ionosphere at a wide range of velocities and frequencies and play an important role in the exchange of momentum and energy between various regions of the upper atmosphere. On January 15, 2022, at 04:15 UT the Hunga Tonga-Hunga Ha'apai Volcano eruption was powerful enough to reach space. Using ionospheric total electron content (TEC) and Global Navigation Satellite Systems (GNSS) ground receiver, one from Taiwan and one from the Philippines to produce one-dimensional satellite data over a geographic area. The ionospheric irregularities accompanied by traveling ionospheric disturbances (TIDs) were spatially and temporally varied from about 10:00 UT to 13:00 UT in response to the movement and intensity change of the TIDs. This paper shows that the ionospheric anomalies travelling from southeast to northwest with the speed of 0.27km/s to 0.32km/s. was observed for 7 hours after the eruption. From the eruption, it was observed that the event triggered the propagation across the earth at a consistent speed of ~0.3 km/s- a speed of the ionospheric disturbances was as fast as the atmospheric Lamb wave. The results present indicate that natural phenomena on Earth, such as volcanic eruption of Tonga Volcano shows the global impact on the ionospheric state.

KEYWORDS: TEC, Tonga Volcano, GNSS

Philippines

Impact of St. Patrick Geomagnetic Storm of 2015 on Ionosphere using GNSS over Low-Latitude Region

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This study examines the impact of the St. Patrick's Day geomagnetic storm of 2015, on ionospheric plasma density in the low-latitude Southeast Asian region. Using data from Global Navigation Satellite System (GNSS) stations, the research investigates the correlation between the geomagnetic storm and variations in ionospheric total electron content (TEC). Triggered by a coronal mass ejection from the Sun on March 15, 2015, with a recorded speed of approximately 668 km/s, the storm led to a significant rise in the disturbance storm time (Dst) index. During the main phase, the Dst index dropped to a minimum of –223 nT, impacting ionospheric TEC. GNSS measurements revealed a notable enhancement of about 25 TECU during the storm's main phase, observed across 10 stations, followed by a depletion with a maximum of approximately 33 TECU on PBAS (Basco, Batanes, Philippines). The recovery phase showed TEC depletion across all stations throughout the day. Ionospheric irregularities in the Philippine sector, where the usual occurrence of these irregularities was suppressed during the strong geomagnetic storm. This suppression is attributed to the reduced pre-reversal enhancement electric field creating conditions unfavorable for ionospheric irregularities. The findings underscore the intricate relationship between geomagnetic storms and ionospheric plasma density variations, emphasizing the importance of comprehensive GNSS TEC measurements in understanding the dynamics of such events in the low-latitude Southeast Asian region.

KEYWORDS: ionosphere, space weather, plasma irregularities

Philippines

Open Platform for enhancing Public Transport Quality of service (QoS) through congestion pricing strategies and insurance telematics

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Road traffic congestion is a major problem in most cities all over the world. This is true especially in developing countries like the Philippines which bring about serious productivity losses, increased fuel wastage and huge negative impact to the economy. A by the National Economic and Development Authority (NEDA) and Japan International Cooperation Agency (JICA) in 2014 estimated the economic losses to be 2.4 billion pesos a day. The same study also showed that the root causes of traffic congestion are increasing ownership and use of private vehicles, inefficiency of mass transit and improper pedestrian activity.

In this light, there is a need to pursue a regulatory regime where public transport services are given priority over the use of private care. One possible solution is the introduction of a congestion pricing scheme where the use of the private car is discouraged in favor of the greater use of mass transport system. Congestion pricing can be categorized as a Travel Demand Management (TDM) measure which are strategies that promote the effective, efficient and equitable use of existing and renewable resources, as opposed to increasing supply of transport facilities.

In essence, congestion pricing encompasses a set of strategies and techniques aimed at developing charges that will effectively discourage motorists from entering a congested area during certain periods of high traffic congestion. Multiple forms of congestion pricing have been implemented, including schemes covering the inner city (as in London), a significant part of the metropolitan area (as in Singapore), or a wider, perimeter area (as in Oslo). Other proposals have looked at charging on the basis of such factors as time of day or type of vehicle. According to GTZ (2002), the principal objectives of road and congestion pricing are the following:

- Produce a shift in routes;
- Bring a change in the time of travel;
- Generate revenue;
- Mitigate negative environmental impacts; and
- Improve quality of life.

The development of congestion pricing strategies should be coupled by a regulatory regime that price public transport highly. As such, public transport franchising and operations should be modernized through the introduction of a performance-based management system whereby well-performing operators are rewarded and non-performers are weeded out of the system. This would need the introduction of advanced insurance telematics that monitor the operations on a per-lane and per-second basis.

Usage-based insurance (UBI) is a type of auto insurance that, depending on the specific insurer's program, can measure how far a vehicle is driven, where it's driven, and/or how it's driven. In Singapore, a bus operator Tower Transit implemented telematics system which improved bus drivers' behaviors on the road. From July 2016 to May 2017, from 15%, the percentage of drivers in the "red zone" (deemed to have made unsafe moves) dropped to 2%. Over the same period, the accident numbers have fallen by 50%, with "at fault" cases plunging by 70%. Tower Transit's telematics system – which tracks vehicle performance in real time via GPS and sensors and is tied to driver incentives. In Singapore, a number of motor insurers have used telematics-based schemes to reward safe policyholders.

This paper explores the development of a GNSS-based vehicle telemetry platform for monitoring public transport Quality of Service (QoS) monitoring system through a comprehensive validation of enabling technologies (including computer vision, wireless sensor networks (WSN) and internet communication) and conduct of stakeholder analysis and policy studies. The case study area is the alignment of the EDSA Busway service.

KEYWORDS: congestion pricing, insurance telematics, public transport

Russian Federation

GLONASS Status

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The presentation is devoted to GLONASS status and plans of development. The composition and status of the GLONASS constellation is provided. GLONASS civil services, including their status, infrastructure, areas of effect, channels and provided information, are described. The GLONASS launch campaign updates and information on onboard equipment carried by different types (batches) of GLONASS satellites is provided. Charts and maps illustrate relevant GLONASS Basic Service performance. The plans for future High-Orbit GLONASS Space Complex are indicated. Status of GLONASS High-Accuracy Service and System for Differential Correction and Monitoring (Russian SBAS) and their plans of development are also reported. Special attention is paid to the information support of GLONASS users and GLONASS contributions to the Sustainable Development.

KEYWORDS: GLONASS, GNSS, PNT

Saudi Arabia

Industrial Solid Waste Landfill Mapping in arid Environments, using SBAS-InSAR Techniques

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This study focuses on the subsidence observation of an industrial solid waste landfill in Dhahran, Saudi Arabia, utilizing Interferometric Synthetic Aperture Radar (InSAR) technology. The data for this investigation was collected from the Alaska Satellite Facility (ASF) using the ASF data search platform from 2016 to 2023. The Small Baseline Subset (SBAS) technique, employed in interferometric synthetic aperture radar (InSAR) and HyP3+Mintpy for time series analysis, was utilized to monitor ground deformations over time. The InSAR analysis showed a subsidence rate of 4.32cm/yr in the landfill area, highlighting potential ground movements that could have implications for infrastructure stability and environmental considerations. To validate the accuracy of the InSAR results, Ground-Based Navigation Satellite Systems (GNSS) data was used, providing additional confidence in the observed subsidence patterns. Safe Management (SM) for Industrial Waste plays a pivotal role in the transportation, treatment, and safe disposal of industrial and hazardous waste generated in the Dhahran region. These services provided handling of petroleum and petrochemical industry wastes, hydrocarbon sludges, drilling fluids, slurries, solids, contaminated soils, and oil spills. This research contributes to the understanding of subsidence phenomena in industrial solid waste landfills, particularly in the context of Dhahran, Saudi Arabia. The integration of InSAR technology, specifically the SBAS technique, with GNSS validation enhances the reliability of the observed subsidence rates. The findings of this study, in conjunction with SM's waste management services, hold significance for environmental monitoring, infrastructure management, and the sustainable development of waste disposal facilities in the region.

KEYWORDS: SBAS-InSAR, GNSS, Landfill, Waste, Dhahran.

Thailand

Development of space weather forecast system in Thailand

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Total Electron Content (TEC) in the Earth's ionosphere and Global Navigation Satellite Systems (GNSS) are significantly impacted by space weather, which are complicated phenomenon caused by solar activity. To successfully mitigate the possible effects from space weather, it is essential to comprehend and forecast space weather. This work examines the complex interrelationships between GNSS and space weather, highlighting the risks and disturbances brought on by geomagnetic storms, solar flares, and coronal mass ejections. The utilization of GNSS data which are obtained from GNSS receiver in Thailand can be used to calculate the TEC and ionospheric delay and further analyzing the ionospheric disturbances. Moreover, Thailand's national strategy and policy encourage space weather research and emphasize the nation's current facilities. This work also aims to disseminate GISTDA's (Geo-Informatics and Space Technology Development Agency) experiences in international partnerships and collaborations between Thailand and other nations. These partnerships are critical in enabling the exchange of knowledge, experience, and efficient procedures in space weather research and mitigation.

KEYWORDS: Ionospheric irregularity, Space weather, Total electron content.

Thailand

Performance evaluation of low-cost GNSS receiver using MADOCA corrections with the Precise Point Positioning (PPP) mode in Thailand

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The Precise Point Positioning (PPP) GNSS technique is widely used in various fields, whether it is a post-processing or a real-time application. The accuracy of the PPP-GNSS technique depends on the number of phases of GNSS data, the type of receiver, the method of data processing, and the GNSS errors correction. Therefore, the Japan Aerospace Exploration Agency (JAXA) has developed the 'Multi-GNSS Advanced Demonstration Tool for Orbit and Clock Analysis' (MADOCA), the GNSS errors correction for the PPP-GNSS solution. This correction provides the estimate precise orbit and clock offset for GPS, GLONASS, Galileo, and QZSS to serve the PPP-GNSS in Japan and nearby area. This research aims to evaluate the performance of low-cost GNSS receiver using MADOCA correction with the PPP mode in Thailand. The real-time MADOCA correction was applied to PPP-static and PPP-kinematic modes using the UBLOX F9P low-cost receiver. The 7-day GNSS data was observed as the PPP-static mode, while the kinematic GNSS data were also observed by the moving vehicle. The initial results show that the PPP-static provided horizontal and vertical accuracy is 0.09 and 0.13 meters, whilst the PPP-kinematic obtained horizontal and vertical accuracy is 1.24 and 2.22 meters, respectively.

KEYWORDS: Precise Point Positioning, MADOCA correction, PPP GNSS Thailand.

Thailand

National Time Scale generation and distributions

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National Institute of Metrology Thailand (NIMT) generates and physically realised the official timescale for Thailand based on the clock measurements and observed timing signals from GNSS to compared the UTC(NIMT) operated by the caesium frequency standards with the UTC time scales determined by the International Bureau of Weights and Measures (BIPM). UTC(NIMT) timescales are disseminated through Internet network using network time protocol as well as GNSS measurements and corrections in several formats.

NIMT GNSS timing receivers have been calibrated; hence, systematic uncertainties are improved and provide data for time comparisons based on GNSS common-view and precise point positioning determinations for multi-GNSS constellations and multi-frequencies.

This present provides the GNSS time dissemination results to the national positioning and timing infrastructure and discuss approaches to maintain positioning, navigation and timing resilience and integrated with the national quality infrastructure based on measurement standards and calibrations.

KEYWORDS: UTC(NIMT) time scale, GNSS time disseminations, GNSS calibration transfers.

Tunisia

Multi-Sensor Data Fusion improving Traffic Signs Recognition

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In recent years, the global surge in interest surrounding autonomous driving has been accompanied by remarkable technological advancements facilitated by artificial intelligence, leading to an unparalleled level of industrialization. The autonomous driving system comprises three primary functional modules: perception, cognition, and execution. The perception module integrates various sensors such as LiDAR, RADAR, cameras, IMU, BDS/GPS, and odometers. The inherent complementarity of multimodal sensing data is determined by the differences in measurement principles. Multimodal data fusion emerges as an effective method to enhance the performance of the perception module. Leveraging multimodal sensor data fusion and its own state, autonomous vehicles achieve driving trajectory planning. Subsequently, the control module is utilized to derive control instructions for the steering wheel, accelerator, and brake. However, image recognition, particularly in the context of traffic signs, faces challenges due to external environmental interference. Ensuring accurate and reliable recognition under diverse conditions poses difficulties. This work introduces an improved vision-based algorithm for traffic sign recognition in autonomous driving, incorporating deep learning and multi-sensor data fusion, especially GNSS data.

The proposed work dynamically determines the optimal size of the region of interest (ROI) through four key aspects. Initially, a prior map containing ample traffic sign information is generated based on multi-sensor data (RTK BDS/GPS, IMU, camera, and LiDAR) in a standard environment. Analyzing the relationship between sensor errors and the optimal ROI size, an adaptively dynamic adjustment (ADA) model is established. Using multi-sensor data fusion positioning and the ADA model, the optimal ROI predicts the location of traffic signs. Finally, YOLOv8 is employed to extract and identify image features. Evaluation using Tunisian city road tests demonstrates the algorithm's relatively high accuracy in complex scenarios, promising practical applications in the field of autonomous driving technology.

The joint calibration of sensors was the most important step of this work, exerting a substantial influence on the algorithm's accuracy to a certain extent. It is important to clarify that the calibration work referred to here concerns the adjustment of external installation parameters, typically excluding the calibration of internal sensor parameters. The joint calibration of sensors result in achieving temporal and spatial synchronization of data from diverse sensors by converting the coordinate system of IMU, camera, BDS/GPS, and LiDAR.

Subsequently, we conducted calibration to establish the positional relationship between the BDS/GPS antenna, camera, and LiDAR. The BDS/GPS receiver computes and outputs longitude, latitude, and altitude information based on the online antenna center. Similar to the IMU and camera calibration, we computed online the longitude, latitude, and altitude information of the camera and LiDAR by considering the relative position relationship between the antenna and the camera.

The BDS/GPS receiver integrated into autonomous vehicles features real-time dynamic (RTK) differential capabilities, ensuring positioning precision of 4 cm (root mean square error) under normal working conditions.

This work has been done with a collaboration between SUP'COM, the Tunisian Beidou Center and Actia Engineering Services as explained in the application form.

KEYWORDS: Autonomous driving, multi-sensor data fusion, deep Learning.

United States of America

Estimation of Ionospheric Scintillation Index S_4 from Rate of Change of Total Electron Content Index (ROTI) in Low Latitudes

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Ionospheric scintillation is one of the main error sources that can degrade the quality of satellite signals and hence can cause significant errors in positioning based on Global Navigation Satellite System (GNSS). Scintillation is usually characterized by amplitude and phase scintillation index (S_4 and σ_ϕ). However, specialized receivers that can generate the scintillation indices are not available worldwide, which limits the application of these approaches. In spite of that, there are numerous inexpensive geodetic receivers that are capable of measuring the Total Electron Content (TEC) and Rate of TEC (ROTI). The ROTI is a commonly used measure of ionospheric irregularities level.

In order to overcome this problem, the relationship between ROTI and scintillation indices (S4 and σ_ϕ) has been widely studied. [1] noted that the ratio ROTI/ S_4 changes from night to night at low latitudes in response to changes in zonal irregularity drift. [2] proposes a theoretical model justifying that the statistical measures of TEC fluctuations are related to measures of ionospheric irregularities and associated scintillations. The new theorical model for ROTI that explicitly accounts for the dependence on the sampling interval, satellite motion, propagation geometry and the spectral shape, strength, anisotropy and drift of ionospheric irregularities. This model is a scaled version of the structure function of phase fluctuations imparted to the wave by the irregularities described in [3].

The relationship between ROTI and S4 can be represented in the following equation:

$$S_{4w}^2 = \frac{\delta t^2}{c^2}\frac{\rho_F^{2\nu-1}F_S(\nu)\zeta(\nu)}{G}\frac{2\pi\Gamma\left(\nu+\frac{1}{2}\right)}{\Gamma\left(\nu-\frac{1}{2}\right)}\cdot ROTI(\delta t)^2\cdot\left[\frac{q_0^{2\nu-1}}{1-2\left|q_0V_{eff}\delta t/2\right|^{\nu-1/2}k_{\nu-1/2}(q_0V_{eff}\delta t)/\Gamma(\nu-1/2)}\right] \quad (1)$$

where c = -0.1865 TEC/rad, ν is related to the irregularity spectral index as $p^{(3D)} = 2\nu + 1$, ρ_F is the Fresnel scale, and $\zeta(\nu)$ and G are known geometrical factors. V_{eff} is the effective scan velocity, which depends on the satellite scan, irregularity drift, and magnetic field orientation. δt is the cadence of the TEC data used to compute ROTI. q_0 is the outer scale wavenumber. Γdenotes the gamma function. K is the Bessel function of the second kind.

The focus of this work is to estimate the ROTI using different sampling intervals (1 sec and 10 sec) based on GNSS receivers located in low latitudes then, the S_4 index is calculated using the relationship of ROTI/S4 observed in the equation above and described in detail in [4]. S_4 index was estimated using measured drift from cross-correlated observations of geostationary satellite signals at 250 MHz by Scintillation Network Decision Aid (SCINDA) network. For stations located far apart from the drift monitor, a climatological RISA model for drift was developed from the VHF scintillation

data. Furthermore, this study evaluates the estimation of S_4 index using different GPS frequencies (L1, L2C and L5).

Acknowledgements

This work has been performed in the framework of the NASA Grant under grants 80NSSC20K1405.

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KEYWORDS: GNSS, Ionospheric Scintillation, Rate of total electron content index.

Uzbekistan

DEM of the Mountain Terrain based on the GNSS

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This article provides an analysis of the construction of digital elevation models (DEMs) of mountainous terrain using SRTM data, topographic map and GNSS survey. Various types of surveys with advantages and disadvantages when carrying out engineering and construction work are briefly presented. The requirements for centering instruments and geodetic works of terrain with complex terrain are outlined. The technique of topographic survey with GNSS Trimble R4-3 in the hilly terrain of the Tashkent region is especially emphasized. The measurements were carried out in real time (RTK), where a GNSS rover was used instead of a pole at a distance of 50 -100 meters from the picket points. The selected area was covered by 178 picket points, for which rectangular coordinates and heights were calculated. The maximum value of the geometric factor PDOP was 1.4 for the study area due to the absence of obstacles during the passage of radio signals from satellites. Shows the area of view on a digital map created in GIS using fine and approximate segmentation. Spatial DEM images in a rectangular coordinate system, constructed by three methods, are graphically presented. According to the vertical profiles of the digital model, it has been proven that the use of the navigation method is more accurate compared to SRTM and topographic maps. Digital models propose to take into account not only the physical and geographical characteristics and topographic properties of the area, but also the presence of points in the geodetic network. The feasibility of using DEMs when laying railways, power lines, and drawing territorial boundaries of the Central Asian republics and regional centers is proposed in this work.

KEYWORDS: DEM, SRTM data, GNSS Trimble R4-3.