
LISN
SECOND LOW-LATITUDE IONOSPHERIC
SENSOR NETWORK WORKSHOP
São José dos Campos - SP Brazil, November 7-10, 2011

Abstracts

Correcciones de retraso ionosférico

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Una de las fuentes de mayor error en esta precisión, está relacionada con la propagación de la señal, principalmente debido a la refracción ionosférica. En el Ecuador, se han desarrollado varios estudios sobre el Contenido total de electrones en la Ionósfera y su repercusión en las mediciones GPS, además al obtener con éxito las falsas distancias desde GPS navegador, se abre la posibilidad de aplicar correcciones para mejorar las precisiones. Esta investigación consideran correcciones de Retraso Ionosférico con el fin de desligar procesos diferenciales y obtener coordenadas tridimensionales con menor error, optimizando así el uso de Navegadores. En la investigación se tomo en cuenta cuatro procesos principales - Toma o Recolección de Datos GPS El resultado de esta etapa fue los valores de falsas distancias desde el GPS navegador de dos puntos ubicados en Sangolquí y Latacunga. - Cálculo de los valores de retraso ionosférico, se calculó el contenido total de electrones (TEC) correspondiente a la época de rastreo del navegador, con los cuales fueron corregidas las falsas distancias provenientes del navegador. - Corrección de falsas distancias y obtención de coordenadas corregidas, se aplica las correcciones de retraso ionosférico en las mediciones de las falsas distancias. Mediante el desarrollo de un programa en MATLAB se automatizó el proceso. - Comparación de coordenadas y evaluación del método, al comparación entre los valores de coordenadas obtenidos versus las coordenadas precisas de los puntos de control, y las variables estadísticas arrojadas por el proceso, se determinó la bondad de las correcciones, lo que permitió emitir las conclusiones necesarias de las técnicas aplicadas. Con el fin de evaluar la precisión de los resultados obtenidos, se comparó entre los datos de las coordenadas precisas de los puntos de control “LATA” y “Estadio” con sus respectivas observaciones corregidas mediante el proceso desarrollado y también con respecto a las mediciones sin haber realizado corrección alguna. En el caso de este proyecto se tomaron tres tiempos referenciales: 30 seg,1 min y 2 min. Se obtuvieron valores de retraso ionosférico entre los 0 y 20 metros, siendo estos valores considerados aptos para la corrección de las falsas distancias observadas. El método revela consistencia significativa para los datos utilizados, logrando correcciones desde 1 hasta 13 m. para las X, Y, Z

An investigation of the characteristics of low-latitude amplitude scintillation and implications for GPS receiver performance

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Ionospheric scintillations are variations in the phase and/or amplitude of a trans-ionospheric radio signal caused by electron density irregularities in the ionosphere. These fluctuations in the radio signal can degrade the accuracy of Global Navigation Satellite Systems (GNSS). In this work we investigate the characteristics of amplitude scintillation observed at low latitudes and analyze the effects on the GPS receiver performance. For this study, we analyzed an extensive set of 32 days of high-rate (50 Hz) measurements made by a GPS-based scintillation monitor deployed near the Equatorial Anomaly peak during high solar flux conditions. These measurements were used to investigate the magnitude and rapidity of amplitude scintillation. We used the results of this analysis to evaluate the effects of scintillation on GPS receiver performance using different approaches. Here, we present the variability of the decorrelation time ($\tau 0$) of the scintillation patterns as a function of scintillation intensity (S4), and as a function of local time. We found that faster and deeper fades are more frequently observed for larger S4 values as pointed out in previous studies. Using scintillation indices, we estimated that a significant (above a few percent) probability of cycle slips (PCS) occurs when $S4 \geq 0.7$. PCS can reach 15-30% during certain scintillation scenarios ($S4 > 0.7$ and $\tau 0 < 0.4$ seconds). We also propose an alternative way to compute the probability of cycle slips that takes into account the fading duration (PFS). The results of this approach show a 38% probability of cycle slips during scenarios where S4 is close to 1 and $\tau 0$ near 0.2 seconds.

Ingesting different kinds of data into NeQuick

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NeQuick is the ionosphere electron density model developed at the Aeronomy and Radiopropagation Laboratory of the Abdus Salam International Centre for Theoretical Physics (ICTP) - Trieste, Italy with the collaboration of the Institute for Geophysics, Astrophysics and Meteorology of the University of Graz, Austria. It is a quick-run model particularly designed for trans-ionospheric propagation applications that has been conceived to reproduce the climatological behavior of the ionosphere. In order to provide \"weather-like\" descriptions of the ionospheric electron density, different electron density reconstruction techniques have been implemented. They are based on the NeQuick adaptation to GPS-derived Total Electron Content (TEC) data and ionosonde measured peak parameters. In the present paper an overview of these ingestion techniques will be given and specific case studies based on the ingestion of LISN data will be illustrated.

The LISN observatory: Past, Present and Future

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The Low-latitude Ionospheric Sensor Network (LISN) is a distributed observatory designed to nowcast the state and dynamics of the low latitude ionosphere. The LISN observatory is comprised of GPS receivers, flux-gate magnetometers and Vertical Incidence Pulsed Ionospheric Radar (VIPIR) ionosondes. LISN strives to measure the day-to-day variability of the low-latitude ionosphere with a regional scope (50° in longitude), and to conduct investigations of the low latitude ionosphere to develop forecasts of the electric fields, densities and equatorial spread F (ESF) over the South American continent. During the first years of operations the following tasks have been conducted: (1) Maps of total electron content (TEC) over South America. (2) Maps of TEC depletions and TEC perturbations associated with the passage of traveling ionospheric disturbances (TID). (3) Campaigns to detect medium-scale (~100 km) TIDs using 3 GPSs separated by 5-20 km. This presentation shows initial results on the seasonal/ longitudinal distributions of TEC depletions over South America and the relationship of these distributions with the variability of TEC and the occurrence of TEC perturbations associated with gravity waves. This presentation will also mention the instrument installations to be conducted in the near future.

Deducing Ionospheric Turbulence Parameters from High-Rate GPS Observations during the COPEX Campaign

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Previous authors have reported on the morphology of GPS scintillations and irregularity zonal drift during the 2002 Conjugate Point Equatorial Experiment (COPEX) in Brazil (Muella et al., J. Atmos. S.-T. Phys., 2008; de Paula et al., J. Geophys. Res., 2010). In this work, we attempt to characterize the turbulent ionospheric medium that produced these scintillations. Using high rate (10 Hz) measurements of GPS signal intensity at Boa Vista (2.9N, 60.7W), Alta Floresta (9.9S, 56.1W), and Campo Grande (20.5S, 54.7W), we report on the variation of turbulent intensity, spectral index, and irregularity zonal drift as a function of latitude and local time during the COPEX experiment. The method of analysis is new and, unlike analytical theories of scintillation based on the Born or Rytov approximations, it is valid for strong scatter when the scintillation index (S4) saturates due to multiple-scatter effects. We propose to instrument the magnetic field line along which the LISN ionosondes are deployed with high rate GPS receivers. Doing so will enable routine and systematic investigation of the latitudinal and local time morphology of ionospheric turbulence that produces radio wave scintillations at low-latitudes.

Real Time Ionosphere Maps from GNSS Active Network 1

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GNSS has definitely established as an important tool for the observation of the atmosphere and ionosphere parameters. After the turn off the SA (Selective Availability) the ionosphere influence became the largest error source on the band L signals broadcasted by the GPS satellites. The signal that travels across the ionosphere allows obtaining information about the ionosphere layers. The code delay and phase advance on propagation of GPS signals reflect the behavior of the ionosphere as function of TEC (Total Electron Content). Therefore, the TEC determination can be accomplished from double frequency GNSS data measurements. Real time ionosphere maps have been generated from data of reference stations equipped with dual frequency GNSS receivers. In the process we have used data from both the GNSS-SP-Network (GNSS Active Network of West of São Paulo State) and RBMC-IP (Network Brazilian for Continuous Monitoring of GNSS), which have been broadcasting GNSS data in real time using the NTRIP (Networked Transport of RTCM via Internet Protocol). An algorithm based on a Kalman filter has been developed for ionosphere modeling at low latitudes and for the estimation of ionospheric parameters: absolute vertical TEC (VTEC) and rate of change of TEC (RTEC) for monitoring ionospheric behavior. In the algorithm, the ionospheric vertical delay is modeled by quadratic function series. However, other modeling functions are being implemented, with purpose to improve the model efficiency and spatial coverage. In this work we report on real-time processing of the GNSS-SP-Network and RBMC-IP data and present results obtained with the algorithm.

AIRES and RAPEAS on the move

Claudio Brunini (1) and Diego Janches (2)

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We report on this presentation an update on two closely related projects with relevance to LISN: AIRES (Argentina Ionospheric Radar Experiment Station) and RAPEAS (Spanish acronym for Argentina Network for Upper Atmosphere Research). AIRES\' main goal is the deployment and long term operation of a face of the Afvance Modular Incoherent Scatter Radar (AMISR) close to La Plata city, in Argentina , where it is possible to perform ionospheric measurements of the geomagnetic conjugate point of the Arecibo Observatory in Puerto Rico. The initial construction of 16 AMISR panels and the infrastructure for the their deployment in Argentina have been initiated in March 2011, in the framework of a memorandum of understanding agreed between the U.S. National Science Foundation (NSF) and the Argentina National Council for Scientific and Technical Research (CONICET). In addition, in August 2011, CONICET created RAPEAS, which main objective is to maximize the benefits of AIRES as well as other networks and instruments in Argentina dedicated to Upper Atmosphere research. Over forty scientist and engineers from fifteen scientific and academic institutions are currently part of RAPEAS. Both, RAPEAS and AIRES will create a great synergy within the Argentina Upper Atmosphere community and will open new opportunities for international collaborations among which, the LISN project should play a relevant role.

Determination of the Sharp, Longitudinal Gradients in Equatorial ExB Drift Velocities Associated with the 4-cell, Non-migrating Structures

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Previous studies have established the existence of a 4-cell, longitude pattern in equatorial F region ionospheric parameters such as TEC and electron densities and in daytime, equatorial ExB drift velocities. A recent paper, for the first time, quantified the longitude gradients in ExB drift associated with the 4-cell tidal structures and confirmed that these sharp gradients exist on a day-to-day basis. Using the Ion Velocity Meter (IVM) on the Communication/Navigation Outage Forecast System (C/NOFS) satellite to obtain daytime, vertical ExB drift velocities, it was found, for example, that for October 5, 6 and 7, 2009 in the Atlantic sector, the ExB drift velocity gradient was about 1m/sec/degree. For March 23, 24 and 25, 2009 in the Peruvian sector, it was about -4m/sec/degree. This talk summarizes past observations of the sharp longitude gradients in vertical ExB drift velocities and the effect of these sharp gradients on theoretically-calculated ion density distributions as a function of latitude and longitude. We also present initial, ground-based magnetometer-inferred vertical ExB drift velocities from the LISN (Low-latitude Ionospheric Sensor Network) chain of magnetometers at 285 E. geographic longitude and 305 E. geographic longitude that provide the day-to-day and seasonal variability in ExB drifts at the boundary between the Peruvian longitude sector and the Atlantic longitude sector. The advantages of these continuous, daytime observations are discussed.

Ionosphere Response to the M9 Tohoku Earthquake Revealed by Satellite Observations on South American Stations. Preliminary results.

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The recent M9 Tohoku Japan earthquake of March 11, 2011 was the largest recorded earthquake ever to hit this nation. We retrospectively analyzed the temporal and spatial variations of GPS/TEC for different stations in South American (14 equatorial stations and 11 midlatitude stations). These changes characterize the state of the ionosphere several days before the onset of this earthquake. Our first results show that on March 10th a rapid increase of Total Electron Content was observed from the satellite data and an anomaly. The GPS/TEC data indicate an increase and variation in electron density reaching a maximum value on March 10. Starting on this day in the lower ionospheric there was also confirmed an abnormal TEC variation over the epicenter. From March 10-11 a large increase in electron concentration was recorded at all four Japanese ground based ionosondes, which return to normal after the main earthquake. We found a positive correlation between the atmospheric and ionospheric anomalies and the Tohoku earthquake. This study may lead to a better understanding of the response of the atmosphere / ionosphere to the Great Tohoku earthquake.

The day-to-day longitudinal variability of the global ionospheric density distribution

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A number of recent studies have shown a clear global longitudinal variability of ionospheric density distribution, forming a wavenumber four structure in a fixed local time sector. However, almost all of these studies have had to rely on the statistical overview of the longitudinal structure of the global density distribution, and only reported dayside and evening sectors. For the first time, using the GPS receivers on the ground and onboard LEO satellites, we present the longitudinal variability of the global density distribution in a day-by-day case. We also observed an interesting wavenumber four structure in the post-midnight sector. The shifting of the peaks' location as a function of geographic longitude and latitude has been also observed, suggesting that the peaks appears to be a geomagnetic field aligned TEC enhancements. The main characteristics of post-midnight TEC are described as a function of longitude, latitude, local time and season during periods of low solar flux conditions.

Equatorial electrodynamics and ionospheric density distribution difference between African and South American sectors

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Abstract: Accurate estimation of global vertical distribution of ionospheric and plasmaspheric density as a function of local time, season, and magnetic activity is required to improve the operation of space-based navigation and communication systems. The vertical density distribution, especially at low and equatorial latitudes, is governed by the equatorial electrodynamics that produce a vertical driving force. The vertical structures of the equatorial density distribution can be observed by using tomographic reconstruction techniques on ground-based GPS TEC. Similarly, the vertical drift, which is one of the possible driving mechanisms that govern the equatorial electrodynamics and strongly affects the structure and dynamics of the ionosphere in the low/mid-latitude region, can be estimated using magnetometer observations. We present tomographically reconstructed density distribution and the corresponding vertical drifts at two different longitudes: the East African, and west South American sectors. Chains of GPS stations in the east African and west South American longitudinal sectors, covering the equatorial anomaly region of meridian ~37ºE and 290ºE, respectively, are used to reconstruct the vertical density distribution. Similarly, magnetometer sites of AMBER and INTERMAGNET for the east African sector and SAMBA and LISN are used to estimate the vertical drift velocity at two distinct longitudes. The comparison between the reconstructed and Jicamarca ISR measured density profiles shows excellent agreement, demonstrating the usefulness of tomographic reconstruction technique in providing the vertical density distribution at different longitudes. Similarly, the comparison between magnetometer estimated vertical drift and other independent drift observation, such as from VEFI onboard C/NOFS satellite and JULIA radar, shows excellent agreement. The observations at different longitudes, using recently deployed limited ground-based instruments suggest, the vertical drift velocities and the vertical density distributions have significant longitudinal differences.

Incoherent Scatter Density Measurements in the Topside E-region at Jicamarca

E. Kudeki, J. L. Chau, M. Milla

Recent VIPIR measurements at Jicarmaca show indications of electron density structures and fluctuations in the upper E-region that will be presented by Chau at al. (2011). These structures can be associated with and possibly cause the generation of the so-called 150 km irregularities observed in the equatorial ionosphere. In this talk we will present incoherent scatter radar data collected using the Jicamarca Faraday rotation mode concurrently with the VIPIR observations discussed in Chau at al. (2011). The ISR data also support the conjecture that the 150 km altitude region may have structured electron densities at intermediate scales related to the generation of the meter scale 150 km irregularities. Plans for coordinated VIPIR and ISR Incoherent Scatter Density Measurements in the Topside E-region at Jicamarca E. Kudeki, J. L. Chau, M. Milla Recent VIPIR measurements at Jicarmaca show indications of electron density structures and fluctuations in the upper E-region that will be presented by Chau at al. (2011). These structures can be associated with and possibly cause the generation of the so-called 150 km irregularities observed in the equatorial ionosphere. In this talk we will present incoherent scatter radar data collected using the Jicamarca Faraday rotation mode concurrently with the VIPIR observations discussed in Chau at al. (2011). The ISR data also support the conjecture that the 150 km altitude region may have structured electron densities at intermediate scales related to the generation of the meter scale 150 km irregularities. Plans for coordinated VIPIR and ISR measurements will also be discussed.

Using FORMOSAT-3/COSMIC GPS data to improve the La Plata Ionospheric Model

Juan Federico Conte (GESA, Facultad de Ciencias Astronómicas y Geofísicas & CONICET), Francisco Azpilicueta (GESA, Facultad de Ciencias Astronómicas y Geofísicas & CONICET), Claudio Brunini (GESA, Facultad de Ciencias Astronómicas y Geofísicas & CONICET), Diego Janches (NASA)

In the framework of the AIRES (Argentine Ionospheric Radar Experiment Station) Project, we are currently upgrading the La Plata Ionospheric Model (Brunini et al., 2011b). Inspired by the IRI model (Bilitza, 2002) and based on the Jones & Gallet (1962) mapping technique, after a process of data assimilation is applied, this semi-empirical model is capable of reproducing electron density profiles dependent on the Universal Time, the geographical location and the solar activity level. At the moment, the data assimilation technique only processes the raw-data obtained from ground-based dual-frequency GPS measurements. Nevertheless, the model is also capable to incorporate FORMOSAT-3/COSMIC electron density profiles externally calculated which, combined with the ionospheric information obtained from the ground-based GPS measurements are used to correct the coefficients of the Jones & Gallet formulation. Consequently, we are currently analyzing and pre-processing GPS raw-data from the FORMOSAT-3/COSMIC mission and appropriately modifying our model in order to incorporate this data to our formulation to have a better description of the electron density profile, especially for the top-side region of the ionosphere.

GEORED Project: Spatial Geodesy Network for Geodynamics Research in Colombia, South America

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GEORED, the acronym for “Geodesia: Red de Estudios de Deformación” has been adopted for the Project “Implementation of the National GPS Network for geodynamics.” Initiated in 2007 by the Colombian Institute of Geology and Mining (INGEOMINAS), GEORED is a research and development project based on GPS technology which takes a multifaceted approach to cataloguing and the defining the geodynamics of Northwest South America and also of the Caribbean zone in order to reduce the associated hazards in these study areas. Our current endeavors are focused on the acquisition of high quality GPS data to be shared by intergovernmental institutions and university research centers within Colombia as well as collaborative international research efforts including reciprocal data sharing between the neighboring countries of Panama, Venezuela, Peru and Ecuador. Currently, the GEORED Project is managing 33 continuously including: 31 GEORED GPS continuously operating stations, composed of Trimble Net receivers and Trimble choke-ring and zephyr antennas; the Bogotá IGS GPS station (BOGT), installed under the agreement between JPL-NASA and INGEOMINAS; and the San Andres Island station, installed under the MOU between UCAR and INGEOMINAS. In addition to the permanent installations, more than 180 GPS campaign sites have been constructed and are being occupied one time per year. The obtained results confirm the oblique subduction of the Nazca Plate and Carnegie aseismic ridge collision processes at the Colombia-Ecuador trench which are assumed to be the mechanism for the transpressional deformation and the “escape” of the North Andes Block (NAB). The northernmost vectors in Colombia are indicative of the ongoing collision of the Panama Arc with northwestern Colombia. Distinct changes in vector magnitude and direction are now becoming distinguishable within, at least, three distinct zones. Key words: GNSS, strain, geodynamics, Colombia

Space Weather Program in Brazil

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Brazilian Space Weather program (EMBRACE) started at INPE in 2008. It is planned to establish the “Center for space weather information and prediction” in 2012. It is aimed to monitor events of the solar activity and their impacts on the earth´s space environment, and to predict the influence on the space-based and ground-based technological systems. Our specific concerns are to monitor peculiar physical processes in the equatorial ionosphere, such as equatorial electrojet, the ionization anomaly and the plasma bubbles. These processes affect radio wave propagation and GNSS applications. The South Atlantic geomagnetic anomaly (SAGA) is also a great concern for satellite operations. Groundbased observation systems monitor the sun and earth´s space environment by solar radio telescopes (BDA), conjugate point ionospheric sounders, GNSS receivers, magnetometer arrays, optical imagers, radio frequency radars, as well as electro-magnetic sensors for GIC. Recent progress in these monitoring system and data processing system will be presented.

Integrated GNSS Geodynamic System for Brazil

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The scope of this project is the deployment of a world-class technological and research infrastructure in order to document the continental and oceanic lithosphere's dynamic responses to the tectonic forces that are acting on the South American Plate, by the continuous monitoring of the Earth's surface changes, with multipurpose sensors collocated at permanent sites in the continent and oceanic islands. The system uses ground-based continuously operating state-of-the art sensors, such as multi-channel, multi-frequency GNSS receiver (Trimble Net-R8) and choke-ring antenna, three component vector fluxgate magnetometer, two component telluric sensor (electrode), and three component atmospheric parameter sensor (temperature, pressure and humidity). Also, a data repository and analysis center provides support for an open use in related research and applications. The long-term pursued goals are i) Improve availability and coverage of South American GNSS civil services; ii) Produce a "Stable South American Platform Reference Frame" that meets the highest possible precision; iii) Contribute to studies of tectonic plate kinematics by measuring the Earth's surface displacements due to ground deformations; iv) Test for regional intraplate crust deformations in active and non-active seismic zones; v) Identify regional non-tectonic motions; vi) Provide data integration with seismic, geodetic, gravimetric and tide gauge networks for monitoring sea-level changes and hazardous landforms; vii) Contribute to Atmospheric and Space Weather forecasting and web services; viii) Improve Ionosphere and Troposphere regional models at low latitudes; ix) Produce GNSS-derived low latitude ionosphere Total Electron Content (TEC) maps, during quiet and perturbed geomagnetic conditions; x) Contribute to national and international geodetic networks consistent with the ITRF; xi) Improve the Geoid model and estimated Orthometric Heights from GNSS-derived ellipsoidal heights; xii)) Foster research and applications with considerable economic and societal impacts; xiii) Facilitate cross-disciplinary synergism among universities, government, and private sector, fostering human resources, research and applications.

An overview of the ionospheric research at INPE, Brazil

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The National Institute for Space Research (INPE) has celebrated its 50th anniversary this year (2011). Since its beginning INPE has developed ionospheric research using ground-based instruments and payloads onboard of sounding rockets. So it is not incorrect to say that the ionospheric research in Brazil is also celebrating its half-centenary. During this time period important studies were conducted by the ionospheric group at INPE that evidenced the peculiarities of the ionospheric region over the Brazilian region. Some of these results will be presented in this talk.

IONOSPHERIC STUDIES IN COLOMBIA

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Colombia is located just below the northern anomaly of the equatorial ionosphere, for this reason its high atmosphere is rich in a wide variaty of ionospheric phenomena. A set of ionospheric sensors has been deployed by LISN all over the Colombian territory. For instance, there is a GPS receiver in Santa Marta, being the most to the north instrument in South America. In Leticia there is a magnetometer on the same meridian aligned in a north-south direction with the magnetometer of Puerto Maldonado in Peru and with the magnetometer installed in Casleo, El Leoncito, Argentina. A report will be given about the current activities that the ionosphere research group ARGOS is carrying out regarding TEC observations, development of a model for TEC calculations and our future plans into the assimilation of ionospheric data. Possible applications as regards to GBAS navigation in Colombia will be discussed too. Keys words: Ionosphere, TEC, GPS, magnetometer, GBAS

A Geophysical approach to assess Natural Disasters and Space Weather impacts on Earth

Jean-Pierre Raulin CRAAM/EE/UPM

Recently, the International Council for Science (ICSU) has approved a project entitled \"A Geophysical approach to assess Natural Disasters and Space Weather impacts on Earth\", proposed by the Union Radio Scientifique Internationale (URSI) and The Scientific Committee on Solar- Terrestrial Physics (SCOSTEP). The project is coordinated by the Centro de Radioastronomia e Astrofísica Mackenzie (CRAAM), at the Presbyterian Mackenzie University, São Paulo, Brazil. The main objective is to incentive the development of a regional center for the use of Geophysics as a new approach for Natural Disaster prevention, and to assess the impacts of Space Weather phenomena on the Earth\'s environment and technological systems. Since radio communications and observations are important to assess geophysical hazards, the former objective implies a natural collaborative activity between Latin-American scientists involved in radio and geophysical sciences. The South American region is particularly affected by Natural Disasters as consequences of Earthquakes, El Niño, and Global Change related phenomena. Casualties and property losses could be significantly reduced by discussing and providing improved geophysical methods to evaluate the risk of such natural hazards. In the same region Space Weather impacts and effects are enhanced, because it spreads over a large latitudinal sector, including equatorial regions and the South Atlantic Magnetic Anomaly. It is therefore crucial to characterize all aspects of the Space Weather dynamics, from the long-term and transient solar phenomena, to the arrival of magnetic clouds at the Earth\'s orbit responsible for disturbed geomagnetic conditions, all of them capable to affect the Earth\'s atmosphere and terrestrial technological systems. Groups of excellence on these subjects already exist in South America, and an intense network of instrumental facilities is growing rapidly. Then, for the first time, it is desirable to join efforts and discuss converging research activities within a common regional structure. In this presentation we will discuss different scientific aspect of the project and how we plan to implement it in the region.

Ionosphere effects on GNSS positioning: models and mitigation investigation.

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The main aim of this presentation is to provide an overview of some UNESP activities related with the developments of models and mitigation of the ionosphere effects on GNSS positioning. Details of the Mod_Ion model will be given, together with few results of its application on point positioning. It will include post-processing and real time developments on this area. Details of CIGALA project, funded by the European Community within the context of FP7, in which UNESP is the main partner in Brazil, will also, be addressed. It will include an overview of the deployed network together with the preliminary results on the computation of ionosphere scintillation parameters, either from GPS or GLONASS. Results on the mitigation approach based on stochastic model will also be presented. Finally, details of the system developed to correct 2nd order ionosphere effects will also be presented.

Exploring the equatorial daytime F1 region with multi-frequency and multi-volume radar studies

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The daytime equatorial F1 region (i.e., between 130-170 km) it is not well understood. For many years, the main source of information has arrived from coherent echoes (or so-called 150-km echoes) detected with VHF radars, most of them used also as MST radars (e.g., Jicamarca, Pohnpei, EAR, Gadanki). Most of these echoes are now known to come from waves that have been enhanced above waves in thermal equilibrium. The physical mechanisms generating these echoes are still elusive. Nonetheless, useful plasma drifts (therefore electric fields) can be measured by measuring the Doppler shifts of these echoes. In order to understand more the background conditions of the region where these echoes occur as well as their spatial and temporal structure, in the last few months we have conducted a series of experiments: (1) concurrent measurements of coherent and incoherent scatter echoes using the main 50 MHz Jicamarca radar and receiving antennas south of Jicamarca, (2) multi-frequency radar observations using the newly deployed digital ionosonde called VIPIR, and (3) high resolution (range and time) electron density measurements using Faraday rotation. Special emphasis will be devoted to the new observations made with the VIPIR system. Preliminary results using the multi-frequency observations indicate that the F1 region, when “visible” present significant range/time/frequency structure that could be related to the 150-km radar echoes.

COLOMBIAN IONOSPHERIC MODEL BASED ON TEC OBSERVATIONS AND RESULTS

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Geospace physics has increasingly growth in importance in the last years. The development of new space technologies must take into account the interaction due space weather and terrestrial atmosphere. Consequently, the ionosphere is a very important zone because of its characteristics, properties and the influence in electromagnetic waves. A model aimed to provide information related with total electron content (TEC) in ionosphere is presented. Studied data was collected from an ionospheric station based on a dual-frequency GPS receiver located at Bogota, Colombia. The presented model is based on the analysis of the variation of the satellital electromagnetic waves that pass through the ionosphere. Slant TEC was calculated from pseudorange and carrier phase observables starting from Observation files. Next, using Navigation files, GPS orbits were estimated. By assuming the ionosphere as a single layer, the wave vector crosses such a layer through a piercing point, vertical projection of TEC was obtained for that point. Finally a comparison between the designed and others models is showed. On the other hand, using the Colombian Ionospheric Model, the behavior of the TEC variations due to the CME generated on June 4th, 2011, and the differences between equinoxes and solstices over Colombian territory are studied. Keys words: Ionosphere, TEC, CME, solar cycle, GPS

IONOSPHERIC STUDIES FOR THE UNDERSTANDING OF THE EARTH\'S DYNAMICS IN COLOMBIA: PRELIMINARY APPROACH

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The lithosphere-atmosphere coupling is one of the most controversial topics in the current scientific world. Electromagnetic phenomena involved during and before seismic events continue to attract attention not only as possible earthquake precursors but also as a description of the earth\'s crust and its dynamics, understanding the latter as the main reason for our research. However, it is not possible to describe a system such as an independent one because the earth is in fact, a system of systems; in that way, we can think about a potential relationship between the lithosphere and atmosphere. Taking into account studies about different sources such as explosions on ground, large volcanic eruptions and rocket launches that excite atmospheric infrasonic waves generating acoustic and gravity oscillations that reach eventually the ionosphere layers, triggering variations of the critical plasma frequency (foF2) and fluctuations in the electron density, we are trying to understand how the lithosphere electromagnetic phenomena are also involved in these density variations. For these purpose we are using Global Navigation Satellite Systems (GNSS) data to measure the ionospheric total electron content (TEC), knowing that this technique has received attention as a potential tool to detect these kind of perturbations, but only as an indicator of a process that it is not possible to be explained by now due to the lack of a consistent physical framework that explain the electromagnetic phenomena propagation to the ionosphere and the influences of other events like geomagnetic storms, changes in the solar radiation, among others.

Keywords: Lithosphere-atmosphere coupling, GNSS, TEC, electromagnetic phenomena

Meridional Variations of Equatorial Scintillations During the COPEX Campaign

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Numerous studies of geophysical observables associated with large-scale instabilities in the post-sunset equatorial ionosphere have been conducted for several decades; these observables include electric fields, electron density profiles, total electron content (TEC), plasma and neutral drifts, scintillations and coherent radar backscatter. Despite a general understanding of the local correlations between these parameters during the on-set and evolution of equatorial bubbles, detailed knowledge of the simultaneous variations of these parameters as a function of latitude on a given magnetic meridian is lacking. During the Oct-Nov 2002 Conjugate Points Equatorial Experiment (COPEX) campaign was conducted at three sites in western Brazil; one site was situated at the magnetic equator while the other two were selected at magnetic conjugate locations approximately ±10° MLat. The campaign was organized and coordinated by the Aeronomy Group at the Brazilian National Institute for Space Research (Instituto Nacional de Pesquisas Espaciais-INPE). A number of diagnostic instruments, including digisondes, GPS scintillation and TEC diagnostics, VHF scintillations and plasma drifts, and all-sky imagers were operated routinely throughout the campaign period. The work presented here focuses on the meridional variations of GPS and VHF scintillations from the northern to the southern anomaly regions (~ ±15° MLat) and their correlation with total electron content and peak electron density over the same spatial extent. The key issue for consideration is whether the scintillation intensity is directly proportional to electron density (i.e., TEC) across a flux tube implying constant ΔN/N within the instability region, or whether some other relative scaling between the density and scintillation exists. The outcome of this investigation guides techniques for extrapolating local measurements to other latitudes based on knowledge of the meridional density structure from, for example, an ionospheric model of the ambient density.

Spread-F quantification from ionograms

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New capabilities of the Jicamarca radar and its cluster of instruments

Marco Milla and Jorge Chau

The Jicamarca incoherent scatter radar is improving its capabilities for probing the Equatorial ionosphere. An automatic beam steering (ABS) system is under construction at Jicamarca. The system will make possible to switch between different antenna positions without human intervention. Additionally, a new digital reception system has been designed and built at the observatory. JARS (Jicamarca Acquisition Radar System) is capable of sampling simultaneously 8 antenna channels with faster sampling rates and larger dynamic ranges than before. In addition to these improvements, various instruments have been installed at Jicamarca in recent years. These instruments provide the opportunity to conduct simultaneous measurements of the ionized and neutral atmosphere. Jicamarca is the center of operation of the LISN network. The data collected with GPS receivers and magnetometers distributed in South America are sent to Jicamarca daily for their analysis. Also as part of the LISN project, a modern ionosonde system (VIPIR) has been installed at Puerto Maldonado (Peru), providing high-resolution ionograms with multiple antennas. Moreover, a network of Fabry-Perot interferometers has been deployed in Peru. One of them was installed in a hill nearby Jicamarca, the others are located in the cities of Nazca and Arequipa (south of Lima). Using this instruments we can conduct common volume observations of the upper atmosphere and measure neutral winds every night. Finally, The JASMET meteor radar, the bistatic Jicamarca-Paracas radar, and the SOUSY radar complete the set of instruments. All these improvements allow us to study the Equatorial ionosphere in greater detail than before.

Behavior of the total electron content over three stations of the LISN zone

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A study of the behavior of the total electron content (TEC) has been done using measurements obtained at Jicamarca, Perú (12.0 S; 283.0 E) and at Tucumán (26.9 S; 294.6 E) and San Juan (31.5 S; 294.6 E), Argentina. The database includes TEC data derived from ground-based ionosonde data (ITEC) and from GPS satellite signals (GPSTEC). The diurnal, seasonal, solar activity variations and the day to day variability have been analyzed. Comparisons with the predictions of the last version of the International Reference Ionosphere model (IRI-2007) are also done. The results reveal that the total electron content increases gradually from hours of minimum TEC (05-06 LT) in all the seasons reaching maximum values around midday. At sunset the TEC values begin to decrease reaching minimum values around sunrise. The TEC measurements generally show lower values in winter than in summer. The winter-summer differences are not so evident in the year of low solar activity. The largest daytime peak values are observed in the two equinoctial months. The shape of the seasonal variation of IRI TEC predictions is, in general, similar to those observed in the TEC obtained from the ionograms. The IRI predictions generally overestimate the total electron content during nighttime and underestimate during daytime. Taking into account that the most contribution of TEC comes from the topside electron density profile, these results suggest that the discrepancies between IRI predictions and TEC measurements are due to the shape of the topside profile assumed by the model. In addition some incoherent scatter radar (ISR) profiles obtained in Jicamarca have been compared with the IRI and NeQuick models.

Ionospheric Model (LPIM) as a tool for scientific and technological applications

Mauricio Gende and Claudio Brunini

Within the framework of the SIRGAS pilot experiment, the authors of this paper have been producing Vertical Total Electron Content (VTEC) since July 2005. These maps exploit all the GNSS data available in the South American region and routinely compute a regional VTEC model with a delay of ten days using La Plata Ionospheric Model (LPIM). In 2007 a distributed multi-instrument observatory, which includes GNSS receivers, was installed in Argentina within the framework of Low-latitude Ionospheric Sensor Network (LISN) project. These receivers can transmit raw observations instantaneously as one of LISN aims is to monitor the ionosphere in real time. This paper presents results of a near real time adapted LPIM implementation, which can produce single site VTEC estimation and predictions. Comparisons with post processes VTEC values and other software real time VTEC estimation were done, showing agreement with a few TEC units. Limitations regarding real time signal processing are also discussed. Oral presentation Data Analysis and interpretation

GPS radio holography as a tool for remote sensing of the atmosphere, mesosphere, and terrestrial surface from space

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GPS radio occultation (RO) signals are highly coherent and precise, and thus sufficient for holographic investigation of the atmosphere, ionosphere, and the Earth's surface from space. In principle, three-dimensional radio-holographic remote sensing is possible by using new radio holographic equations to retrieve the radio field within the atmosphere from a radio field known at some interface outside the atmosphere. A simplified two dimensional form of the radio-holographic equations which are developed under an assumption of local spherical symmetry can be used to obtain two dimensional radio images of the atmosphere and terrestrial surface. To achieve this, radio holograms recorded by a GPS receiver onboard a low earth orbit (LEO) satellite at two GPS frequencies can be used and focused synthetic aperture principle applied. Analysis of GPS/MET RO data is presented to show the effectiveness of a radio-holographic approach. It is shown that the amplitude of GPS radio signals (in addition to phase data) can be used to obtain detailed altitude profiles of the vertical gradient of refractivity in the atmosphere and electron density in the mesosphere. The results demonstrate the applicability of GPS radio holography for a detailed global study of the natural processes in the atmosphere and mesosphere.

STORM-TIME TOTAL ELECTRON CONTENT AND ITS RESPONSE TO PENETRATION ELECTRIC FIELDS OVER SOUTH AMERICA

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In this study the ionospheric response due to the severe magnetic storm of 7–10 November 2004 is investigated by analyzing GPS Total Electron Content (TEC) maps constructed for the South America sector. In order to verify the disturbed zonal electric fields in South America during the superstorm, ionospheric vertical drift data obtained from modeling results are used in the analysis. The vertical drifts were inferred from dH magnetometer data (Jicamarca-Piura) by the use of its relationship with the equatorial electrojet and the equatorial zonal electric fields. Also were used vertical drifts measured by the Jicamarca ISR. Data from a digisonde located at S˜ão Luís, Brazil (2.33° S, 44.2°W, dip latitude 0.25°) are presented to complement the Jicamarca equatorial data. Penetration electric fields were observed by comparing the equatorial vertical drifts and the Interplanetary Electric Field (IEF). The TEC maps obtained from GPS data reflect the ionospheric response over the South America low-latitude and equatorial region. They reveal unexpected plasma distributions and TEC levels during the main phase of the superstorm on 7 November, which is coincident with the local post-sunset hours. At this time an increase in the prereversal enhancement was expected to develop the Equatorial Ionization Anomaly (EIA) but we observed the absence of EIA. The results also reveal well known characteristics of the plasma distributions on 8, 9, and 10 November. The emphasized features are the expansion and intensification of EIA due to prompt penetration electric fields on 9 November and the inhibition of EIA during post-sunset hours on 7, 8, and 10 November.

Equatorial TEC over South American sector with different magnetic declination angles

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We study the climatology of the Total Electron Content (TEC) as observed by GPS receivers in two equatorial stations in South America with different magnetic declination angles, São Luís (2.33° S, 315.8ºE, declination = -19o) in Brazil and Arequipa (16.5°S, 288.5ºE, declination = 0.5o) in Peru. TEC variations for three solar activity levels (high, moderate and low) have been analyzed. TEC values recorded over São Luís are larger than that ones over Arequipa independent of the season and solar cycle conditions. The main aim of the present work is to investigate the longitudinal differences in the TEC values associated with the large variations in the magnetic declination angle using the Sheffield University Plasmasphere Ionosphere Model (SUPIM). The equatorial ionospheric answers to combined effects of thermospheric neutral winds and zonal electric field will be also analyzed for the South American sector.

Detection of Spread-F and fof2 values using Digisonde and VIPIR instruments

Dr.Preeti Bhaneja (CIRES) Dr.Terrence W. Bullett (CIRES)

Ionosonde data from midlatitude and equatorial sites have been obtained and analyzed. The stations include Wallops Island, Boulder, Dyess, Vandenberg, Jicamarca and Kwajalein. Midlatitude data for more than eleven years (1999-2010) and equatorial data for two years (2010-2011) has been processed and analyzed. VIPIR data from a couple of years for Wallops Island and Jicamarca have also been analyzed. The digisonde ionograms are recorded every 15 minutes/hour, while the VIPIR ionograms are recorded every minute, 24 hours/day. For our study, we have used night-time data from 7 PM – 5 AM local time, making a total of 11 hours data/night, giving a total of 44 ionograms/night and 660 ionograms/night for the digisonde and the VIPIR instruments respectively. Various algorithms have been written to process the raw data and determine spread F by using edge detection and pattern recognition techniques. Algorithms have also been written to find fof2 values for obtaining the density profile of the ionosphere. The results obtained are compared with manually scaled and ARTIST scaled ionograms to determine the accuracy of the algorithms. Seasonal and solar cycle variations of midlatitude spread F has been determined and similar results are expected to be determined for equatorial spread F.

Ground Based Augmentation System (GBAS)

Ricardo Elias Cosendey

Longitudinal variation of equatorial spread F occurrence over South America

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In this report comparative study has been carried out of the equatorial spread F longitudinal occurrence characteristics analyzing digisonde data from two longitudinally separate stations and TEC GPS data to get the ionospheric conditions that generate spread F irregularities in the SA continent. Digisonde ionospheric parameters were measured to describe the ionospheric local conditions over São Luís (Brazil) and Jicamarca (Peru) stations, and we found a longitudinal/seasonal/day-to-day variation in these parameters. To support our finding we use TEC GPS data from Low Latitude Ionospheric Sensors (LISN) Network. Using Automatic Bubble Detection Algorithm (ABDA) on TEC data, it was possible to find out bubble signatures (hundreds of kilometers scale size) between September and December months. The bubble occurrence pattern over SA in general follows the characteristics of bubbles detected previously with VHF radar, digisonde and satellite (e.g. DMSP, CHAMP), that are large occurrence on September-October in the west and on December- January in the east. However, we had observed bubble signatures all over the continent among September to December period. Digisonde data from São Luís located at 2.33ºS, 44.2ºW and 1.3ºS dip latitude, and Jicamarca located at 12.4ºS, 77.2ºW and 1ºN dip latitude were used to measure the day-to-day longitudinal variation.

Equatorial Sp. F: an historical review

R. Woodman

Jicamarca Radio Observatory

First Results of GPS data and the contribution for water loading evaluation in Amazon Basin

Sonia Maria Alves Costa, Ana Cristina Oliveira Cancorro de Mattos e Denizar Blitzkow

With the advent of spatial technologies in the last decades provided important information about out planet completely unknown until now. GNSS (Global Navigation Satellite Systems) develop import role in the Earth sciences because with this technology it is possible get information of atmosphere layers, lithosphere, besides other applications. The goal of this presentation is show the results of LISN GPS stations installed in Amazon region (from 2008 to 2010) and their importance for the continental hydrology. GPS data was processed with a scientific software Bernese with models and strategies recommended by IGS (International GNSS Service). The vertical ground displacement occurs when the surface of the Earth oscillates in response to seasonal loading fluctuations imposed on the lithosphere. GPS time series indicates an annual cycle of vertical displacement with a peak-to-peak amplitude of 80-70 mm in Manaus and Parintins stations where was founded the strongest hydrological signal of Grace mission, used in this case, for comparisons with GPS time series. The Earth's vertical displacements in Leticia, Tefé and Alta Floresta reach 60-50 mm. It will be proposed new monumentation for GPS stations in order to use their data for geodynamics investigations.

Advanced Ionospheric Sounding

Todd Walter, Juan Blanch, and Per Enge

Stanford University

Use of the Global Positioning system (GPS) by aviation is already widespread for oceanic, en route, and terminal area guidance. Many countries have also developed or are developing augmentation systems to allow Global Navigation Satellite Systems (GNSSs) to support more demanding aviation applications including precision approach. These systems have been developed and approved for operations in high to mid-latitude regions. As they are all single-frequency systems, they are strongly impacted by ionospheric delay effects. The risk of differential ionospheric delays affects the availability and coverage of all of these systems. To date, augmentation systems have not been approved for operation in equatorial areas because the risk of strong ionospheric gradients is much higher. Further, ionospheric scintillation is more likely to cause interruptions to satellite tracking in the equatorial region. These two challenges make it very difficult to obtain the same level of performance enjoyed at high and mid-latitudes. New signals and constellations are being fielded that will improve this situation. Having two frequencies allows direct estimation of the ionospheric delay, eliminating ionospheric gradients as a cause for concern. Additional satellite measurements may allow some to be interrupted while still retaining service; therefore reducing the impact of scintillation. There remains an interest in single frequency operation in equatorial areas. Therefore there is a need for better characterization of the spatial and temporal variations of the ionospheric delay at the GPS L1 frequency. In particular, the potential magnitude of delay differences over short baselines (<20 km) and timescales (<300 seconds); how well the ionosphere can be modeled by a 2-dimensional thin shell approximation; and the potential magnitude of features that can elude sampling by a reference network or that fit inside a five degree by five degree grid cell. For dual frequency operations, the primary challenge will be scintillation. There is a need to better understand the frequency and spatial correlation of deep fades at both the L1 and L5 frequencies. The time between fades and depth of the fades are also important characteristics to understand.

Comparing LISN Model Results to Jicamarca Radar Data

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The LISN model uses available magnetometer and TEC observations from the Low-Latitude Ionospheric Sensor Network to determine the neutral wind drivers of the low latitude ionosphere and current dynamo. The E region tides and F region neutral winds driving the low-latitude ionosphere and dynamo electric fields are determined through an ensemble data-model inversion. The LLIONS ionosphere model and the Simple Electric Field model are coupled self-consistently to provide the electron specification and plasma drifts for the South American sector. The Jicamarca Radar observations of electron density and electric fields are used to examine the resulting LISN model solutions. Additionally, a more detailed look at the electrodynamics of the afternoon and evening are given for the period of January 1 to 15 of 2009.