AGU CHAPMAN CONFERENCE

Addis Ababa, Ethiopia | 12–16 November 2012

# Longitude and Hemispheric Dependence of Space Weather

Blue Nile Falls

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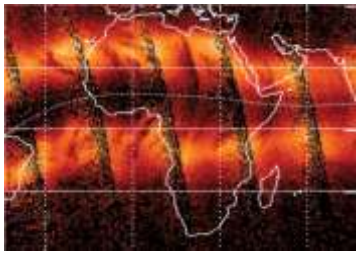
Addis Ababa, Ethiopia | 12–16 November 2012

# PROGRAM & ABSTRACTS



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# Preface

This international Chapman conference expands upon previous meetings on space weather in at least two ways:

- Emphasis will be on the hemispheric and longitudinal dependence of the ionosphere and thermosphere response to major solar events.
- Expansion of the study of space weather by examining the Earth system response during times when solar and geomagnetic activity are not so extreme; for instance plasma irregularities or "bubbles" can occur on any night even when geomagnetic activity is benign, and have a severe impact on satellite communication and GPS navigation.

The conference has at least two broader objectives:

- Assemble an international group of heliophysics scientists to plan and discuss current and needed observations at mid and low latitudes in the African longitude sector, a region that has never been explored in detail using ground-based instruments. In order to have a complete global understanding of equatorial ionosphere motion and take the global modeling effort one step forward, deployment of ground-based instruments in Africa is essential. Therefore, strong interaction between scientists from instrument donor and host institutes is crucial in order to have successful instrument deployment and continuous data retrieval process.
- Enhance the space science education and research interest in the continent. The interaction between African and other international scientists will significantly spark interest in space science education and research throughout Africa. It will facilitate international collaborations, gain exposure in African universities, and encourage the next generation of African scientists to become inspired by space science. The conference will also provide ideal opportunities for African scientists and graduate students to communicate their scientific results to the international scientific community.

The conference is focused on at least six main science themes:

(1) Hemispherical Dependence of Magnetospheric Energy Injection and the Thermosphere-Ionosphere Response
(2) Longitude and Hemispheric Dependence of Storm-Enhanced Densities (SED)
(3) Response of the Thermosphere and Ionosphere to X-Ray and EUV Time-History during Flares
(4) Quiet-Time Longitude Spatial Structure in Total Electron Content and Electrodynamics
(5) Temporal Response to Lower-Atmosphere Disturbances
(6) Ionospheric Irregularities and Scintillations

Conveners:

Tim Fuller-Rowell
Endawoke Yizengaw
Patricia Doherty
Gizaw Mengistu

# LONGITUDE AND HEMISPHERIC DEPENDENCE OF SPACE WEATHER

12–16 November 2012 | Addis Ababa, Ethiopia

# PROGRAM

| Time | Title | Presenter | Chairs |
|---|---|---|---|
| **Sunday (11 November 2012)** | | | |
| 5:00PM-7:00PM | Registration and Welcome Reception—Intercontinental Addis Hotel | | |
| **Monday (12 November 2012)** | | | |
| **Opening Ceremony** | | | |
| 8:00AM-8:45am | Late Registration (Please try to register Sunday evening) | | |
| Begin 9:00AM | Opening Remarks by LOC Chair | B. Damtie | Mengistu |
| 9:05AM-9:10AM | Opening remarks by Nigerian Minister of Science and Technology | | |
| 9:10AM-9:15AM | Opening remarks by South African Minister of Science and Technology | | |
| 9:15AM-9:30AM | Implementing AGU's vision, mission and strategic plan: efforts to date and future opportunities | C. McEntee (Su. Basu) | |
| 9:30AM-9:45AM | ISWI/SCOSTEP contribution to the development of space science in Africa | N. Gopalswamy | |
| 9:45AM-10:00AM | AMISR in Africa | R. Behnke | |
| 10:00AM-10:15AM | Role of NASA-ILWS to the African space science development | M. Guhathakurta | |
| 10:15AM-10:25AM | Remarks from the ICTP | S. Radicella | |
| 10:25AM-10:40AM | Conference Opening Speech by Ethiopian Deputy Prime Minister and Minister of Education | H. E. Mr. Demeke Mekonnen | |
| 10:40AM-11:10AM | Coffee Break | | |

| African Space Agency Activities | | | |
|---|---|---|---|
| 11:10AM-11:30AM | An overview of the South African National Space Agency (SANSA) *(Invited)* | L. McKinnell | Mengistu |
| 11:30AM-11:50PM | Nigerian Space Agency *(Invited)* | Minster Sci. & Technology | |
| 11:50PM-12:10PM | The experience of space science and astronomy education and research in Ethiopia *(Invited)* | S. Tessema | |
| 12:10PM-12:30PM | Some achievements of the International Heliophysical Year (IHY) and International Space Weather Initiative (ISWI) *(Invited)* | C. Amory-Mazaudier | |
| 12:30PM-12:50PM | Scientific exploration using GNSS systems in Africa *(Invited)* | P. Doherty | |
| 12:50PM-2:00PM | Lunch Break | | |
| **Hemispherical Dependence of Magnetospheric Energy Injection and the Thermosphere-Ionosphere Response** | | | |
| 2:00PM-2:30PM | Hemispherical dependence of magnetospheric energy injection *(Invited)* | E. Zesta (M. Moldwin) | Fuller-Rowell/ Yizengaw |
| 2:30PM-2:50PM | Asymmetry in hemispheric characteristics in Sq behavior over Africa within latitudes 29°N and 35°S | A. B. Rabiu | |
| 2:50PM-3:10PM | Differences in ionospheric response to magnetic disturbances at the northern and southern hemispheres | J. Laštovička | |
| 3:10PM-3:30PM | Ionospheric response, characterized by variations in GPS derived TEC monitored at Lagos, Nigeria, to the intense storm of 9$^{th}$ March 2012 | L. Amaeshi | |
| 3:30PM-3:50PM | Physical implications for discrepancy between the summer and winter PC indices observed in the course of magnetospheric substorms | O. Troshichev | |
| 3:50PM-4:20PM | Coffee Break | | |
| 4:20PM-4:50PM | Global-scale ultraviolet imaging of the hemispheric and longitudinal dependence of the thermosphere and ionosphere *(Invited)* | L. Paxton | Rabiu/ Doherty |

| | | | |
|---|---|---|---|
| 4:50PM-5:20PM | Tomographic imaging of ionospheric electron density over Eastern Africa using multi-platform instrumentations and model ionospheric total electron content *(Invited)* | G. Mengistu Tsidu | |
| 5:20PM-5:40PM | Daytime altitude and longitude variations of the equatorial, topside magnetic field-aligned ion transport at solar minimum | A. Burrell | |
| 5:40PM-6:00PM | A real-time model of the equatorial ionospheric zonal electric field | M. Nair | |
| Evening | Open | | |

## Tuesday (13 November 2012)

## Longitude and Hemispheric Dependence of Storm-Enhanced Densities (SED)

| | | | |
|---|---|---|---|
| 8:30AM-9:00AM | Longitude variations in storm enhanced densities *(Invited)* | R. Heelis | Damtie/ Bailey |
| 9:00AM-9:20AM | Explaining the very intense geomagnetic storm of November 20-21, 2003, and the pre-storm phenomenon | V. Chukwuma | |
| 9:20AM-9:40AM | Observations of SED during the storm of August 3-4, 2010 | Su. Basu | |
| 9:40AM-10:00AM | The response of African equatorial GPS-TEC to intense geomagnetic storms during the ascending phase of solar cycle 24 | A. Akala | |
| 10:00AM-10:20AM | A global ionospheric range error correction model for single frequency GNSS users | N. Jakowski | |
| 10:20AM-10:50AM | Coffee Break | | |
| 10:50AM-11:20AM | CEDAR system science: Geospace thermal plasma redistribution-longitude and hemispheric dependence of storm-enhanced densities, SAPS, and geomagnetic storms *(Invited)* | J. Foster | McKinnell/ Heelis |
| 11:20AM-11:40AM | Statistical study of the Equatorial $F_2$ layer at Ouagadougou during solar cycles 20, 21 and 22, using Legrand and Simon's classification of geomagnetic activity | F. Ouattara | |

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|---|---|---|---|
| 11:40AM-12:00PM | The ionospheric $F_2$-layer and magnetic storm of May 29th, 2010: A comparism between Ilorin, Hermanus and Jicamarca | B. Joshua | |
| | | | |
| 12:00PM-12:20PM | Closing the geophysical data gap–Midlatitude ionospheric characterization using GPS TEC time and position variability derived from GPS measurements in Zambia | P. Sibanda | |
| | | | |
| 12:20PM-12:40PM | Solar Cycle 24 observations of storm enhanced density and the tongue of ionization | A. Coster | |
| | | | |
| 12:40PM-2:00PM | Lunch Break | | |
| **Response of Thermosphere and Ionosphere to X-Ray and EUV Time-History During Flares** | | | |
| 2:00PM-2:30PM | Spectrally-resolved X-Ray and extreme ultraviolet irradiance variations during solar flares *(Invited)* | T. Woods | Moldwin/ Doumbia |
| | | | |
| 2:30PM-3:00PM | The ionospheric response to solar EUV variability *(Invited)* | P. Anderson | |
| | | | |
| 3:00PM-3:20PM | Effects of radio burst on GPS measurements over Africa | O. Obrou | |
| | | | |
| 3:20PM-3:40PM | Simultaneous observation of ionospheric irregularities over the African region | C. Ngwira | |
| | | | |
| 3:40PM-4:00PM | Coffee Break | | |
| | | | |
| 4:00PM-4:30PM | Tracing solar energy through the upper atmosphere: the response of lower thermospheric nitric oxide to solar flares and the impact of this response on the ionosphere *(Invited)* | S. Bailey | Obrou/ Valladares |
| | | | |
| 4:30PM-4:50PM | Signatures of Anatolian bump in ITNE-CIDR of Egypt | A. Mahrous | |
| | | | |
| 4:50PM-5:10PM | Effects solar transients on the ionospheric ionization and their positional dependence | S. Tripathi | |
| | | | |
| 5:10PM-5:30PM | Equatorial electrojet ground induced currents: Are there power grid space weather impacts at equatorial latitudes? | M. Moldwin | |
| | | | |
| 6:30PM-9:30PM | Poster Session—Jupiter International Hotel Refreshments served | | |

| Wednesday (14 November 2012) | | | |
|---|---|---|---|
| **Quiet-Time Longitude Spatial Structure in Total Electron Content and Electrodynamics** | | | |
| | | | |
| 8:30AM-9:00AM | Determining the sharp, longitudinal gradients in equatorial **E×B** drift velocities associated with the boundaries of the 4 - cell, non-migrating structures *(Invited)* | D. Anderson | |
| | | | |
| 9:00AM-9:20AM | Variability of Total Electron Content and the IRI model predictions over equatorial stations | E. Oyeyemi | |
| | | | |
| 9:20AM-9:40AM | On the variabilities and uncertainties in the measurement of absolute (true) TEC over Indian equatorial and low latitude sectors | P. Rao | Baki/ Caton |
| | | | |
| 9:40AM-10:00AM | Characteristics of the Equatorial $F_2$ ionospheric layer at low solar activity period *(Invited)* | J. Adeniyi | |
| | | | |
| 10:00AM-10:20AM | Modeling the equatorial electric field in the African sector using ground magnetic observatory data | P. Alken | |
| | | | |
| 10:20AM-10:50AM | Coffee Break | | |
| | | | |
| 10:50AM-11:20AM | Wave forcing from the lower atmosphere *(Invited)* | E. Talaat | |
| | | | |
| 11:20AM-11:50AM | The climatological and day-to-day longitudinal variability of the global ionospheric density distribution *(Invited)* | E. Yizengaw | |
| | | | |
| 11:50AM-12:10PM | On the longitudinal variation of the equatorial electrojet, its dependence on the geomagnetic main field intensity *(Invited)* | V. Doumbia | Ouattara/ Amory-Mazaudier |
| | | | |
| 12:10PM-12:30PM | The effects of **E×B** drifts on the equatorial ionosphere during extreme solar minimum | J. Klenzing | |
| | | | |
| 12:30PM-1:30PM | Lunch Break | | |
| | | | |
| 2:00PM-6:00PM | Field Trip | | |
| | | | |
| Evening | Open | | |
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| Thursday (15 November 2012) | | | |
|---|---|---|---|
| **Temporal Response to Lower-Atmosphere Disturbances** | | | |
| 8:30AM-9:00AM | Ionospheric response to lower atmospheric disturbances and impact on space weather *(Invited)* | L. Goncharenko | Mahrous/ Coster |
| 9:00AM-9:30AM | Ionospheric electrodynamics response at low latitudes to lower-atmosphere disturbances *(Invited)* | J. Chau | |
| 9:30AM-9:50AM | Observations of TIDs over South America | C. Valladares | |
| 9:50-10:10AM | Gravity wave dynamics and mesospheric temperature variability over Africa–A plan for new measurements | P. Loughmiller | |
| 10:10AM-10:30AM | Comparison of thermospheric winds and temperatures measured simultaneously in Peru and Brazil by Fabry-Perot interferometers | J. Meriwether | |
| 10:30-11:00AM | Coffee Break | | |
| 11:00AM-11:30AM | Modeling and predicting the space weather response to terrestrial weather *(Invited)* | T. Fuller-Rowell | Chau/D. Anderson |
| 11:30AM-11:50AM | Forecasting auroral radio absorption from the epsilon parameter | O. Ogunmodimu | |
| 11:50AM-12:10PM | Ionosphere characterization at low latitudes using TEC global maps | S. Radicella | |
| 12:10PM-12:30PM | Validation of IRI-2007 and NeQuick2 and TEC ingestion into NeQuick 2 to model East-African equatorial Ionosphere | M. Nigussie | |
| 12:30PM-12:50PM | Quasi 16-day periodic meridional movement of Equatorial Ionization Anomaly | D. Zhang | |
| 12:50PM-2:00PM | Lunch Break | | |
| **Ionospheric Irregularities and Scintillation** | | | |
| 2:00PM-2:30PM | Longitudinal variations of low latitude irregularities and scintillation *(Invited)* | K. Groves | Tessema/ Foster |
| 2:30PM-2:50PM | Low latitude ionospheric scintillation and ionospheric irregularity Drifts observations w/ GPS-SCINDA and VHF receiver in Kenya | J. Olwendo | |

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|---|---|---|---|
| 2:50PM-3:10PM | C/NOFS Observations of Longitudinal Ionospheric Variability | O. de la Beaujardière | |
| 3:10PM-3:30PM | Day-to-day and seasonal TEC variability time-shift near the Equatorial Ionospheric Anomaly region over Africa *(Invited)* | P. Baki | |
| 3:30PM-3:50PM | Source variability of strong convection influence on the upper atmosphere and ionosphere | R. Friedel | |
| 3:50PM–4:20PM | Coffee Break | | |
| 4:20PM-4:50PM | Deep gravity wave dynamics and responses in the thermosphere and ionosphere *(Invited)* | D. Fritts | Mbane/ Jakowski |
| 4:50PM-5:20PM | Modeling of the longitudinal dependence of equatorial plasma bubbles *(Invited)* | J. Huba | |
| 5:20PM-5:40PM | Development of an ionospheric map for Africa | N. Ssessanga | |
| 5:40PM-6:00PM | Impact of Arctic and Antarctic ionospheric scintillations on GNSS | S. Skone | |
| 7:00PM-11:00PM | Conference Dinner Banquet Hiber Ethiopia National Restaurant | | |

## Friday (16 November 2012)

## Infrastructure Development

| | | | |
|---|---|---|---|
| 8:30AM-8:45AM | Equatorial ionospheric scintillation effects on GNSS and SATCOM: Real-time observations with the Scintillation Network Decision Aid (SCINDA) *(Invited)* | R. Caton | Adeniyi/ Groves |
| 8:45-9:00AM | MAGDAS and other magnetometer networks in the African continent and some of their scientific benefits *(Invited)* | G. Maeda | |
| 9:00AM-9:15AM | Overview of European Space Agency (ESA) *(Invited)* | N. Jakowski | |
| 9:15AM-9:30AM | Overview about AFREF network *(Invited)* | A. Nonguierma | |
| 9:30AM-9:45AM | AfricaArray—An environmental monitoring network and capacity building initiative for Africa *(Invited)* | A. Wondem | |

| | | | |
|---|---|---|---|
| 9:45AM-10:15AM | Coffee Break | | |
| | | | |
| **Panel Discussion** | | | |
| 10:15AM-12:15AM | Infrastructure and Capacity Building: What observations and activities are needed in the region to address the outstanding science questions?<br><br>5 minute opening statements followed by open discussion | F. Anad<br>L. McKinnell<br>C. Amory-Mazaudier<br>J. Adeniyi<br>S. Tessema<br>S. Radicella<br>K. Groves | Fuller-Rowell/ Basu |
| | | | |
| 12:15PM-12:30PM | Wrap up closing remarks | Fuller-Rowell/ Basu/Doherty | |
| | | | |
| 12:30PM-12:45PM | Final Closing remarks Ethiopian Minister of Science and Technology | H.E Mr. Dessie Dalike | |
| | | | |
| 12:45PM-2:00PM | Lunch Break | | |
| **Open time for side meetings** | | | |
| Afternoon | Open for side meetings | | |
| | | | |

# ORAL ABSTRACTS

*Abstracts for the oral talks are listed in the order they appear in the program schedule.*

**Implementing AGU's Vision, Mission and Strategic Plan: Efforts to Date and Future Opportunities *(Invited)***

Chris McEntee[1]

[1]American Geophysical Union, Washington, DC, USA

In June 2010, the American Geophysical Union (AGU) adopted a strategic plan with a focus on scientific leadership and collaboration, and science for the benefit of society. In this brief review, participants will become familiar with the AGU vision: AGU galvanizes a community of Earth and space scientists that collaboratively advances and communicates science and its power to ensure a sustainable future; the AGU mission: The purpose of the AGU is to promote discovery in Earth and space science for the benefit of humanity; and the AGU four goals: Scientific Leadership and Collaboration; Science and Society; Talent Pool; and Organizational Excellence. Attendees will be informed about specific activities in AGU publications, meetings, outreach, and education along with programs and services for supporting scientists in developing and underserved countries. A particular emphasis will be placed on specific opportunities currently underway and being considered for African countries.

Dr. Chris McEntee
Executive Director/CEO, American Geophysical Union

---To be presented by:
Dr. Sunanda Basu
Boston College and American Geophysical Union

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**An overview of the South African National Space Agency (SANSA) *(Invited)***

Lee-Anne McKinnell[1]

[1]Space Science, South African National Space Agency, Hermanus, South Africa

The South African National Space Agency (SANSA) has a mandate, as outlined in the South African National Space Agency Act, 2008 (Act No 36 of 2008), to co-ordinate and integrate national space science and technology programmes and conduct long-term planning and implementation of space related activities in South Africa, for the benefit of the citizens of South Africa. SANSA was established in 2010, and launched on the 10 December 2010. The agency became operational on 1 April 2011. SANSA has 6 formal programmes: Space Operations, Earth Observation, Space Science, Space Engineering, Human Capital Development and Science Advancement. The first four programmes are led by Directorates of SANSA and the final 2 are overarching programmes.
Space science is an important driver for scientific enquiry, knowledge creation, technology development, and innovation. It is also an acknowledged instrument for human capital development and has always been a vehicle for stimulating interest, awareness, understanding, and appreciation of science amongst the youth and the general public. The SANSA Space Science directorate leads the space science programme. This presentation will provide an overview of the newly established SANSA with emphasis on the Space Science Directorate.

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**The Experience of Space Science and Astronomy Education and Research in Ethiopia *(Invited)***

Solomon Belay Tessema[1], Gizaw Mengistu Tsidu[2], Tefera Waluwa Wondemagegn[3], Kemal Bedri[4], Baylie Damtie[5], Endawoke Yizengaw[6], and Gebregiorgis Abrha Fekade[7]

[1]Astronomy and Astrophysics, Entoto Observatory and Kotebe College, Addis Ababa, Ethiopia
[2]Physics, Addis Ababa University, Addis Ababa, Addis Ababa, Ethiopia
[3]Ethiopian Space Science Society, Addis Ababa, Addis Ababa, Ethiopia
[4]Ethiopian Space Science Society, Addis Ababa, Addis Ababa, Ethiopia
[5]Physics, Washera Geospace and Radar Science Laboratory, Bahir Dar University, Bahir Dar, Ethiopia
[6]Institute for Scientific Research, Boston College, Chestnut Hill, USA
[7]Physics, Mekele University, Addis Ababa, Tigray, Ethiopia

Nowadays understanding more about space science, its benefits, and the technology it has brought to everyday life is becoming an essential helping global key to the overall development of any nation. It addresses the world's most urgent problems. There are a lot of improvements that space science has produced and the ways in which it might contribute in the future to tackling key global challenges. Presently, Space science and Astronomy education and research are increasingly becoming the center of attention in Africa. The various applications of these subjects, including communication and natural resource management, and future potentials have attracted the focus of policy makers and institutions in many African countries. Fortunately, in the recent few years (less than a decade ago) in Ethiopia overwhelmingly space science activity from various sectors is in progress. Since then, there is a dynamically ongoing astronomy development in Ethiopia, from creating astronomy awareness to constructing an astronomical observatory that will facilitate higher level astronomical observatories in the potential sites in Ethiopia and supports space science, Astronomy and technology infrastructure developments in collaboration with local and international working groups. Government has given attention by including astronomy/space science in the educational curriculum. Some universities are training professionals in space science and related fields. The Washera Geospace and Radar Science laboratory at Bahir Dar University trains in Radar systems, equatorial ionosphere physics, and computational physics, and mainly develops the techniques for measuring and modeling the Equatorial ionosphere. The Laboratory has done a lot of activities, including summer school, short term trainings, and gives frequent conferences. At Addis Ababa University (AAU), we have a GeoSpace section that trains and develops research in space science, atmospheric science, climate modeling, and satellite remote sensing. To this end, the number of space science instrumentations in Ethiopia has also jumped from just one fluxgate magnetometer six years ago to many different instruments (GPS receivers to ionosondes and powerful optical telescopes). Since its establishment in 2004, the ESSS has carried out valuable activities and has played great roles in promoting, training workshops, preparing inter-zonal continental and national conferences, and creating and establishing international collaborating working groups. Also the quadripartite members agreement for astronomy, space science, and technology development in Ethiopia, ESSS, AAU, Ministry of Education (MOE) and Ministry of Science and Technology (MOST), and most recently the consortium agreement signed by many of the Ethiopian senior universities in the use and management of Entoto Observatory and research center are some of the considerable activities. So in this article we try to address and give the detailed information and activities just mentioned.

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**Some achievements of the International Heliophysical Year (IHY) and International Space Weather Initiative (ISWI)**

Christine Amory-Mazaudier[1]

[1]Laboratoire de Physique des Plasmas, LPP/Polytechnique/UPMC/CNRS, Saint-Maur-des-Fossés, France

During the last decades, many efforts were made in the framework of IHY and ISWI programs in order to develop Space Science in Africa. This paper points out the success: 1) in the deployment of GPS and magnetometers over Africa; 2) in the organization of schools; and 3) in the training of PhD students.
We also present some advances in research made in the framework of IHY and ISWI projects and conclude with new perspectives to pursue the development of Space Science in Africa.

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**Scientific Exploration Using GNSS Systems in Africa *(Invited)***

Patricia H. Doherty[1]

[1]Institute for Scientific Research, Boston College, Chestnut Hill, MA, USA

Africa's Science and Technology Plan of Action [1] clearly states Africa's commitment to develop and use science and technology for socio-economic transformation and full integration into the world economy. The leading socio-economic problems that continue to cripple much of Africa include hunger, extreme poverty, erosion of natural resources and natural

disasters. Global Navigation Satellite Systems (GNSS), such as the Global Positioning System (GPS), are a space technology that can help address these problems and ultimately meet the goals of Africa's Science and Technology Plan of Action [1]. Specifically, GNSS applications can be used to increase food security, manage natural resources, provide efficient emergency location services, improve surveying and mapping, and provide greater precision and safety in land, water and air navigation systems. It also has applications in numerous fields of scientific study including space weather, geophysics, geography, geology, ecology, and biology. The benefits of GNSS for Africa have been recognized. International organizations have initiated the deployment of GNSS ground based stations for both geodetic and conservation activities, and scientific exploration. As Africa begins to employ and benefit from GNSS applications, it is important to initiate programs in GNSS science and technology at the university level for capacity building. This presentation will focus on the many opportunities to utilize GNSS systems for scientific studies in space weather, geodesy, remote sensing, and positioning and navigation. The presentation will further discuss the potential to maximize the scientific capabilities of the next generation of navigation satellites by discussing the benefits of the modernized GPS system, GLONASS, and the Galileo systems. GNSS systems are now located on every continent and they provide a source of continuous measurements that are useful for applications with societal benefits and for scientific exploration. These systems have already revealed fascinating details of the worldwide ionosphere, including some of the longitudinal differences of this dynamic phenomenon. This presentation hopes to further encourage these studies with the next generation of GNSS signals and systems and to exploit new opportunities.

Reference: 1) Africa's Science and Technology: Consolidated Plan of Action (2006). The New Partnership for Africa's Development (NEPAD) Website]. Available from: <www.nepadst.org>

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**Hemispherical dependence of magnetospheric energy injection *(Invited)***

Eftyhia Zesta[1], Athanasios Boudouridis[2], James Weygand[3], Endawoke Yizengaw-Kassie[4], Peter Chi[3], Mark Moldwin[5], and John Wise[1]

[1]AFRL/RVBXP, Air Force Research Laboratory, Albuquerque, NM, USA
[2]Space Science Institute, Boulder, CO, USA
[3]Earth and Space Sciences, UCLA, Los Angeles, CA, USA
[4]Institute for Scientific Research, Boston College, Chestnut Hill, MA, USA
[5]Atmospheric, Oceanic and Space Sciences, University of Michigan, Ann Arbor, MI, USA

Energy transfer from the solar wind to the magnetosphere and into the ionosphere- thermosphere system is propagated via multiple routes, and the coupling efficiency depends on IMF and solar wind conditions, as well as on the prior state of the magnetosphere. Some of the energy can be deposited to the ionosphere in a more direct path, for example via applied E-fields and the cross polar cap potential, and some of the energy gets processed in magnetospheric regions first before it gets released, for example during the substorm process, auroral precipitation, and currents. There is good evidence that such energy is not always released in the two hemispheres symmetrically and the asymmetry can have sources such as the structure of the Earth's magnetic field, seasonal variations, IMF conditions, and more. The magnetospheric Ultra Low Frequency (ULF) waves constitute an excellent diagnostic of how energy is transported through this complex system. We will explore the question of how energy is deposited asymmetrically in the two hemispheres by (a) studying the asymmetry in the power of ULF waves at magnetically conjugate locations on the two hemispheres, and (b) studying the conjugacy and/or asymmetries of auroral currents during quiet and disturbed conditions. We will examine individual cases as well as larger statistical results, and investigate the connection between asymmetric magnetic perturbations and the state of the ionosphere and thermosphere.

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**Asymmetry in hemispheric characteristics in Sq behaviour over Africa within latitudes 29°N and 35°S**

Akeem Babatunde Rabiu[1, 2], Olawale R. Bello[2], E. O. Falayi[2, 3], O. S. Bolaji[2, 4], and K. Yumoto[5]

[1]Engineering and Space Systems, National Space Research and Development Agency, Abuja, Nigeria
[2]Space Physics Laboratory, Federal University of Technology, Akure, Nigeria
[3]Physics, Tai Solarin University of Education, Ijagun, Nigeria
[4]Physical Sciences, Bells University of Technology, Ota, Nigeria
[5]Space Environment Research Centre, Kyushu University, Fukuoka, Japan

This work considered the Sq variation along the geographical meridian 32°–40°E taken advantage of meridian chain of 12 MAGDAS geomagnetic observatories installed within latitudes 29°N and 35°S. From the International Heliophysical Year to International Space Weather Initiative, the Space Environment Research Centre of Kyushu University, Japan, installed 11 units of Magnetic Data Acquisition Systems MAGDAS within the east African window. Magnetic records from these

stations have been employed in various research efforts to obtained interesting results hitherto unknown. Behaviour of Sq at the northern hemisphere is found not to be absolutely the same with that of the southern hemisphere. This present effort reviewed some of these results. Temporal and latitudinal variations of Solar quiet daily Sq variation in the three geomagnetic field components H, D, and Z have been investigated within the meridian window. The discrepancy in the flow of the interhemispheric field-aligned currents (IHFACs) along the sector is investigated and probable mechanisms responsible for the asymmetry in IHFACs discussed.

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**Differences in Ionospheric Response to Magnetic Disturbances at Northern and Southern Hemisphere**

Dalia Buresova[1] and Jan Laštovička[1]

[1]Aeronomy, Institute of Atmospheric Physics, Academy of Sciences of the Czech Republic, Prague, Czech Republic

The paper is focused on differences in ionospheric reaction to magnetic disturbances above selected ionospheric stations located at different magnetic longitudes of Northern and Southern Hemisphere. We analysed variability of critical frequency $foF_2$ and the *F*-layer peak height $hmF_2$ obtained for different longitudinal sectors of both hemispheres for initial, main and recovery phases of magnetic storms of different intensity, which occurred within the last two solar cycles. In general, the recovery phase is characterized by an abatement of perturbations and a gradual return to the "ground state" of ionosphere. Magnetospheric substorms, typical for the main phase, as a rule cease during the storm recovery phase. However, observations of stormy ionosphere show significant departures from the climatology also within this phase comparable with those, usually observed during the storm main phase. The paper also deals with the ionospheric reaction to magnetic disturbances during the prolonged solar minimum of 2007-2009.

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**Ionospheric response, characterized by variations in GPS derived Total Electron Content (TEC) monitored at Lagos, Nigeria, to the intense storm of 9th March 2012**

Larry Lemchukwu Amaeshi[1] and Paul Obiakara Amaechi[1]

[1]Physics, University of Lagos, Lagos, Nigeria

Our civilization is becoming increasingly dependent on space-borne technological systems such as communication satellite systems and Global Navigation Satellite Systems, an example of which is the Global Positioning System (GPS), the first operational GNSS. The performance and reliability of these systems depend very much on space weather. This underscores the interest in space weather studies and research. A major space weather event is geomagnetic storm. It is a temporary disturbance in Earth's magnetosphere. It impacts on the state of the ionosphere. During a geomagnetic storm most, if not all ionospheric parameters are disturbed. Any of these parameters, which include $foF_2$, Nm, in effect TEC, and the plasma drift velocity, can be used to investigate ionospheric response to geomagnetic storms. In this work, we have investigated the response of the ionosphere over Lagos (6.50ºN; 3.40ºE, dip angle 3.10ºS), to the intense storm (Dst -133 nT) that occurred on the 9th of March 2012; by investigating the variations on the GPS derived TEC, against the quiet condition behaviour. We chose this storm because it is the most intense since 2008, when we started capturing TEC data at our site. Also, the storm was preceded by a moderate one which occurred on the 7th of March, thus enabling some related comparisons to be made. The TEC data analysed was captured using Novatel 4004B dual frequency GPS receiver donated to us by Institute for Scientific Research, Boston College, Chestnut Hill, MA, USA. Our results are interpreted in light of relevant interplanetary conditions: namely solar wind and pressure, interplanetary e solar wind intensity and IMF Bz, on the storm days. The investigation reveals, among others: (i) an enhanced TEC on the day of the intense storms; (ii) a bifurcation in the diurnal variation of TEC about 15 hrs LT (UT+1) , on March 7. These results are consistent with the interplanetary conditions, (as will be elaborated in the main text); on the 7th, when there was the TEC bifurcation, there was a reduction in solar wind pressure, and in the interplanetary *E*-field intensity, both events occurring ~1200 UT, while the bifurcation occurred ~1500 hrs. The time interval, in our opinion, represents the ionospheric response/reaction time to the interplanetary disturbances. This reduced pressure suggests lower particle penetration, and the reduced *E*-field intensity suggests reduced prompt penetration of *E* field into the Earth. Both events explain the observed bifurcation in the diurnal variation of TEC on the day in question. And on the 9th there was enhanced *E*-field intensity, which probably meant enhanced **E**×**B** effect. This would lift the ionospheric *F* layer to heights where there is less loss mechanism(s) processes taking place. Thus the observed TEC increase is explicable in terms of the electro-dynamical processes. These results support a strong coupling of the magnetosphere-thermosphere-ionosphere (MTI) system during storms.

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**Physical implications for discrepancy between the summer and winter PC indices observed in the course of magnetospheric substorms**

Oleg A. Troshichev[1] and Alexander S. Janzhura[1]

[1]Geophysics, Arctic and Antarctic Research Institute, Saint-Petersburg, Russian Federation

The PC index based on a statistically justified relationship between the polar cap magnetic activity and the interplanetary electric field EKL has been derived as a value standardized for the EKL intensity regardless of season, UT and hemisphere. As a result, the summer and winter PC indices are consistent with one another under ordinary conditions. Discrepancies between the summer and winter PC indices arising in the course of magnetospheric substorms are analyzed in this paper. The magnetospheric substorms start only if the PC index reaches the definite threshold value >1.5 mV/m for substorms), in case of isolated substorms the summer PC index increase being followed by a delayed growth of the winter PC index. This regularity is explained by quite different conditions in the summer and winter polar regions for closure of the Region 1 field-aligned currents (FAC), which are responsible for the cross-polar cap voltage and, correspondingly, for magnetic activity in the polar caps: the high ionospheric conductivity in summer sunlit polar cap does not limit the raise of FAC intensity in response to solar wind impact on the magnetosphere, as opposed to the winter dark low-conducting ionosphere, where the Region 1 FAC closure is dependent on the auroral ionosphere conductivity and strongly affected by the auroral particle precipitation. As conductivity in the auroral oval raises owing to growth of the particle precipitation, the conditions for closure of the Region 1 field-aligned currents in the winter dark polar region are improved and summer and winter PC indices level off. The powerful sawtooth substorms are characterized by continuous very intense particle precipitation in the auroral zone, which supports the extreme high conductivity of the auroral ionosphere. As a result, the Region 1 FAC intensity in the winter polar cap extremely increases whereas conditions of the Region 1 FAC closure in the summer sunlit ionosphere are only trivially affected. Since the coefficients describing the relationship between EKL and the polar cap magnetic activity were derived for statistically justified (i.e. mean) conditions, their application to such abnormal situation, as intense field-aligned currents in the winter dark polar region, should lead to overestimation of the winter PC index. It is just this regularity that typical of powerful magnetic disturbances, like to sawtooth substorms. The summer and winter PC indices decline and level off as soon as the intense auroral particle precipitation terminates and the auroral ionosphere in the winter and summer polar caps returns to the ordinary (statistically justified) state.

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**Global-scale ultraviolet imaging of the hemispheric and longitudinal dependence of the thermosphere and ionosphere *(Invited)***

Larry Jason Paxton[1], Hyosub Kil[1], Yongliang Zhang[1], and Joseph Comberiate[1]

[1]Applied Physics Laboratory, The Johns Hopkins University, Laurel, MD, USA

In this paper, we review some of the things that we have learned about the response of the thermosphere and ionosphere during disturbed and undisturbed conditions. We will provide a very brief overview of what the measurements mean and how the data and data products can be accessed. The goal of that overview is to generate future collaborative activities. These resources will be placed in the context of the conference. In particular, we will show: 1) the results of our work on the evolution of thermospheric "storm fronts" as imaged in changes in composition (the O/N2 ratio) and how that response varies with longitude, hemisphere and solar cycle; 2) the large scale structure of the nightside *F*-region ionosphere and the variation with longitude; and 3) the distribution of ionospheric bubbles and what we can learn from the tomographic inversion of those bubbles. As powerful as UV remote sensing from low Earth orbit (it is only from LEO that we can perform tomographic reconstruction of the 3D structure of bubbles from a single platform), there are many other important measurements that can help address technical problems in the equatorial region. We will highlight some of the data sources we'd like to develop and the tools and partnerships we'd like to see enhanced.

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**Tomographic imaging of ionospheric electron density over Eastern Africa using multi-platform instrumentations and model ionospheric total electron content *(Invited)***

Gizaw Mengistu Tsidu[1]

[1]Physics, Addis Ababa University, Addis Ababa, Ethiopia

The electron density distribution of the low latitude ionosphere during the solar minimum 2008 period has been investigated by the 3D-computerized tomography technique using a Damped Least Square inversion with second order Tikhonov Regularization DLSTR) based algorithm. Ionospheric total electron content (TEC) data obtained from the NeQuick model, slant relative TEC data measured at a chain of stations receiving transit satellite transmissions over Eastern Africa, with majority of these in Ethiopia, and COSMIC TEC are used in this analysis. Application of second order

Tikhonov regularization in 3D tomography context is not straightforward due to spatial and temporal inhomogeneity in signal and noise in TEC. A regularization scheme which takes into account the inhomogeneity is proposed. The issue of optimum measurement information as a trade-off between minimum norm errors in measurement and that arise due to smoothing constraints in the DLSTR algorithm during the reconstruction of ionospheric structures is being addressed through use of L-curve method using the ground-based GPS receivers and model TECs. The performance of the new 3D computerized tomography inversion algorithm in driving realistic electron density profiles has been assessed in reproducing the equatorial ionization anomaly (EIA) in addition to its application to investigate complicated ionospheric density irregularities. Results show that the solution of this algorithm gives a very good reconstructed image of the low-latitude ionosphere and the EIA within it. While some minimum norm is fulfilled, the DLSTR algorithm is always found to lead to smooth solution whereby some density irregularities can be removed altogether. As a result, we employ a multi-platform 3D tomography, now including COSMIC TEC, to decrease voxel size and increase number of ray paths. The results show that additional fine scale structures are obtained. Moreover, the degree of freedom which describes relative information content of the measurement versus smoothing constraint has increased. The relative improvement in vertical resolution of electron density profiles in a multi-platform tomography and methodology for complete error characterization are described.

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**Daytime altitude and longitude variations of the equatorial, topside magnetic field-aligned ion transport at solar minimum**

Angeline Gail Burrell[1], Roderick A. Heelis[1], and Russell A. Stoneback[1]

[1]Physics, University of Texas at Dallas, Richardson, TX, USA

In the topside ionosphere, the transport of ions between the northern and southern hemispheres is determined by the ion density, composition, and field-aligned drift velocity. As the plasma has a high mobility along the magnetic field at these altitudes, field-aligned drifts occur readily as a result of field-aligned gravitational forces, collisional forces, or pressure gradients. Examination of the field-aligned ion drift and flux therefore allows the influence of thermospheric, electrodynamic, and chemical processes to be investigated. Daytime observations of the field-aligned drift and flux near the geomagnetic equator were obtained using the Coupled Ion Neutral Dynamics Investigation on board the Communications/Navigation Outage Forecast System satellite for the period of extremely low solar activity present in 2008 and 2009. Previous studies have shown that topside field-aligned drifts are most strongly influenced by the lower thermosphere during the daytime. As altitude increases, however, the decrease in ion density allows the influence of other physical processes to become more significant. The altitude and longitude variations of the field-aligned drift and flux presented in this study are used to examine the influence of the lower thermosphere, **E**×**B** drift, and chemical processes at altitudes extending up to the $O^+/H^+$ transition height.

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**A real-time model of the equatorial ionospheric zonal electric field**

Manoj C. Nair[1] and Stefan Maus[1]

[1]Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado (NOAA/National Geophysical Data Center), Boulder, CO, USA

In the equatorial ionosphere of the Earth, the wind driven currents coupled with the Earth's primarily horizontal magnetic field produce the equatorial zonal electric field. The zonal electric field is the primary driver of two important features of the equatorial ionosphere: (1) The Equatorial Ionization Anomaly (EIA), and (2) plasma density irregularities, also known as spread-*F*. During propagation through the ionosphere, communication and navigation radio signals are attenuated, delayed and scattered by these ionospheric features. Prediction of the zonal electric field is therefore a key to the real-time specification of the ionosphere. We divide the zonal electric field into a climatological contribution plus the prompt-penetration contribution caused by the solar wind effects. We use our transfer-function based model [*Manoj et al*., 2008] driven by the interplanetary electric field measured by the Advanced Composition Explorer (ACE) satellite to predict the prompt-penetration effects in real-time. The zonal electric field is predicted about one hour in advance, covering all local times and longitudes. The real-time prediction is available as a Google application at http://www.geomag.us/models/PPEFM/RealtimeEF.html. The benefit of this application to space weather forecasting is twofold: As the driver of the equatorial plasma fountain, the predicted zonal electric field is a leading indicator by 2-3 hours of the EIA and the Total Electron Content (TEC) of the equatorial ionosphere. Secondly, rapid uplift of the ionosphere by strong eastward electric fields is known to induce spread-*F*. Prediction of enhanced prompt penetration electric fields in the eastward direction therefore supports the forecast of radio communication and navigation outages in the equatorial region.

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**Longitude variations in storm enhanced densities *(Invited)***

Roderick A. Heelis[1]

[1]University of Texas at Dallas, Richardson, TX, USA

Storm Enhanced Densities (SED) have been defined and described with varying degrees of precision. They are seen in the ionosphere at low and middle latitudes and have been associated with storm-induced changes in the ionospheric electric field and thermospheric neutral winds. The global distribution of electric fields and winds produces storm effects that are similarly distributed in latitude, longitude and local time and the connections between phenomena observed at different locations remains a challenge to our understanding. In this presentation, we provide a brief overview of some of the major ionospheric perturbations associated with storm enhanced densities, discuss the mechanisms that could be responsible and the expected longitude dependencies that could be verified using models and tested by observations.

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**Explaining the very intense geomagnetic storm of November 20-21, 2003, and the pre-storm phenomenon**

Victor Uzodinma Chukwuma[1]

[1]Physics, Olabisi Onabanjo University, Ago Iwoye, Nigeria

An investigation of the very intense geomagnetic storm of November 20-21, 2003, is presented. The heliophysical, solar wind, and geomagnetic data used in the study are GOES 5-minute values of Solar X-rays: 1–8 A, the total magnetic field B, plasma temperature Tp, plasma beta, alpha/ proton ratio, interplanetary electric field Ey, the proton number density Nsw, the solar wind flow speed Vsw, the solar wind dynamic pressure Psw, the IMF Bz component in the GSM coordinate and hourly values of the low-latitude magnetic index, Dst. The Ionospheric data used in this study consists of hourly values of $foF_2$ obtained from a network of ionosonde stations located in the East Asian sector: Manzhouli, Chongqing, Guangzhou, Hainan; Australian Darwin, Learmonth, and Mundaring; the European/African sector: Juliusruh/Rugen, Rome, Athens and Grahamstone, and the American sector: Goosebay, Milestone Hill, Wallops Island, Puerto Rico, and Jicamarca. Our result show that the intense storm of November 20-21, 2003 resulted from interplanetary structure which belong to the shock-driver gas configuration, with the presence of the magnetic cloud in the interval 1500 UT, November 20-0000 UT, November 21 and the location of sheath in the interval 0900-1500 UT, November 20. Presently, the pre-storm ionospheric phenomena under investigation only occurred at Hainan, Learmonth, Mundaring, and Goosebay with respective 32%, 22%, 24% and 49% enhancement in peak electron density at ~0800 UT on November 20 and a strong depletion of ~ -33% between 0100 and 0600 UT at Jicamarca of the same day. The pre-storm phenomena did not display a systematic latitudinal dependence, which makes an explanation by means of the magnetospheric electric field rather unlikely. There is also no longitudinal dependence. The lack of latitudinal and longitudinal dependence of the pre-storm phenomena could suggest their origin from local time effect. Furthermore, a 6% increase in $hmF_2$ observed at Learmonth cannot account for enhancement in $foF_2$ at that station. Also the positive storm observed at Goosebay at 0800 UT cannot be accounted for by the uplifting of the $F_2$ region because the ionospheric plasma at this station was moved downward by 8% at this time. The present results appear to suggest that pre-storm ionospheric phenomena could be the result of some collaborative underlying mechanisms.

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**Observations of SED during the storm of August 3-4, 2010**

Cesar E. Valladares[1], Sunanda Basu[1], Patricia Doherty[1], Keith Groves[1], and Endawoke Yizengaw[1]

[1]Institute for Scientific Research, Boston College, Chestnut Hill, MA, USA

During magnetically disturbed periods, large electric fields promptly penetrate into low latitudes modifying the quiet time pattern of densities and scintillations. At mid latitudes, sunward convecting plumes of enhanced ionospheric densities known as SEDs are seen in the afternoon and dusk sectors at the equatorward edge of the sub-auroral polarizations stream (SAPS). SEDs have a strong impact on space weather as they are able to suppress availability of the FAA WAAS system Precision Approach levels of service over varying portions of the coverage area. This paper presents observations from several arrays of GPS receivers operating in North America, the Caribbean region, and South America that have been used to examine the formation, severity, inter-hemispheric symmetry and evolution of mid-latitude enhancements and steep gradients in total electron content (TEC) that developed during the August 3-4, 2011 storm. On August 03, two regions of enhanced TEC extending parallel and across the United State, resembling SEDs, were formed almost simultaneously near 22 UT. The TEC enhancement located westward was placed between Panama and Mexico and it was seen intruding into mid latitudes. The second TEC enhancement was located to the east and moved poleward and extended into high latitudes reaching Alaska at 23 UT. After this time both enhancements broadened and decayed almost simultaneously leaving a region of enhanced TEC values in the Caribbean region that persisted until 04 UT on August 04, 2010. GPS receivers in

South America indicated an absence of SEDs in the conjugate southern hemisphere. These observations are placed within the context of large TEC values that are commonly observed over Central America during quiet magnetic conditions.

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**The Response of African equatorial GPS-TEC to intense geomagnetic storms during the ascending phase of solar cycle 24**

Andrew Oke-Ovie Akala[1], Akeem Babatunde Rabiu[2,.3], Emmanuel Oluwafemi[3], Emmanuel O. Somoye[4], Elijah O. Oyeyemi[1], and A. B. Adeloye[3]

[1]Physics, University of Lagos, Lagos, Lagos, Nigeria
[2]Engineering and Space Systems, National Space Research and Development Agency, Abuja, Nigeria
[3]Physics, Federal University of Technology, Akure, Nigeria
[4]Physics, Lagos State University, Ojo, Lagos, Nigeria

This study presents the response of African equatorial GPS-TEC to intense geomagnetic storms that occurred during the ascending phase (2011) of solar cycle 24. Specifically, three intense geomagnetic storms were considered: September 26–27, 2011 storm (Dst -103 nT), October 25, 2011 (Dst: -137 nT), and March 9 storm (Dst: -133 nT). Furthermore, the response of GPS-TEC data from an African equatorial station: Lagos (6.52ºN, 3.4ºE, 3.04ºS magnetic latitude) [NIGERIA] to the geomagnetic storms under investigation was also studied. We also examine the causative roles of IP structures in the formation of the intense geomagnetic storms. All the intense storms were found to be associated with CME-induced transients, and their drivers were sheath fields behind the shocks. At the African equatorial station, TEC exhibits positive response to geomagnetic storms, with an enhancement in the order of 6 TECU around 1300–1500 UT. Keywords: Geomagnetic storms; equatorial ionosphere; GPS-TEC.

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**A global ionospheric range error correction model for single frequency GNSS users**

Norbert Jakowski[1] and Mohammed Mainul Hoque[1]

[1]Institute of Communications und Navigation, German Aerospace Center, Neustrelitz, Germany

Transionospheric navigation and radar systems operating at single frequencies of less than 10 GHz are impacted by ionospheric refraction. Since the ionospheric delay is proportional to the total electron content (TEC) of the ionosphere along the ray path, a user friendly TEC model is helpful in various applications. Thus, a global TEC model (NTCM-GL) has recently been developed in DLR. The basic approach of the model is presented and the performance is discussed in comparison with GNSS single frequency correction models such as the Klobuchar or GPS model and the NeQuick model. The empirical approach describes functions on season, local time, geographic/geomagnetic location, and solar irradiance conditions. The solar activity is controlled by the solar radio flux index F10.7. The approach needs only 12 coefficients for describing the main ionospheric features in good quality. The model approach is based on global TEC data provided by the Center for Orbit Determination in Europe (CODE) at the University of Berne over more than half a solar cycle (1998-2007). The model fits to these input data with a negative bias of 0.3 TECU (1 TECU=1x1016$^{m-2}$) and a RMS deviation of 7.5 TECU. It has been found that the NeQuick and NTCM-GL model show a similar performance which is by a factor of nearly 2 better than the performance of the Klobuchar model at the European sector. Since the coefficients cover a full solar cycle, no updating is required. Hence, NTCM-GL may easily be used as a correction model for single frequency GNSS applications.

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**CEDAR system science: Geospace thermal plasma redistribution - longitude and hemispheric dependence of storm-enhanced densities, SAPS, and geomagnetic storms *(Invited)***

John C. Foster[1]

[1]Atmospheric Sciences, Millstone Hill Observatory, Massachusetts Institute of Technology, Westford, MA, USA

Storm-time thermal plasma redistribution provides an excellent example of the cross-discipline, system-level Geospace problems which are a focus of the recent CEDAR Strategic Plan. Plasma redistribution is a multistep, system-wide process involving the equatorial, low, mid, auroral, and polar latitude regions, and significant magnetosphere-ionosphere coupling and feedback. Penetration electric fields enhance the equatorial ionization anomaly peaks, while polarization electric field effects at the dusk terminator redistribute the low-latitude total electron content (TEC) in both longitude and latitude. The particular configuration of the magnetic field in the Atlantic sector due to the offset of the poles and declination effects near the SAA creates a preferred longitude/ Universal Time sector (western Atlantic/21 UT) for the buildup of enhanced TEC on field lines inside the dusk plasmapause. This TEC enhancement forms a localized source for the intense storm enhanced

density (SED) erosion plumes that are observed over the Americas during major storms. In a second set of storm-time processes, ring current enhancements generate strong poleward-directed subauroral polarization stream (SAPS) electric fields in the evening sector as field-aligned currents close through the low-conductivity ionosphere. This leads to the erosion of the sub-auroral TEC enhancement, and the overlying plasmasphere boundary layer, transporting the SED plumes to the noontime cusp in the ionosphere and to the dayside magnetopause at high altitudes. These greatly enhanced fluxes of cold plasma traverse the cusp and enter the polar cap forming the polar tongue of ionization and providing a rich source of heavy ions for the magnetospheric injection and acceleration mechanisms that operate in these regions [*Foster,* 2008]. The UT (longitude) dependences of these plasma redistribution processes lead to a potential UT dependence in the development of severe geomagnetic (Geospace) storms. *Foster & Coster* [2007] used ground-based GPS TEC, DMSP overflights, and Millstone Hill radar observations to identify a repeatable discrete localized enhancement of total electron content (TEC) in magnetic-conjugate regions at dusk in the American sector during large magnetic storms. This longitude-specific 'Florida effect' also is seen in the spaceborne plasmasphere imagery made with the IMAGE EUV and FUV instruments. *Foster & Rideout* [2007] investigated the degree of magnetic conjugacy of the stormtime ionospheric perturbation. The SED plumes streaming away from the sub-auroral source regions closely follow magnetic conjugate paths and serve as a tracer of the location and strength of disturbance electric fields. They concluded: 1. The SED plume occurs in magnetically conjugate regions in both hemispheres. 2. The position of the sharp poleward edge of the SED plume is closely conjugate. 3. The SAPS flow channel is observed in magnetically conjugate regions. 4. The strong TEC enhancement at the base of the SED plume in the North American sector is more extensive than in its magnetic conjugate region. 5. The entry of the SED plume into the polar cap near noon, forming the polar TOI, is seen in both hemispheres in magnetically conjugate regions.

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**Statistical study of the Equatorial $F_2$ layer at Ouagadougou during solar cycles 20, 21 and 22, using Legrand and Simon's classification of geomagnetic activity.**

Frédéric Ouattara[1] and Christine Amory Mazaudier[2]

[1]École Normale Supérieure de l'Université de Koudougou, Koudougou, Burkina Faso
[2]Laboratoire de Physique des Plasmas, CNRS, UPMC, Saint-Maur-des-Fossés, France

We present the statistical analysis of the diurnal variations of the *F* layer at the equatorial station of Ouagadougou from 1966 to 1998 (≥ ~ 11 680 days). We consider the three main factors of variability: 1) the season (spring, summer, autumn and winter), 2) the phase of the sunspot cycle (ascending, maximum, descending and minimum), 3) the geomagnetic activity classified by Legrand and Simon in four classes : slow solar wind, high solar wind streams, fluctuating solar wind and shock activity. We easily identify the influence of the solar wind speed and shock activity on the diurnal pattern of the *F* layer. Shock and recurrent activity tend to enhance or diminish the morning or afternoon maximum of the $F_2$-layer critical frequency. The difference of the diurnal $foF_2$ variation during the increasing and decreasing phase of the sunspot solar cycle is explained by different solar wind regimes. The slow solar wind dominates during the increasing phase of the sunspot cycle and the fluctuating solar wind dominates during the decreasing phase of the sunspot cycle. This paper demonstrates that it is possible with large data base to bring up significant morphologies of the diurnal variation of the $foF_2$ critical frequency as a function of (1) different solar events such as quiet solar wind, fluctuating wind, recurrent high stream wind, and CMEs; (2) solar cycle phases and, (3) seasons. It is an approach connecting directly the critical frequency of the $F_2$ layer to solar parameters. Keywords: Ionosphere, geomagnetic activity, solar activity.

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**The ionospheric $F_2$-layer and magnetic storm of May 29th, 2010: A comparism between Ilorin, Hermanus and Jicamarca**

Benjamin Joshua[1], Jacob Olusegun Adeniyi[2], Isaac A. Adimula[2], and John Shola Adebiyi[3]

[1]Physics, Kebbi State University of Science and Technology, Aliero, Nigeria
[2]Physics, University of Ilorin, Ilorin, Nigeria
[3]Industrial Physics, Landmark University, Omo-Aran, Nigeria

The responses of the $F_2$-layer to the magnetic storm of May 29th, 2010 at Ilorin (Lat. 8:53°N, Long. 4.5°E.) was compared to that of, Jicamarca ( Lat. -12°N, Long. 283.2ºE) and Hermanus ( Lat. -34.42°N, Long. 19.22°E) and 61% increase in the $N_mF_2$ was observed at Ilorin, over 100% increases at Hermanus, and 34% increase was observed at Jicamarca, all at the day side, while night side increases of over 100% and 53% was observed at Hermanus and Jicamarca respectively, no night time increase observed at Ilorin, when compared with the quiet day variations; we also observed a decrease of 16% in $h_mF_2$ at Ilorin, 18% day-side increase and 31% night side increase at Hermanus, and an increase of 28% in the day side, 39% increase in the night side at Jicamarca. All these features observed during the geomagnetic storm and quiet days have been explained in terms of the magnetospheric current, solar wind and movement of ionization caused by the cross field of the electric field (E) and the earth's magnetic field B. we also obtained and compared the DH field values measured at Ilorin,

MAGDAS station & the Dst index values measured by WDC Kyoto and It was observed that the minimum value of DH during the magnetic storm days fairly corresponds to the minimum value of the Dst index.

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**Closing the geophysical data gap–Midlatitude ionospheric characterization using GPS TEC time and position variability derived from GPS measurements in Zambia**

Patrick Sibanda[1] and Mark B. Moldwin[2]

[1]Physics Department, University of Zambia, Lusaka, Zambia
[2]Atmospheric Oceanic and Space Sciences, University of Michigan, Ann Arbor, MI, USA

The IHY 2007-2009 campaign resulted in the establishment of five new instruments in Zambia that now provide continuous geophysical data. These include a magnetometer (MAGDAS) and four GPS receivers. These installations provide a valuable data resource for the investigation of the variability of the ionosphere over this region and present an opportunity to expand the as yet unknown area of space dynamics over Africa. Total Electron Content (TEC) as an important characteristic of the Earth's ionosphere, carries information on time and position variability of the ionosphere and is therefore a useful sensor of ionospheric climatology. The study presents the first results and analysis of TEC variability using data from the GPS receivers in Zambia and highlights the recent progress made in developing space science studies in Zambia which has previously suffered a lack of ionospheric measurements. This expanding database of GPS data over Zambia is a valuable resource for the scientific community world over as it provides an extension of the dense South African database northwards and will allow useful validations of existing ionospheric models.

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**Solar cycle 24 observations of storm enhanced density and the tongue of ionization**

Anthea J Coster[1], John Foster[1], Philip J Erickson[1], and Evan Thomas[2]

[1]Millstone Hill Observatory, Massachusetts Institute of Technology, Westford, MA, USA
[2]Virginia Tech, Blacksburg, VA, USA

Storm Enhanced Density (SED) plumes form at mid-latitudes during geomagnetically disturbed conditions and have been observed over the USA for more than two decades [e.g., *Foster*, 1993]. Observations of SED have also been reported over South America [*Coster et al*., 2003], over Europe [*Yizengaw et al.*, 2006], and over Japan [*Maruyama*, 2006]. *Foster and Rideout* [2007] performed a detailed study of SED magnetic conjugacy for several storms. They observed that most, but not all, SED features exhibited elements of magnetic conjugacy and appeared simultaneously in both hemispheres. This implies that tongue of ionization (TOI) structures, thought to be an extension of the SED plasma, may form simultaneously over the two poles. The SED feature that does not appear to be conjugate is the magnitude of TEC enhancement at the base of the SED plume. The amount of TEC enhancement at the base of the plume appears to exhibit localized and longitude-dependent features, perhaps due to the offset of the geographic and geomagnetic poles in the American sector [*Coster et al.*, 2007]. The recent addition of several GPS receivers in the Antarctic has led to improvements in TEC spatial coverage in the South Pole region. New tools have also been developed for merging Super Dual Auroral Network (SuperDARN) observations of HF irregularities with the GPS TEC spatial data set. SuperDARN measures the backscattered power and **E**×**B** drift velocities of decameter scale plasma irregularities. The fusion of SuperDARN and GPS TEC data sets has provided a more detailed view of the TOI and associated conjugacy effects. We will report on new comparisons of SEDs and TOIs observed in both northern and southern hemispheres during the 2008-2012 time period.

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**Spectrally-resolved X-Ray and extreme ultraviolet irradiance variations during solar flares *(Invited)***

Thomas N. Woods[1]

[1]Laboratory for Atmospheric and Space Physics (LASP), University of Colorado at Boulder, CO, USA

New solar soft X-ray (SXR) and extreme ultraviolet (EUV) irradiance observations from NASA Solar Dynamics Observatory (SDO) EUV Variability Experiment (EVE) provide full coverage from 0.1 to 106 nm and continuously at a cadence of 10 sec for spectra at 0.1 nm resolution. These observations during flares can usually be decomposed into four distinct characteristics. Firstly, the emissions that dominate during the flare's impulsive phase are the transition region emissions, such as the He II 30.4 nm. Secondly, the hot coronal emissions above 5 MK dominate during the gradual phase and are highly correlated with the GOES X-ray. A third flare characteristic is coronal dimming, seen best in the cool coronal EUV emissions such as the Fe IX 17.1 nm. The coronal dimming appears to be related to coronal mass ejections (CMEs), thus representing a new way to possibly estimate CME events from SDO observations. As the post-flare loops reconnect and cool, some EUV coronal emissions peak a few minutes after the GOES X-ray peak. One interesting variation

of the post-eruptive loop reconnection is that warm coronal emissions (e.g., Fe XVI 33.5 nm) sometimes exhibit a second large peak separated from the primary flare event by many minutes to hours, with EUV emission originating not from the original flare site and its immediate vicinity, but rather from a volume of higher loops. We refer to this second peak as the EUV late phase. The characterization of many flares during the SDO mission is provided, including quantification of the spectral irradiance from the coronal dimming and EUV late phase that cannot be inferred from GOES X-ray diagnostics.

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**The ionospheric response to solar EUV variability**

Phillip Charles Anderson[1]

[1]Physics, University of Texas at Dallas, Richardson, TX, USA

The ionosphere is primarily produced by EUV photons from the sun. Its structure therefore naturally is strongly responsive to solar EUV variability. Just as with the troposphere, a correlation of ionospheric structure with solar variability is expected, but how that variability specifically drives the global and regional structure of the ionosphere is not well understood. This is largely because of the lack of simultaneous and continuous measurements of the spectral distribution of the solar EUV and measurements of the ionospheric structure. Such measurements are now being provided by the SDO, TIMED, C/NOFS, and DMSP spacecraft. These spacecraft provide a unique opportunity to develop a more complete understanding of the link between solar EUV variability and the ionosphere. We present the results of an investigation of both the global and local response of the ionosphere to solar EUV, correlating the overall EUV flux as well as individual spectral bands with the ionospheric temperature and composition at various altitudes, latitudes, local times, seasons, and altitudes.

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**Effects of radio burst on GPS measurements over Africa**

Olivier K. Obrou[1], Jean Baptiste Ackah[1], and Bonaventure Okere[2]

[1]Physics, Université de Cocody à Abidjan, Côte d'Ivoire
[2]University of Nigeria, Nsukka, Nigeria.

It is well known that the solar has its own season that is 11 years periodically. For the current solar cycle, we are about to reach what is call the solar maximum. During this period, the far ultraviolet portion of the solar electromagnetic spectrum is intensified causing the earth's ionosphere to be denser and thicker. An important number of solar flares are observed. The resulting high energy electrons produce intense broadband burst of radio waves from HF to above L-band. The next solar maximum is expected to occur in May 2013. It is an opportunity to test the performance of most of the GNSS equipment including the GPS receivers used to study the characteristics of the ionosphere particularly in the African continent. The solar radio bursts have been widely studied and known to be sources of notable problems for radio communication systems; however, their impact on GPS systems are not largely documented (*Lanzerotti et al.*, 1999). To the receiver, a solar radio burst is a wide-band radio interference source that causes an effective decrease in the received carrier-to-noise ratio. In this paper, we are examining the impact of two radio burst events as seen by the GPS receivers installed at Nsuka and Lagos two Nigerian SCINDA and LISN stations.

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**Simultaneous observation of ionospheric irregularities over the African region.**

Chigomezyo M. Ngwira[1, 2] and Gopi Seemala[3]

[1]Physics, Catholic University of America, Washington, DC, USA
[2]Heliophysics Division, NASA Goddard Space Flight Center, Greenbelt, MD, USA
[3]Research Institute for Sustainable Humanosphere, Kyoto University, Kyoto, Honshu, Japan

Ionospheric storms represent large global disturbances of the ionospheric F region electron density in response to geomagnetic storms. This study investigates the ionospheric response during two successive minor geomagnetic storms that occurred on 13-14 September 2004. In particular, we use total electron content (TEC) measurements to investigate the presence of ionospheric irregularities over four low-latitude stations in the African sector, a region that has been less studied. Ionospheric irregularities are known to cause fading and phase fluctuation of L-band radio navigation signals such as those used by the Global Positioning System (GPS), and are a common feature in the equatorial and low-latitude ionosphere. On 13 September, the storm did not appear to hinder the development of irregularities as they were observed over all the stations. In contrast, irregularities were rarely observed at two of the 4 stations under study and where completely absent over the other two stations during the event on 14 September. The DSMP F15 satellite post-sunset flight over the African region observed deep density depletion on 13 September which are associated with the presence of ionospheric plasma bubble irregularities. Furthermore, an analysis of delta-H (difference between the observed and

nighttime horizontal geomagnetic component) reveals that there was a penetration electric field, which is associated with a strong equatorial electrojet, observed in the post-sunset hours on 13 September, while a negative perturbation of delta-H, which is associated with the counter-electrojet, was observed on 14 September.

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**Tracing solar energy through the upper atmosphere: the response of lower thermospheric nitric oxide to solar flares and the impact of this response on the ionosphere *(Invited)***

Scott Martin Bailey[1], Brentha Thurairajah[1], Karthik Venkataramani[1], and Cissi Ying-tsen Lin[1]

[1]Electrical Engineering, Virginia Tech, Blacksburg, VA, USA

As solar photon energy is deposited into the upper atmosphere, the immediate ionization, dissociation, and excitation of atoms and molecules leads to important modifications of the composition and temperature there. A key product of these energetic processes is nitric oxide. Though always a minor species, NO plays a strong role in the thermospheric energy balance because unlike the major species O, $O_2$, and $N_2$, it emits efficiently in the infrared. Radiance from NO is then a key process by which the atmosphere cools in response to solar energy deposition. The presence of NO has other important impacts on the chemistry and ion composition in the atmosphere. Solar flare soft X-ray irradiance provides a highly variable energy source to the lower thermosphere. During a solar flare, the overall soft X-ray irradiance between 0.1-7 nm is increased with most of the increase between 0.1-2 nm. The excess of 0.1-2 nm soft X-rays leads to more NO production near its peak altitude of 110 km. Because of the short duration of the flare, the NO enhancements are localized in longitude. In this talk, we utilize 3D models that include all relevant chemical and dynamical processes to study NO in the lower thermosphere and discuss the solar flare production of NO. We show results where these models are driven by new observations of solar flare solar irradiance from the EUV Variability Experiment (EVE) on the Solar Dynamics Observatory. We show that X-class flares can typically lead to doubling of the NO density and that this has significant impacts on the local ionospheric structure.

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**Signatures of Anatolian bump in ITNE-CIDR of Egypt**

Ayman Mohamed Mahrous[1] and Trevor Garner[1]

[1]Space Weather Monitoring Center, Cairo, Egypt

The Ionospheric Tomography Network of Egypt (ITNE) is a chain of passive UHF/VHF receivers, known as Coherent Ionospheric Doppler Receivers (CIDRs). The first ITNE-CIDR was installed at Helwan University (geographic latitude 29.9 deg., longitude 31.3 deg.) in May 2008. Each receiver measures the Doppler shift in UHF (400 MHz) and VHF (150 MHz) signals from radio beacons on board LEO satellites. Each CIDR system is capable of tracking up to three different beacon satellites with different offsets in frequency at any given time. This study examined more than one hundred LEO satellite passes, in which the satellite flew over the Anatolian Plateau. The study shows that bumps and ripples frequently occur at the edge of the Anatolian plateau with an ionospheric perturbation in the D(TEC)/D(t) measurements. There are three types of perturbations: bumps (a single peak with an amplitude D 0.01 TECu/sec and an ionospheric pierce point (IPP) latitudinal width of at least 1 degree), ripples (a large central peak surrounded by several smaller peaks) and waves (several comparable peaks). The majority of these perturbations occur near the edge of the Anatolian plateau.

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**Effects of solar transients on the ionospheric ionization and their positional dependence**

Sharad Chandra Tripathi[1], Parvaiz Ahmad Khan[1], Aslam A. Muhammad[1], Pramod Kumar Purohit[2], and Ashok Kumar Gwal[1]

[1]Physics, Barkatullah University, Bhopal, Madhya Pradesh, India
[2]National Institute of Technical Teachers' Training and Research, Bhopal, Madhya Pradesh, India

Solar Transients. Flares, Coronal Mass Ejections, and Energetic Particles are the main drivers affecting the space environment near Earth. Solar radiations EUV and X-rays are found to be responsible for the ionospheric ionization usually; however, some local effects do as well. In this study, we have investigated the effects of solar radiation in the above wavelengths on the ionospheric ionization and their positional dependence. We have found that the ionization is directly related to the flux budget of the radiation and also found that mostly the solar transients occurred on the western hemisphere of the solar disc have strong effects on the ionospheric ionization. For this study GOES observations have been used for X-ray wavelength and that of SOHO for EUV as well. For ionospheric parameters, we have used ionosonde data from various stations on the globe.

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**Equatorial electrojet ground induced currents: Are there power grid space weather impacts at equatorial latitudes?**

Mark B. Moldwin[1]

[1]Space Research, University of Michigan-AOSS, Ann Arbor, MI, USA

Auroral electrojet ground induced currents (GIC) are well known space weather effects in the auroral zones and mid-latitudes. The Equatorial Electrojet (EEJ) gives rise to large ground magnetic perturbations within a few degrees of the geomagnetic equator. As electrification and trans-national power grids develop in regions below the EEJ in South America, Africa, India, and Southeast Asia, space weather GIC impacts should become more prevalent. This study estimates GIC perturbations in equatorial Africa.

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LONGITUDE AND HEMISPHERIC DEPENDENCE OF SPACE WEATHER
12–16 November 2012 | Addis Ababa, Ethiopia

*The abstracts for the Poster Session are located after the rest of the oral abstracts.*

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**Determining the sharp, longitudinal gradients in equatorial E×B Drift velocities associated with the boundaries of the 4-cell, non-migrating structures *(Invited)***

David N. Anderson[1]

[1]Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado (NOAA/Space Weather Prediction Center), Boulder, CO, USA

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 **E×B** drift velocities. A recent paper, for the first time, quantified the longitude gradients in **E×B** 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 **E×B** drift velocities, it was found, for example, that for October 5, 6 and 7, 2009 in the Atlantic sector, the **E×B** 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. In this paper we present results from a multi-instrument study of the sharp longitude gradients in the daytime **E×B** drift velocities at the boundaries of each of the 4-cell, non-migrating structures. We utilize both the C/NOFS IVM observations of **E×B** drift velocities and the ground-based magnetometer-inferred **E×B** drift velocities. We incorporate the LISN (Low-latitude Ionospheric Sensor Network) magnetometer chains in the South American sector and compare these magnetometer-inferred **E×B** drift velocities with C/NOFS IVM **E×B** drift observations. Finally, we theoretically model the ionospheric response to these sharp longitude gradients using the Global Ionosphere Plasmasphere (GIP) time-dependent model. In essence, the steeper the longitude gradient in **E×B** drifts, the steeper the longitude gradient in the equatorial anomaly crest location. We present the observational **E×B** drift results and the calculated electron density distributions and suggest future studies that would be able to account for such sharp gradients in **E×B** drift velocities at the boundaries of the 4-cell structures.

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**Variability of Total Electron Content and the IRI model predictions over equatorial stations**

Elijah O. Oyeyemi[1], Adekola O. Adewale[1], Andrew O. Akala[1], Jacob O. Adeniyi[2], and Busola Olugbon[1]

[1]Physics, University of Lagos, Lagos, Nigeria
[2]Physics, University of Ilorin, Ilorin, Nigeria

This paper discusses the ability of the International Reference Ionosphere IRI-2007 to predict variability of total electron content (TEC) measurements during year 2010. TEC measurements from two equatorial stations (Kigali 1.94ºS, 30.1ºE and Ilorin 8.48ºN, 4.67ºE) are used in this study. The results obtained show that the predicted values by the IRI model follow the normal trend of the TEC experimental values. A comprehensive analysis of diurnal and seasonal variations, and relative deviations between the experimental and the IRI model predictions are presented.

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**On the variabilities and uncertainties in the measurement of absolute (true) TEC over Indian equatorial and low latitude sectors**

Paluri Venkata Sri Rama Rao[1], Venkatesh Kavutarapu[1], Prasad SVVD Dasari[1]

[1]Physics, Andhra University, Visakhapatnam, Andhra Pradesh, India

The Indian sector encompasses the equatorial and low latitude regions where the ionosphere is highly dynamic and is characterized by the Equatorial Ionization Anomaly (EIA) resulting in large latitudinal electron density gradients causing ambiguities in the estimation of range delays in satellite based augmentation and navigation systems. The diurnal and latitudinal variations in the day-to-day variability of the Total Electron Content (TEC) in the Indian sector during the low sunspot period 2004-2005 are studied and presented. The diurnal and seasonal variations of standard deviations in the TEC measured at ten different Indian stations located from equator to the anomaly crest region and beyond are presented. The day-to-day variability in TEC is found to be lowest at the equatorial station, Trivandrum, and increases with latitude up to the crest region of EIA and decreases beyond. A correlation analysis has been carried out between TEC value at 1300 hrs LT and solar indices parameters namely sunspot number (SSN), F10.7 and EUV. This reveals that the correlation is more during equinoctial months and less during summer months and the correlation coefficients observed over the anomaly locations are lower compared to those at the equatorial and low latitudes. Further, the measurements of TEC using grid based studies are also carried out with a view to ascertain the uncertainties in the measurement of the absolute value of TEC. The TEC derived from different satellite ray paths visible in the 50 x 50 grid over any particular location at any particular given point of time have shown significant differences in the TEC derived from one ray path to the other leading to the possibility of introducing errors in the interpolation technique. Also, the TEC values derived simultaneously along two different satellite ray paths simultaneously passing through the same sub-ionospheric point at the same point of time are found to be quite different from each other. These uncertainties are found to be more pronounced at and around the EIA anomaly crest region with larger variations particularly around noon-time hours. Therefore, the uncertainties in the conversion of VTEC to STEC and vice versa in the 50x50 degree configuration using the obliquity factor in the equatorial and low latitudes are also discussed and the need for much closer grid configuration is suggested.

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**Characteristics of the Equatorial $F_2$ ionospheric layer at low solar activity period *(Invited)***

Jacob Olusegun Adeniyi[1] and David Olalekan Ayokunnu[2]

[1]University of Ilorin, Ilorin, Nigeria
[2]The Polytechnic, Ibadan, Nigeria

The equatorial ionosphere has peculiarities which makes it different from the ionosphere over other regions because, the magnetic field is nearly horizontal in this region. This study is on the comparison of ionospheric parameters at three equatorial stations; namely Ilorin, Nigeria (8.5ºN, 4.5ºE), in Africa; Fortaleza, Brazil (3ºS, 38ºW), and Jicamarca, Peru (12ºS, 76.8ºW), in the American sector. The data used are those of year 2010, a year of low solar activity. The results from the study showed that Ilorin and Fortaleza have almost the same distinct features while Jicamarca shows some disparity.

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**Modeling the equatorial electric field in the African sector using ground magnetic observatory data**

Patrick Alken[1], Arnaud Chulliat[2], and Stefan Maus[1]

[1]University of Colorado at Boulder, Boulder, CO, USA
[2]Institut de Physique du Globe de Paris, Paris, France

The day-time eastward equatorial electric field (EEF) in the ionospheric E-region plays an important role in equatorial ionospheric dynamics. It is responsible for driving the equatorial electrojet (EEJ) current system, equatorial vertical ion drifts, and the equatorial ionization anomaly (EIA). Due to its importance, there is much interest in accurately measuring and modeling the EEF. However, there is a severe lack of high quality data with the notable exception being the JULIA coherent scatter radar in Peru. In this work, we propose a method of estimating the EEF using CHAMP satellite-derived latitudinal current profiles of the day-time EEJ along with delta H measurements from ground observatories in Africa. Observatories Samogossoni (SAM, 0.18 degrees magnetic latitude) and Tamanrasset (TAM, 11.5 degrees magnetic latitude) were used for this study to produce a time series of electrojet current profiles. These current profiles are then inverted for estimates of the EEF. We compare our results with the global climatological electric field model EEFM, based on CHAMP satellite magnetic measurements. This technique can be extended to any pair of ground observatories which can capture the day-to-day strength of the EEJ.

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**Wave forcing from the lower atmosphere *(Invited)***

Elsayed Rasmy Talaat[1], Xun Zhu[1], Syau-Yun Hsieh[1], Larry Paxton[1], and Daniel Smith[1]

[1]Applied Physics Laboratory, The Johns Hopkins University, Laurel, MD, USA

Waves that originate in the troposphere grow in amplitude as they travel upwards into decreasing density at higher altitudes where they become the most prominent dynamical features of the Ionosphere-Thermosphere-Mesosphere (ITM). At low latitudes, the wind-driven *E*-region dynamo generates large-scale electric fields, causing upward plasma drifts that combine with pressure forces and gravity to form the equatorial ionization anomaly in electron density. As a result, variability in *E*-region winds could translate upwards into the low-latitude ionosphere. The dominant dynamical feature in the *E* region is the diurnal tide, and its longitudinal, seasonal, interannual, and daily variability are important factors in understanding the behavior of the ionosphere. In addition, planetary and gravity waves modify the zonal mean temperature and winds through dissipation and momentum deposition. The effects of these waves on the ITM are expected to depend on the level of solar activity. For all types of waves, how high they penetrate into the thermosphere depends on the temperature, wind, and viscosity profiles. Current observations have shown signatures of gravity waves, planetary waves and tides in upper atmospheric measurements of winds, temperature, and ion density. Recent global observations of the low latitude neutral atmospheric and ionospheric structure revealed by TIMED/SABER, TIMED/GUVI, COSMIC/FORMOSAT, TOPEX, JASON, and groundbased total electron content (TEC) allow us to investigate the interplay between the neutral, plasma, and background fields. We examine two approaches to capture the modes of spatial and temporal variability observed in the ionosphere: 1. decomposition into modes as functions of local time and zonal wavenumber and 2. analysis using empirical orthogonal function (EOF) decomposition and the corresponding principal component analysis (PCA) technique. The spectral analysis of the different time series of reveals how different mechanisms such as solar flux variation, change of the orbital declination, nonlinear mode coupling, and geomagnetic activity are separated and expressed in different modes. We examine similar analysis performed on output from the Thermosphere-Ionosphere-Electrodynamics General Circulation Model (TIE-GCM) to provide insight for the interpretation of the observed phenomena. This talk examines the relationship between the variability observed in mesospheric and lower thermospheric dynamical fields to variations observed in the low latitude ionosphere using these long-term global observations and through simulations using the TIE-GCM.

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**The climatological and day-to-day longitudinal variability of the global ionospheric density distribution *(Invited)***

Endawoke Yizengaw[1] and Edgardo E. Pacheco[1]

[1]Institute for Scientific Research, Boston College, Chestnut Hill, MA, USA

The climatological global view of the low-latitudes ionospheric density stimulates further interest in understanding its strong longitudinal variability. One of the problems is that we are not completely certain how the electrodynamics and ion-neutral coupling proceeds at low latitudes, in particular, the longitudinal difference in the dynamics of plasma structures in the low-to mid-latitude ionosphere is not yet fully understood. Numerical studies of latent heat release in the troposphere have indicated that the lower atmosphere can indeed introduce a longitudinal dependence and variability of the low-latitude ionosphere during quiet conditions. For the first time, we present simultaneous observations of the tidally modulated global wind structure, using TIDI observations onboard TIMED satellite, in the *E* region and the ionospheric density distribution

using ground (global GPS receivers) and space-based (C/NOFS in situ density and GPS TEC on CHAMP) instruments. Our results show that the longitudinally structured zonal wind component could be responsible for the formation of wavenumber-4 pattern of the equatorial anomaly. The TIDI observation did not show any clear structure of the meridional wind components, suggesting that the meridional wind may not make a significant contribution to the modification of the E-region dynamo. We also investigated the day-to-day variability and the occurrence probability of wavenumber-4 structure at different local time sectors for the first time, and found that it can occur at all local time sectors. The most significant occurrence is observed during the 1000-2400 LT sector and minimum between 0400 and 0600 LT sector. The seasonal occurrence probability of the wavenumber-4 pattern also shows a maximum during the March-April equinox and June-July solstice. The December-January is the period where the wavenumber-4 structure in average is less dominant than during the rest of the year.

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**On the longitudinal variation of the equatorial electrojet, its dependence on the geomagnetic main field intensity *(Invited)***

Vafi Doumbia[1], Franck Grodji[1], Yves Cohen[2], Christine Amory-Mazaudier[3], and Thanh Le Truong[4]

[1]Atmospheric Physics Laboratory, Université de Cocody à Abidjan, Côte d'Ivoire
[2]Département des Études Spatiales et Planétologie, Institut de Physique du Globe de Paris, Saint-Maur-des-Fossés, France
[3]Laboratoire de Physique des Plasmas, CNRS, UPMC, Saint-Maur-des-Fossés, France
[4]Institute of Geophysics, Vietnam Academy of Science and Technology, Hanoi, Viet Nam

During the last decade, the longitude dependence of the Equatorial Electrojet (EEJ) has been widely examined on the basis of the Oersted and CHAMP satellite magnetic observations, and in very limited extent of surface observations. Most of the studies are in accordance on the "wave four" structure of the EEJ intensity. But none of them has actually explained the background reasons of this behavior. Using the NCAR Thermosphere-Ionosphere Electrodynamics General Circulation Model (TIEGCM), *Doumbia et al.* [2007] have demonstrated that the shape of the longitude profile of the EEJ intensity was controlled by the combined effects of the structures of the geomagnetic main field intensity and of the migrating diurnal and semi-diurnal tides. In the present work, the longitudinal variation of the peak current density of the EEJ is studied through its magnetic signatures from surface and CHAMP satellite magnetic measurements. Correlations between the geomagnetic main field intensity and the EEJ current density are analyzed.

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**The effects of E×B drifts on the equatorial ionosphere during extreme solar minimum**

Jeffrey Klenzing[1], Angeline Gail Buirrell[2], Rod Heelis[2], Joe Huba[3], Rob Pfaff[1], and Fernando Simoes[1]

[1]Space Weather Laboratory, Goddard Space Flight Center, Greenbelt, MD, USA
[2]Center for Space Sciences, University of Texas at Dallas, Richardson, TX, USA
[3]Plasma Physics Division, Naval Research Laboratory, Cheverly, MD, USA

During the recent solar minimum, solar activity reached the lowest levels observed during the space age, resulting in a contracted ionosphere/thermosphere. This extremely low solar activity provides an unprecedented opportunity to understand the variability of the Earth's ionosphere. The average **E×B** drifts measured by the VEFI instrument on C/NOFS during this period are found to have several differences from the expected climatology based on previous solar minima, including downward drifts in the early afternoon and a weak to non-existent pre-reversal enhancement. Using SAMI2 as a computational engine, we investigate the effects of these changes in electrodynamics (as well as the contraction of the thermosphere) for this new baseline ionosphere as a function of longitude and compare the results to the average ion densities measured by C/NOFS and $NmF_2/hmF_2$ measured by COSMIC.

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**Ionospheric response to lower atmospheric disturbances and impact on space weather**

Larisa P. Goncharenko[1], Anthea J. Coster[1], and Jorge L. Chau[2]

[1]Atmospheric Sciences, Millstone Hill Observatory, Massachusetts Institute of Technology, Westford, MA, USA
[2]Radio Observatorio de Jicamarca, Instituto Geofísico del Perú, Lima, Peru

The dynamics and phenomenology of the quiet time ionosphere are affected by vertical coupling in the atmosphere-ionosphere system through atmospheric waves (gravity waves, tides, and planetary waves) that propagate from the troposphere and stratosphere. While the vertical coupling processes driven by tidal forcing and the consequent dynamo electric fields are responsible for major phenomenology of the equatorial and low-latitude ionosphere, interactive processes involving gravity waves and planetary waves are believed to play a significant role in day-to-day variability. Experimental

studies over the last decade have accumulated strong evidence of global coupling from the troposphere to mesosphere, thermosphere, and ionosphere. We will present examples of results demonstrating the coupling by gravity waves, tides, and planetary waves. We will also discuss sudden stratospheric warming events as special case combining effects of high-amplitude stationary planetary waves, tides, and gravity waves, and their implications for the space weather. A particular emphasis will be given to the discussion of temporal development of ionospheric response to sudden stratospheric warmings at different longitudes.

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**Ionospheric electrodynamics response at low latitudes to lower-atmosphere disturbances *(Invited)***

Jorge Luis Chau[1], Larisa P. Goncharenko[2], and Bela G. Fejer[3]

[1]Radio Observatorio de Jicamarca, Instituto Geofísico del Perú, Lima, Peru
[2]Millstone Hill Observatory, Massachusetts Institute of Technology, Westford, MA, USA
[3]Center for Atmospheric and Space Sciences, Utah State University, Logan, UT, USA

We present a review of observations that support the ion-neutral coupling effects at equatorial and low latitudes associated with lower atmospheric disturbances. Special emphasis will be devoted to the ionospheric effects connected to large meteorological events called sudden stratospheric warming (SSW). The main ionospheric effects are clearly observed in the zonal electric fields (or vertical **E**×**B** drifts), total electron content, and peak electron densities. We include results from different ground- and satellite-based observations, covering different longitudes and years. Particular emphasis will be placed in the 2008, 2009, and 2010 campaigns, all of them occurring in the northern hemisphere, as well as the only strong recorded SSW event that occurred in the southern hemisphere in 2002.

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**Observations of TIDs over South America**

Cesar E. Valladares[1] and Robert Sheehan[1]

[1]Institute for Scientific Research, Boston College, Chestnut Hill, MA, USA

We have used TEC values measured by the low-latitude ionosphere sensor network (LISN) GPS receivers and other receivers that are installed in South America to study the characteristics of TIDs and waves that transit across South America. Small networks of 3 closely spaced GPS receivers, and ionosondes that operate continuously in South America were also employed to determine the characteristics of the TIDs. In addition, the high degree of spatial coherence of the TIDs allow us to use TEC measurements from GPS receivers spaced by hundreds of kms to fully probe TIDs over the continent. We have used the Statistical Angle of Arrival and Doppler Method for GPS interferometry (SADM-GPS) algorithm and a cross-correlation method to calculate the TID travel velocities, their propagation direction, and the scale-size of the disturbance. This paper will present the morphology and statistics of TIDs as a function of latitude, longitude, local time, and season. We will also introduce the results of an investigation to correlate the appearance, phase velocity, and angle of propagation of TIDs and tropospheric phenomena, such as the development of deep convection cells observed with the TRMM satellite. Our database of TEC values comprise the years between 2008 and 2010. However, in 2010 TEC values from the Caribbean region were included to study the appearance of TIDs in association with the Inter-Tropical Convergence Zone (ITCZ). We place our results within the context of the generation of ionospheric waves due to gravity waves and orographic features such as the Andes.

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**Longitudinal control of convective ionospheric storms by deep tropospheric convection**

Pamela J. Loughmiller[1], Michael C. Kelley[2], Eugene V. Dao[2], Odile de La Beaujardière[3], Jonah J. Colman[3], Robert H. Holzworth[4]

[1]Tembo Space Dynamics, Houston, TX, USA
[2]Cornell University, Ithaca, NY, USA
[3]Space Vehicles Directorate, Air Force Research Laboratory, Kirtland AFB, NM, USA
[4]University of Washington, Seattle, WA, USA

One of the key factors that will ultimately limit our ability to predict convective ionospheric storms (CIS) is its longitudinal variability. We believe this variability is due in large part to thunderstorms and the related deep convection associated with convective tropospheric storms. The C/NOFS satellite has proven to be a valuable source of new data, particularly when teamed with ground-based experiments; and worldwide lightning location data have become readily available, providing a measure of such weather processes, particularly on the continents. Of course, standard satellite meteorology data have been available for years but have not been applied to this problem. Finally, conventional wisdom states that gravity waves

launched by deep convection simply cannot reach the bottomside of the ionosphere where CIS begins. This has been proven resoundingly wrong by the work of Vadas and Fritts. The original ray tracing was not wrong but left out much of the physics. Many waves reach above the mesosphere where they often break, releasing their momentum into the lower thermosphere. This momentum then becomes a source for those waves that do reach the thermosphere and bottomside ionosphere. We report our analysis of the many long nighttime passes available in the data set. In addition, recent individual case studies are available that allow us to look in the bottomside for near sinusoidal waves during daytime. These wave signatures were found, developed into CIS on the same night, and were detected in the same satellite pass. These cases also had nearby lightning events during the previous two hours.

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**Comparison of thermospheric winds and temperatures measured simultaneously in Peru and Brazil by Fabry-Perot interferometers**

John W. Meriwether[1], Jonathan J. Makela[2], Dan Fisher[2], Ricardo Buriti[3], and Luis Navarro[4]

[1]Physics and Astronomy, Clemson University, Clemson, SC, USA
[2]Electrical and Computer Engineering, University of Illinois, Urbana-Champaign, IL, USA
[3]Physics, Federal University of Campina Grande, Campina Grande, Paraiba, Brazil
[4]Jicamarca Radio Observatory, Instituto Geofísico del Perú, Lima, Peru

Simultaneous measurements of thermospheric winds and temperatures have been obtained during equinoctial and winter periods with Fabry-Perot interferometers located in Peru and Brazil. These results show strong similarities for meridional winds in regard to the characteristic signature of tidal flow. Zonal winds tend to be faster in Peru. This is attributed to higher ion drag caused by the Appleton anomaly over the greater geomagnetic locations for the Brazilian Fabry-Perot interferometers. The results show the midnight temperature maximum phenomenon to pass through both longitudinal sectors simultaneously. These results illustrate the value of monitoring the thermospheric winds and temperatures in separate longitudinal sectors illustrating that the scientific return provided by the operation of a FPI in the African longitudinal sector would be significant and likely unique to Africa.

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**Modeling and predicting the space weather response to terrestrial weather *(Invited)***

Timothy J. Fuller-Rowell[1]

[1]Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado (NOAA/Space Weather Prediction Center), Boulder, CO, USA

It has now been clearly demonstrated from observations that meteorology and lower atmosphere dynamics impacts space weather in a coherent way. During January 2009, in particular, there was a period when total electron content (TEC) increased by 50%, which coincided with a sudden stratospheric warming (SSW). The TEC changes were a consequence of changes in the diurnal variation of equatorial electric fields, due to the very different tidal winds propagating into the lower thermosphere dynamo region from their source in lower atmosphere. The interpretation of the connection between terrestrial and space weather is strongly supported by whole atmosphere model (WAM) simulations. WAM was able to simulate the January 2009 period using the NCEP data assimilation system. Winds from WAM produced a very similar electrodynamic response, agreeing with both the magnitude and phase of incoherent scatter observed of changes in the equatorial vertical plasma drift. As well as following the observed temporal changes in electrodynamics during the period, the numerical simulations were also able to predict the longitude dependence in the response. The data assimilation system was also able to demonstrate the dynamic and electrodynamic response could be forecast several days in advance, suggesting a real forecast capability. As well as impacting plasma density and TEC, the variability in the WAM low resolution (200 km horizontal resolution) dynamic and electrodynamic fields was sufficient to seed ionospheric irregularities in the Boston University high resolution (10 km) model.

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**Forecasting auroral radio absorption from the epsilon parameter**

Olugbenga Ogunmodimu[1], and Farideh Honary[1]

[1]Physics, Lancaster University, Lancaster, UK

The daunting task of developing a true predictive model that can serve space weather community has drawn huge motivation from the availability of solar, heliospheric, and near-Earth data that are reliable and well calibrated. Past works have shown that for prediction purposes, a relationship linking geomagnetic activity with absorption for a given local time and latitude is desirable. Some of the authors [e.g., *Hargreaves*, 1966; *Kavanagh et al*., 2004] are clear on the use of

geomagnetic activity indices rather than solar activity indices as the building block of a predictive module. Fundamentally, the solar wind and IMF play important roles in shaping the magnetosphere and transferring energy and momentum into it. Some of the energy is passed to the electrons that precipitates to the ionosphere and causes radio absorption. Also, a near accurate parameter known for quantifying the energy transfer from the solar wind into the magnetosphere is the Akasofu epsilon parameter which comprise of a viscous and a merging terms. In this work, we perform a post-event correlation analysis of riometer absorption data and use the Akasofu epsilon parameter for the coupling coefficient. . The values of solar wind parameters used [solar wind velocity Vx, the IMF - Bx, By, Bz, and the solar wind proton number measured in GSM coordinate] obtained at the L1 point are from the OMNI data, time delay is taken to account for the propagation of the solar wind to the nose of the magnetosphere. Absorption values are from the Kilpisjarvi riometer station, the SGO riometer chain and the global riometer array (GLORIA). The aim is to be able to predict absorption based on epsilon parameter along the longitude. The result shows a statistical relationship between Absorption and the epsilon parameter, and demonstrate clear similarity with the diurnal variation pattern of auroral absorption which maximises at the early hours of the day, at minimum during the afternoon sector and picks up during the night sector. This is best explained as particles injection during the night sector, precipitates in the early hours and drifts towards the night. The plots below show the fit and equation of the summer month.

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**Ionosphere characterization at low latitudes using TEC global maps**

Sandro M. Radicella[1] and Yenca O. Migoya-Orue[1]

[1]ICT for Development Laboratory, The Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy

Technological applications like GNSS need clear definitions to characterize "nominal" ionospheric conditions and associated variability for assessment and operational purposes. This is also the case that modelers require to validate their models with experimental data. However, in critical geographical regions like the low latitudes belt of the ionosphere such definitions are not at all unambiguous. The behavior of the ionized atmosphere and its variability at different longitudes in the same belt is also different and complicated by the relative position of the geomagnetic equator with respect to the geographic one and the presence of features like the South Atlantic Anomaly. This paper outlines the difficulties related to the definition of "nominal" or "representative" ionosphere and its variability for low latitudes conditions at different longitudes. Using data obtained from TEC global maps, regardless of the uncertainties proper of the maps construction, concrete cases that demonstrate such difficulties are shown. The present study gives clear evidences of the uneven latitudinal and longitudinal distribution of the TEC variability with important maxima in the area of the crests of the equatorial anomaly at those times where the anomaly is well developed. As an example, median and inter-quartile values obtained using the IGS combined global TEC map for two longitudes at the same local time (17:00 LT) for April 2003 (smoothed RI index = 70.1) are shown in the table. The values correspond to the location of the maximum of the southern crest of the equatorial anomaly and at latitude of -60° (middle latitudes). The results of this study illustrate how the increased level of variability at low geomagnetic latitudes is associated to the complex day-to-day behavior of the position and strength of the equatorial anomaly crests. The influence of geomagnetic activity on this behavior is also analyzed and discussed.

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**Validation of IRI-2007 and NeQuick2 and TEC ingestion into NeQuick 2 to model East-African equatorial ionosphere**

Melessew Nigussie[1], Sandro Maria Radicella[2], Baylie Damtie[1], Endawoke Yizengaw[3], and Bruno Nava[2]

[1]Physics, Washera Geospace and Radar Science Laboratory, Bahir Dar University, Bahir Dar, Ethiopia
[2]ICT for Development Laboratory, The Abdus Salam International Center for Theoretical Physics (ICTP), Trieste, Italy
[3]Institute for Scientific Research, Boston College, Chestnut Hill, MA, USA

Empirical models like IRI-2007 and NeQuick2 depend on global ionospheric coefficients that are estimated from unevenly distributed ionosonde measurements. In the region, like Africa, the models estimated the ionospheric peak parameters by interpolation. When one wants to employ the models to specify the ionosphere where very few data have been used for model development, the performances of the models need careful validation. In this work, we have examined the performance of NeQuick2 and IRI-2007 ionospheric empirical models in describing the monthly median characteristics of the equatorial region ionosphere. This is carried out by comparing the vertical total electron content (vTEC) and $NmF_2$ obtained from ground based GPS receivers and digisonde with the corresponding values obtained from these models. We have shown that the performances of both models are better during the medium solar activity period than low solar activity. The present investigation has depicted that both models overestimate the observed vTEC during low solar activity. The modeled and experimental $NmF_2$ have shown good agreement; but the modeled and experimental vTEC have shown significant discrepancy. This discrepancy is shown mainly due to inadequately computed ionospheric slab thicknesses using

IRI-2007 and NeQuick2. In addition, we have investigated the performances of NeQuick2 in the East-African region by assisting the model with measurements from a single Global Positioning System (GPS) receiver, which has been deployed recently. This can be done by first calculating an effective ionization level that drives NeQuick2 to compute slant total electron content (sTEC) which fits, in the least square sense, with the measurements taken from a single GPS receiver. We then quantify the performances of NeQuick2 in reproducing the measured TEC by running the model at four other locations, where GPS stations are available, using the same effective ionization level that we calculated from a single GPS station as a driver of the model. The performances of the model with and without data ingestion have been investigated by comparing the model results with the experimental sTEC and vertical TEC (vTEC) obtained from the four test stations. We found that the model after ingestion reproduces the experimental TEC better as far as about 620 km away from the reference station compared to that of before adaptation. In addition, using the effective ionization level as the driver of the model, we have investigated the performances of NeQuick2 in reproducing the topside total in situ density observed by C/NOFS satellite. We have shown that the model after ingestion reproduces the experimental topside ion density better as far as about 850 km away from the reference station than that before ingestion. In general, we have shown that the capability of NeQuick2 in describing the East-African region of the ionosphere can be improved substantially by data ingestion.

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**Quasi 16-day periodic meridional movement of Equatorial Ionization Anomaly**

Donghe Zhang[1]

[1]Geophysics, Peking University, Beijing, China

Based on the daytime location of Equatorial Ionization Anomaly (EIA) crest derived from GPS observation in China low latitude region during the period from December 1, 2005 to March 31, 2006, a quasi 16-day periodic meridional movement of EIA crest with the maximum amplitude of about 20% relative to the average location of EIA crest has been discovered. In addition, the in phase periodic variations are also revealed in the equatorial electrojet (EEJ) and $F_2$ layer peak height ($hmF_2$) over China Haikou and Chongqing ionosonde stations. The quasi 16-day periodic component in Kp index is very weak or unidentified, and the 16-day periodic component does not exist in F10.7 index. Such large scale periodic meridional movement of EIA crest is ascribed to planetary wave activity in the upper atmosphere and ionosphere. The zonal equatorial electric field with quasi 16-day periodic variation caused by the same periodic scale planetary wave, changes the electron density distribution in the low latitude region via vertical drifting and diffusion along magnetic field line, and finally leads to the quasi 16-day periodic meridional movement of EIA. This finding is important for grasping the ionospheric variation in low latitude region. Further case analysis, simulation and theoretical studies must proceed in order to understand the movements of EIA connected with planetary waves.

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**Longitudinal variations of low latitude irregularities and scintillation *(Invited)***

Keith M. Groves[1], Charles S. Carrano[1], Cesar Valladares[1], Vadym Paznukhov[1], and Ronald Caton[2]

[1]Institute for Scientific Research, Boston College, Chestnut Hill, MA, USA
[2]Space Vehicles Directorate, Air Force Research Laboratory, Kirtland AFB, NM, USA

The structure of the equatorial ionosphere has been well documented by researchers intrigued by substantial meridional gradients in electron density, layer height characteristics, and plasma drifts among other parameters. Zonal variations have also been extensively examined with the principal objective of understanding seasonal differences in Spread F occurrence. In situ space-based observations, such as those from ROCSAT, DMSP, and C/NOFS, provide global observations of the electron density irregularity spectrum, a key aspect of Spread F and radio wave scintillations. While valuable as an indicator of Spread *F* occurrence, such measurements cannot easily be interpreted as a quantitative proxy for scintillation. Nevertheless, the satellite data sets have supported numerous efforts to develop global climatologies of ionospheric irregularities and, by extension, scintillation. In the past 5 years, significant progress has been made in expanding the number of low-latitude ground sensors available to measure scintillation directly. From these observations it is possible to construct a true scintillation climatology for many longitude sectors such that we can now perform meaningful comparisons of the space- and ground-based results. Such comparisons yield both qualitative and quantitative consistencies and inconsistencies that will provide the material for the thrust of the presentation. While space-based observations are subject to altitude biases and limitations imposed by lack of vertical structure knowledge, ground-based observations represent localized observations at a limited number of longitudes. By considering data from both sources, we will attempt to present a coherent overview of the longitudinal variations in equatorial irregularities and scintillations.

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**Low latitude ionospheric scintillation and ionospheric irregularity drifts observations with GPS-SCINDA and VHF receiver in Kenya.**

Joseph Ouko Olwendo[1, 4], Paul Baki[2, 4], Patricia Doherty[3], and Collins Mito[4]

1. Physical Sciences, Pwani University College, Mombasa, Kenya
2. Pure and Applied Sciences, Kenya Polytechnic University College, Nairobi, Kenya
3. Institute for Scientific Research, Boston College, Chestnut Hill, MA, USA
4. Physics, University of Nairobi, Nairobi, Kenya

To investigate the drift velocities of a few hundred metre-scale irregularities associated with equatorial plasma bubbles, we have used a VHF receiver at Nairobi (36.8ºE, 1.2ºS), which has been operational since July 2010, and scintillation data from GPS-SCINDA receivers. An analysis of scintillation index in the year 2011 revealed that scintillation often occurred between 20:00 -01:00 LT at equinoxes and that their occurrence rate was higher during March-April than during the September-October. Equinoctial asymmetry was noticed where scintillation are observed for much longer time in March-April than September-October where they also start at much later times. Drift velocities of irregularities were measured using cross-correlation analysis with the time series of VHF signal intensities observed from the two closely spaced antennas. From a statistical analysis of the drift velocities, the eastward component of drift velocity just after sunset is found to be greater during March-April than during September-October. Based on these results which are the first analysis of drift velocity over this region, we suggest that the east west component of plasma drift velocity may be related to the evolution of plasma irregularities causing scintillations throughout the mechanism causing the prereversal enhancement of the eastward electric fields. The equinoctial asymmetry of the drift velocity and scintillation index could be attributed to the asymmetry of neutral winds in the thermosphere.

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**C/NOFS observations of longitudinal ionospheric variability**

Odile de la Beaujardière[1], Chaosong Huang[1], Jonah Colman[1], Patrick Roddy[1], Eftyhia Zesta[1], Eugene Dao[2], Michael Kelley[2], Geoff Crowley[3], and Robert Pfaff[4]

[1]Space Vehicles Directorate, Air Force Research Laboratory, Kirtland AFB, NM, USA
[2]Cornell University, Ithaca, NY, USA
[3]ASTRA Space, Boulder, CO, USA
[4]NASA, Greenbelt, MD, USA

Launched at a 13 degrees inclination, the Communication/Navigation Outage Forecasting System (C/NOFS) satellite samples all longitudes during each orbit. C/NOFS is thus ideal for studying how the ionospheric ambient density and scintillation-producing irregularities vary with longitude. Irregularities maximize in frequency and amplitude in the America to Africa sector. It has been suggested that waves generated by tropospheric convection propagate upward and launch secondary waves that are responsible for triggering the instability that gives rise to equatorial plasma bubbles. Lightning frequency can be used as a proxy for tropospheric convection regions. We thus examine the possibility that the longitudinal variability is related to the occurrence of lightning, since the frequency of lightning in the equatorial regions is largest in Africa and then South America. We will also present simultaneous data from C/NOFS and from the Traveling Ionospheric Disturbances Designed In Texas (TIDDBIT) system newly installed by G. Crowley in Peru. The purpose is to investigate a possible relationship between C/NOFS ionospheric irregularities and the waves observed below the *F* peak by TIDDBIT. C/NOFS can also be used to investigate longitudinal changes in the ambient density. For example, as the solar cycle increased, the *F*-peak height increased. Close to perigee (400 km), C/NOFS was often below the *F* peak. Preliminary analysis suggests that the *F*-peak altitude varies with longitude and is highest in the America to Africa sector.

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**Day-to-day and seasonal TEC variability time-shift near the Equatorial Ionospheric Anomaly region over Africa *(Invited)***

Paul Baki[1]

[1]Technical and Applied Physics, Kenya Polytechnic University College, Nairobi, Kenya

Day-to-day and seasonal variability of the Total Electron Content are investigated using CHAMP Satellite data and GPS data over Equatorial Africa. It is found that the occurrence of maximum TEC variability in the post-sunset hours shifts between 20 LT to 00.00 midnight LT and the irregularities seem to correlate very well with diamagnetic effects even during quite times. Scintillations are observed almost on daily basis and have some seasonal dependence.

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**Source variability of strong convection influence on the upper atmosphere and ionosphere**

Robert H. Holzworth[1], Brian Burkholder[1], Michael L. Hutchins[1], Michael P. McCarthy[1], Katrina S. Virts[2], James B. Brundell[4], and Reinhard H. Friedel[3]

[1]Earth and Space Sciences, University of Washington, Seattle, WA, USA
[2]Atmospheric Sciences, University of Washington, Seattle, WA, USA
[3]Los Alamos National Labortories, Los Alamos, NM, USA
[4]James Brundell T/A Ultramsk, Dunedin, Otago, New Zealand

Convectively active storms within the troposphere generate a strong influence on the upper atmosphere through gravity wave generation and electromagnetic perturbation. With the advent of global lightning networks, we now have access to the high resolution time and space variability of global thunderstorm activity. Lightning generated whistler-mode plasma waves are well known to penetrate the ionosphere and influence magnetospheric particle populations. Additionally, thunderstorms can be an important source for gravity waves which deposit energy and momentum in the upper mesosphere and lower thermosphere. Therefore, an analysis of the time and space variability of global lightning activity can give us information about where and when to expect the major perturbations in the lower ionosphere from thunderstorm activity.
In this talk we analyze the global climatology of lightning in space and time, using data from the World Wide Lightning Location Network (WWLLN), demonstrating the strong longitudinal and hemispherical variations expected for strong convection. Additionally we will present case studies following major storms to tease out the source function for shorter term variations on the upper atmosphere and ionosphere.

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**Deep gravity wave dynamics and responses in the thermosphere and ionosphere *(Invited)***

David C. Fritts[1] and Joseph Huba[2]

[1]GATS/Boulder, Boulder, CO, USA
[2]Naval Research Laboratory, Cheverly, MD, USA

Gravity waves (GWs) propagating upward from lower atmosphere and mesosphere and lower thermosphere (MLT) sources have the potential to penetrate to high altitudes and exhibit a variety of neutral and plasma responses, depending on their characteristics and propagation environments. Only a small fraction of GW energy arising in the lower atmosphere can penetrate deeply, but these possibilities arise accompanying convective GWs at large scales and high frequencies and GWs arising from fast ocean waves such as tsunamis. MLT sources more easily generate GWs having the larger scales that enable deep penetration; these include secondary GW generation accompanying strong local body forcing and auroral forcing. GWs from these sources typically have high phase speeds and large horizontal and vertical scales, enabling them to propagate quickly to higher altitudes, avoid strong dissipation until quite high altitudes, and attain sufficiently large amplitudes to play significant roles in neutral and plasma dynamics where large amplitudes occur. This talk will review the various neutral and plasma dynamics accompanying these motions, including self-acceleration and instabilities accompanying large GW amplitudes, effects of variable mean structures, and plasma responses to GW perturbations in the *F* layer.

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**Modeling of the longitudinal dependence of equatorial plasma bubbles *(Invited)***

Joseph D. Huba[1]

[1]Naval Research Laboratory, Cheverly, MD, USA

Post-sunset ionospheric irregularities in the equatorial *F* region were first observed by Booker and Wells in 1938 using ionosondes. This phenomenon has become known as equatorial spread *F* (ESF). During ESF the equatorial ionosphere becomes unstable because of a Rayleigh-Taylor-like instability: large scale (10s km) electron density `bubbles' can develop and rise to high altitudes (1000 km or greater at times). Understanding and modeling ESF is important because of its impact on space weather: it causes radio wave scintillation that degrades communication and navigation systems. In fact, it is the focus of the Air Force Communications/Navigation Outage Forecast Satellite (C/NOFS) mission. We will describe 3D simulation results from the NRL ionosphere models SAMI3 and SAMI3/ESF of this phenomenon. In particular, we will examine the longitudinal dependence of ESF focusing on global electrodynamics (e.g., pre-reversal enhancement) and seed mechanisms (e.g., gravity waves). (with J. Krall and D. Fritts)

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**Development of an ionospheric map for Africa**

Nicholas Ssessanga[1]

[1]Space Science, South African National Space Agency, Hermanus, Western Cape, South Africa

An ionospheric map is a computer programme that shows spatial and temporal representations of ionospheric parameters like the electron density, critical plasma frequencies, etc., for every geographical location on the map. To obtain the parameters, data from ionospheric models and instruments such as ionosondes and GPS receivers has to be used. This presentation describes how the International Reference Ionospheric (IRI) model will be incorporated into the development of an ionospheric map for Africa. The IRI has been in use since 1978 with the latest upgrade done in 2011 and is known as IRI-2011. This model has been one of the most consistent in predicting ionospheric parameters over most of the geographical locations. However, the model fails to predict accurately in regions where data was not available during its development, hence the use of data from GPS receivers and other models.

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**Impact of Arctic and Antarctic ionospheric scintillations on GNSS**

Susan Skone[1]

[1]University of Calgary, Calgary, AB, Canada

Global Navigation Satellite System (GNSS) signals are susceptible to ionospheric scintillation in regions where small-scale irregularities in electron density develop. Such effects cause errors in receiver signal tracking loops and, in some cases, loss of signal lock. The latter affects availability, accuracy, and reliability of GNSS, characteristics that are of paramount importance for safety-critical aviation and maritime systems. Recent scintillation simulations conducted at University of Calgary demonstrate 25 percent loss-of-lock for GPS L1 and L2C under severe auroral scintillations. Auroral scintillations in the Canadian Arctic have resulted in loss of navigation capabilities for low-cost marine single-frequency receivers. The University of Calgary currently operates the Canadian CANGIM network of ionospheric scintillation monitors. Sites cover sub-auroral, auroral, and polar Arctic regions for the period 2003-2011 (including severe events from previous solar maximum). University of Calgary also has access to data from a limited network of Antarctic ionospheric scintillation monitors for southern hemisphere studies. Raw GPS observations and scintillation indices are available in the archived databases. In previous studies, auroral and polar scintillation databases have been compiled from the CANGIM data– characterization of polar versus auroral events was based on solar conditions, satellite images, projected boundaries of the auroral oval, and ground-based auroral substorm signatures. The Antarctic database consists of primarily polar cap scintillations. The nature of auroral versus polar scintillation is fundamentally different due to underlying physical processes on closed (auroral) versus open (polar) magnetic field lines. The University of Calgary has developed a physics-based simulator to generate auroral and polar ionospheric scintillation effects in signal samples and a state-of-the-art software receiver capable of processing GPS (L1, L2C, L5), GLONASS and Galileo signals. Simulations are driven by scintillation specifications and parameters obtained from the auroral and polar scintillation databases. This capability allows thorough assessment of the impact of scintillations on GNSS applications. By processing simulated signals with realistic receiver acquisition and tracking algorithms, full performance evaluations can be conducted for various GNSS receiver configurations. In this study auroral and polar ionospheric scintillation events are chosen from the northern and southern hemisphere scintillation databases and the observed real scintillation parameters are used to drive GNSS signal simulations. The simulated signals are processed using the software receiver and impact on observation quality is quantified in terms of loss-of-lock probability and tracking errors; number of satellites affected simultaneously is also determined for the various GNSS and multiple frequencies. The characteristics and impact of scintillation are assessed for northern versus southern hemispheres. The software receiver has capabilities for simulating various oscillator characteristics, correlators, and tracking loop algorithms - such that both low-cost (marine and aviation) and high-cost survey-grade receiver designs are tested.

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**Equatorial ionospheric scintillation effects on GNSS and SATCOM: Real-time observations with the Scintillation Network Decision Aid (SCINDA)** ***(Invited)***

Ronald G. Caton[1] and R. Todd Parris[1]

[1]AFRL/RVBXI-Air Force Research Laboratory, Kirtland AFB, NM, USA

Irregularities in the ionosphere, typically occurring during nighttime hours within 20º of the magnetic equator, affect transionospheric radio signals up to a few GHz in frequency seriously degrading satellite-based navigation and communication systems. During solar maximum conditions, observations of rapid signal fading greater than 20 dB at LBand and 30 dB at UHF are common as are errors in GPS positioning up to 75 m. In the mid-1990s, researchers at the Air

Force Research Laboratory began fielding sites in the equatorial region to monitor ionospheric induced scintillation. Today, the Scintillation Network Decision Aid (SCINDA) is comprised of nearly 40 equatorial stations reporting scintillation statistics for use in ionospheric research and providing SATCOM users with situational awareness of the regional scintillation environment in near real-time. The current generation of SCINDA sensors includes a VHF receiver reporting amplitude scintillation statistics and measurements of the ionospheric drift velocity, a high-rate dual-frequency GPS receiver recording scintillation at LBand frequencies and line-of-sight measurements of the total electron content and a tri-band beacon receiver for low-Earth orbiting satellites. In this paper we will present an overview of system effects due to ionospheric scintillation and introduce the audience to the global SCINDA program.

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**MAGDAS and other magnetometer networks in the African continent and some of their scientific benefits *(Invited)***

George Maeda[1], Kiyohumi Yumoto[1], Endawoke Yizengaw[2], Hideaki Kawano[1], Akimasa Yoshikawa[1], Huixin Liu[1], Masakazu Watanabe[1], Shuji Abe[1], Teiji Uozumi[1], Akihiro Ikeda[3], and Maria Gracita Cardinal[1]

[1]International Center for Space Weather Science and Education, Kyushu University, Fukuoka, Japan
[2]Institute for Scientific Research, Boston College, Chestnut Hill, MA, USA
[3]Liberal Arts and Sciences, Kagoshima National College of Technology, Kirishima, Japan

Since the start of IHY in 2007 and the start of ISWI in 2010, there has been remarkable growth in the deployment of the ground-based magnetometer networks in Africa. There are several factors involved here. Perhaps the primary one is that the space weather research community has finally realized that global continuously operational ground-based instrument coverage is highly essential to address the most fundamental outstanding problems that affect our technological systems. The fluxgate magnetometer is among those important ground-based instruments; and during the last five years the scientific community made a combined effort to fill in some of the largest land mass gaps in Africa, a region that has been devoid of ground-based instrumentation. However, since Africa covers the largest land mass of the equatorial region, the magnetometers deployed so far in the region are woefully inadequate to fill the gaps of our global understanding of the fundamental electrodynamics that govern equatorial ionospheric density irregularities and gradients. In this presentation, we will review the State of all magnetometer networks, either already deployed or planned to be deployed, in the African region, and their scientific benefits for African scientists in particular and for the international scientific community in general.

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**AfricaArray—An environmental monitoring network and capacity building initiative for Africa *(Invited)***

Atalay Ayele Wondem[3], Andrew Nyblade[1], and Ray Durrheim[2]

[1]Geosciences, The Pennsylvania State University, University Park, PA, USA
[2]School of Geosciences, University of the Witwatersrand, Johannesburg, South Africa
[3]Institute of Geophysics Space Science and Astronomy, Addis Ababa University, Addis Ababa, Ethiopia

Launched in 2004, AfricaArray (AA) is a visionary response to the call for continent-wide cooperation in human resources development mainly geared to solving African problems of mitigating geohazard and tapping earth resources. AfricaArray was established through a partnership of three organizations: University of Witwatersrand (Johannesburg, South Africa), Council of Geosciences (Pretoria, South Africa), and The Pennsylvania State University (University Park, Pa., USA). Support has been also provided by other Universities and Geological Surveys in Africa
AfricaArray's academic program currently offers B.Sc., B.Sc. Honours, M.Sc., and Ph.D. degree programmes for many Africans all over the continent. The trained man power is aimed to explore the continent's rich wealth in mineral, petroleum, and geothermal resources for the benefit of the society. Urbanization and infrastructure development is growing fast in Africa while eminent earthquake and volcanic hazard are around the corner. AfricaArray's current noble idea of expanding seismic, GPS and weather stations in Africa enables to monitor and mitigate catastrophic events and enhances development activities in the continent Collocation of the monitoring facilities in Africa is the main strategy being implemented by AfricaArray is cost-effective and very convenient for several reasons mainly in unsecured and hostile environment.

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LONGITUDE AND HEMISPHERIC DEPENDENCE OF SPACE WEATHER

12–16 November 2012 | Addis Ababa, Ethiopia

# POSTER ABSTRACTS

*Abstracts are listed in numerical order according to the set up at the Poster Session.*
*Presenting authors are underlined.*

**Abstract No.** [Control ID]

**1** [1414929]

**Effects of penetration of magnetospheric electric fields at low-latitude on ionospheric parameters**

Mene Niangoran Medard[1], and Obrou Kouadio Olivier[1]

Physics, Université de Cocody à Abidjan, Côte d'Ivoire

Ionosonde data recorded at Korhogo (Latitude + 9.3; Longitude -5.4; Dip -0.67) are used to investigate the effects of the penetration of magnetospheric convection electric field on the $F_2$-layer peak height ($hmF_2$), the total electron content (TEC) and the electron density profile parameters (B0, B1). The variations of those parameters during the magnetic storm of February, the 17th 1993 are compared with those of the reference quiet day (15 February 1993). AS result, we are founded an increase and a decrease of the $hmF_2$ respectively during the penetration of dawn-dusk magnetospheric electric (prompt penetration) and dusk-dawn magnetospheric electric (overshielding) at equator. After the prompt penetration and the overshielding we have respectively high and low TEC values compared to those of a geomagnetic quiet day (February, the 15th 1993). We have also founded that the penetration affects the electron density profile parameters (B0, B1), but its effect is more important on B0 than B1.

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**2** [1452933]

**A magnetopause surface mode excited during a high solar wind speed and an interval of strong northward IMF**

Abiyu Zerfu Nedie[1], Frances Fenrich[1], Robert Rankin[1], and Alex Degeling[1]

Physics, University of Alberta, Edmonton, AB, Canada

ULF waves in the magnetosphere in the range of mHz frequencies are primarily used to clarify and extend our understanding of MHD wave propagation and coupling in the Earth's magnetosphere. This study focuses on the characterization of magnetopause boundary instabilities and ULF waves in the magnetosphere, with the ultimate goal of elucidating the causal relationship between the two. In this study, we analyzed a ULF wave event and characterized the observations with coordinated simultaneous measurements from HF radars, multi-satellite-borne instrumentation, and ground-based magnetometers. The simultaneous presence of data from satellite- borne and ground based instrumentation offered a unique opportunity to diagnose the properties of the observed ULF waves in different parts of the magnetosphere and identify a plausible source mechanism at the boundary. In this event, we traced a clear wave activity in electric, magnetic and plasma flow data near the magnetopause using CLUSTER data and compared it with fluctuations inside the magnetosphere, at ionospheric altitudes and on the ground. Comparisons clearly reveal that ULF fluctuations at the magnetopause coincide with the discrete frequency oscillations observed by HF radars, magnetometers, and spacecrafts inside the magnetosphere. The decay in the electromagnetic Poynting vector and the propagation time delay in the phase of the ULF wave away from the magnetopause along with the underlying upstream solar wind conditions of strong northward IMF and supersonic flow exceeding 640 km/s solidly point to a KH generated surface mode as a sole mechanism driving

the observed global ULF wave event. The fact that we have observed a relatively small azimuthal wavenumber, m = 10 with anti-sunward phase propagation in both dusk and dawn sectors along with the absence of monochromatic dynamic pressure variations or solar wind buffeting is further evidence to support the hypothesis of a KH generated surface mode as a source mechanism. We demonstrate this scenario using a ULF wave model with a source placed on the flank magnetopause. The wave is found to penetrate through the magnetosphere where it excites an FLR at the same frequency as the source. The result of this work demonstrates a well-defined path of energy transfer from the magnetopause into the inner magnetosphere and ionosphere and is a reliable evidence for magnetosphere-ionosphere coupling.

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**3** [1452507]

**Response of ionospheric $foF_2$ over South East Asian sector to geomagnetic storm of 29 October 1973**

David Timothy Wemimo[1], Chukwuma Victor Uzodinma[1]

Physics, Olabisi Onabanjo University, Ago-Iwoye, Nigeria

The auroral electrojet (AE) index was employed for the study of the ionospheric response to the geomagnetic storm of 29 October 1973. The interplanetary magnetic field (IMF) component, Bz, and the low latitude magnetic index, Dst, show that the event is a moderate (Dst = -64 nT, Bz = -5.8 nT) storm. The analysis from the disturbances in ionospheric $foF_2$ during 29-31 October 1973 shows predominantly an enhancement (positive storm) at the mid and low latitude stations. In between the time of storm (14:00 hrs UT on 29 October and 05:00 hrs UT on 30 October), the upper latitudes also show some degree of enhancement. This paper concludes that the reason for the observed positive ionospheric storm over all latitudes under investigation could be due to injection of energy from the solar wind into the auroral region as a result of significant increase in the AE index which causes an uplift of the ionospheric layers to higher altitudes, where the recombination rate is small. Furthermore, this paper confirms the argument that moderate magnetic storms are capable of generating ionospheric storms which are of comparable magnitude with those resulting from intense geomagnetic storms. Keywords: Geomagnetic storm, Moderate storm, Solar wind, Auroral electrojet index, Ionospheric storm response, Interplanetary magnetic field, Magnetic index (Dst)

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**4** [1453579]

**On the effects of geomagnetic storms and pre storm phenomena on low and middle latitude ionospheric $F_2$.**

John Bolarinwa Adekoya[1], Victor Uzodinma Chukwuma[1], Bakare Nurudeen Olusesan[1], and David Timothy Wemimo[1]

[1]Physics, Olabisi Onabanjo University, Ago-Iwoye, Nigeria

This paper presents some features of the ionospheric response observed in equatorial and mid-latitudes region to two strong geomagnetic storms, occurring during Oct. 19-23, 2001 and May 13-17, 2005 and to understand the phenomena of pre-storm that lead to very intense geomagnetic storms. The result point to the fact that pre-storm phenomena that leads to intense ionospheric storm are; large southward turning of interplanetary magnetic field Bz, high electric field, increase in flow speed stream, increase in proton number density, high pressure ram and high plasma beta. The magnitude of Bz turning into southward direction from northward highly depends upon the severity of the storm and the variation in $F_2$ layer parameter at the time of geomagnetic storm are strongly dependent upon the storm intensity. A detailed analysis of the responses of the ionosphere shows that during the storm periods, $foF_2$ values depleted simultaneously both in the equatorial and mid latitude. Observation also shows that low to moderate variations in ionospheric $F_2$ at the pre-storm period may signal the upcoming of large ionospheric disturbances at the main phase. The ionospheric $F_2$ response for low and mid latitude does not show any significant differences during the storm main phase and the pre-storm period. The ionospheric response during the pre-storm period is thought very puzzling. The period is observed to be depleted throughout with low-moderate effect across all the stations in the low and mid latitude. Keywords: Ionospheric $F_2$ layer, ionospheric disturbances, pre-storm phenomena, Geomagnetic storm, ionospheric storm.

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**5** [1450055]

**Effects of the intense geomagnetic storm on 26 and moderate geomagnetic storm on 27-28 September 2011 in the equatorial, low-, mid- and high-latitude *F* region in the American sector**

Rodolfo de Jesus[1], Y. Sahai[1], P. R. Fagundes[1], A. J. de Abreu[1], E. Correia[4, 2], F. C. P. Bertoni[2], C. Brunini[3], M. Gende[3], J. A. Bittencourt[4], and V. G. Pillat[1]

[1]Universidade do Vale do Paraíba, São José dos Campos, São Paulo, Brazil
[2]Centro de Rádio Astronomia e Astrofísica Mackenzie (CRAAM), São Paulo, São Paulo, Brazil
[3]Facultad de Ciencias Astronómicas y Geofísicas, Universidad Nacional de La Plata, La Plata, Argentina
[4]Instituto Nacional de Pesquisas Espaciáis (INPE), São José dos Campos, São Paulo, Brazil

This study presents an investigation of geomagnetic disturbance effects in the equatorial, low-, mid- and high-latitude *F* region in the American sector during the intense geomagnetic storm on 26 September, 2011, which was followed by another moderate geomagnetic storm on 27-28 September 2011. The data from ionospheric sounding and Global Positioning System (GPS) are presented (from 26 to 29 September 2011) and includes both the storms and recovery phases. In this work we used ionospheric sounding observations (ionospheric parameters *F*-region critical frequency ($foF_2$) and minimum *F*-region virtual height (hF)) using the Canadian Advanced Digital Ionosondes (CADIs) operational at São José dos Campos (SJC, 23.2 S, 45.9 W; dip latitude 19.1 S; low-latitude station located under the southern crest of the equatorial ionospheric anomaly), Brazil, and Antarctic (Estação Antartica Comandante Ferraz (EACF), 62.1 S, 58.4 W; dip latitude 37.8 S; high-latitude station). We also present data from stations at Jicamarca (JIC; 12.0 S, 76.8 W, dip latitude 0.13 S; equatorial station), Peru, and Port Stanley (PST; 51.6 S, 57.9 W, dip latitude 31.5 S; mid-latitude station), using digisondes. The GPS observations from 16 receiving stations in the equatorial, low-, mid- and high-latitudes *F* region in the American sector have been used to obtain the measures of the Vertical Total Electron Content (VTEC) and phase fluctuation (rate of change of TEC, TEC min-1). Salient features from these observations will be presented and discussed.

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**6** [1448678]

**On the investigation of Space Weather in the low latitude region**

Victor Uzodinma Chukwuma[1]

[1]Physics, Olabisi Onabanjo University, Ago Iwoye, Nigeria

Space weather research involves studies of the sun, the solar wind, magnetosphere, ionosphere, and thermosphere with regard to their effects on the performance and reliability of space-borne and ground- based technological systems, and wellbeing of man. Central to space weather are geomagnetic storms. Given the level of development in Africa, the defining statement of space weather carries with it the need to increase the investigation of geomagnetic storms in the equatorial ionosphere of Africa by attracting and training of more young scientists. This will help to avert the challenges of space weather in our region. This is the goal of this paper. Presently our results reveal geomagnetic storm effects in the equatorial region, then points out ionospheric storm occurrence in the low latitudes, and explains the solar and interplanetary drivers of geomagnetic storms as well as a method of data analysis.

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**7** [1452197]

**The dependence of storm-enhanced densities (SED) to the geometry and the dynamics of sunspots**

Sinan Güyer[1], Umit Deniz Goker[2], and Zehra Can[1]

[1]Physics, Yildiz Technical University, Istanbul, Turkey
[2]Physics, Bogazici University, Istanbul, Turkey

Variations of the solar spectral irradiance (SSI), in particular variations of the ultraviolet (UV) radiation, influence the Earth climate but only a few percents in total solar irradiance (TSI). Solar radiation below 300 nm is almost completely absorbed in the upper atmosphere and stratosphere. It changes the chemical composition and dynamical parameters of those layers and causes variations of the ozone concentration. In order to understand this, we need to know the interior behavior of the solar atmospheric layers and the solar activity. In this work, we analyzed the geometry and the dynamics of sunspots for both descending and ascending phases of solar cycles 21, 22 and 23 as a first and main step. At the second step, we compared these analysis with the solar spectral irradiance results for the same solar cycles. We also mentioned the anomalies of the descending phase of solar cycle 23. For this analysis, we used data archives such as Solar Radiation and Climate Experiment (SORCE), NASA, Solar Heliospheric Observatory (SOHO) and Active Cavity Radiometer Irradiance

Monitor Satellite (ACRIMSAT). At the third step, we compared the sunspot structure and the possible states of coronal mass ejection events with the behavior of sunspots and influences in the photosphere and chromosphere. We also compared the influences of the solar activity to the ionosphere and stratosphere for the decreasing and increasing phases of the solar cycles. At the fourth step, we determined the relationship between storm-enhanced densities (SED) with the geometry and the dynamics of the sunspots. We constructed all the codes for different situations by using MATLAB programming language. The importance of this work is that we compared the solar interior structure and the atmospheric layers of Earth by using the sunspot geometry and dynamics. Thus, we could determine the effects of the sunspot dynamics on the SED densities in detail.

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**8** [1447216]

**Day-to-day Variability of *foEs* in the Neighbourhood of Equatorial ionosphere**

Emmanuel Oluwafemi Somoye[1, 2], Andrew Oke-Ovie Akala[2, 1], Rasaq Adewemimo Adeniji-adele[1, 2], Eugene Oghenakpobor Onori[1, 2], and Azeez Oladepo Karimu[2, 1]

[1]Physics, Lagos State University., Ojo, Lagos, Nigeria
[2]Physics, University of Lagos, Lagos, Nigeria

Diurnal, seasonal and solar cycle effect of the variability (VR) of the critical frequency of sporadic E layer (*foEs*) is investigated at Ibadan (7.400 N, 3.900 E, 60 S dip) in the African sector during the high solar activity (HSA) year of 1958, moderate solar activity (MSA) year of 1973 and low solar activity (LSA) year of 1965. The diurnal variation of *foEs* VR is characterised by post-midnight (32- 78%) and pre- midnight (8- 58%) peaks during HSA, the only epoch of the three showing these peaks and diurnal trend. Daytime *foEs* VR is however greater during LSA (4 – 54%) and MSA (9- 57%) than during HSA ( 9 – 25% ). HSA post-midnight *foEs* VR is maximum during March Equinox and December Solstice while its daytime value shows no seasonal trend. Seasonal trend in *foEs* VR during LSA is only evident during the latter half of the day with post-noon peak values of 54% and 47% during March Equinox and December Solstice respectively. No Seasonal trend is observed in *foEs* VR during MSA. Comparison of July *foEs* VR of Ibadan with those of Singapore (1.30 N, 103.80 E, 17.60 S dip ) in the Asian sector and Huancayo (120 S, 284.70 E, 1.90 dip ) in the American sector indicates longitudinal dependence of *foEs* VR. At Ibadan and Huancayo during both HSA and MSA, post-midnight *foEs* VR is found to increase with Rz on a general note. At Singapore post-midnight *foEs* is greater at MSA than HSA. Keywords: *foEs*, Variability, Longitude dependence, Rz

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**9** [1452495]

**Relationship between Dst and solar wind conditions during geomagnetic storms**

Bakare Nurudeen Olusesan[1] and Victor Uzodinma Chukwuma[1]

[1]Physics, Olabisi Onabanjo University, Ago-Iwoye, Nigeria

A study of 224 geomagnetic storms of which 83 intense and 141 moderate storms during 1996-2006 has been carried out to investigate the relationship between Dst and solar wind plasma parameters during geomagnetic storms. The geomagnetic storms are primarily associated with two classes of drivers: the magnetic cloud and complex ejecta. Out of 83 intense geomagnetic storms studied, it was found that magnetic cloud were drivers in 43 geomagnetic storm (~ 51.8%) while complex ejecta were responsible for 40 geomagnetic storms (~ 48.2%). The correlation between Dst and B; and between Dst and Bs was 0.76 and 0.90, respectively for geomagnetic storms resulting from magnetic clouds. The correlation between Dst and B; and between Dst and Bs was 0.71 and 0.64, respectively for geomagnetic storms resulting from complex ejecta. Furthermore, it was shown that the correlation between the Dst and V for magnetic cloud and complex ejecta was 0.58 and 0.57, respectively. It was observed that the correlation between Dst and VBs for magnetic cloud and complex ejecta were 0.77 and 0.71, respectively. Further study of 141 moderate geomagnetic storms shows that the magnetic cloud comprised nearly (33.3%) of the storms while the complex ejecta comprised of about 66.7%. The result shows that the number of magnetic cloud occurrence is nearly double that of complex ejecta. The correlation between Dst and B; and between Dst and Bs was 0.38 and 0.64, respectively for geomagnetic storms resulting from magnetic clouds. The correlation between Dst and B; and between Dst and Bs was 0.43 and 0.53, respectively for geomagnetic storms resulting from complex ejecta. In addition, it was shown that the relationship between the Dst and V for magnetic cloud and complex ejecta was 0.15 and 0.11, respectively. It was observed that the relationship between Dst and VBs for magnetic cloud and complex ejecta were 0.64 and 0.59 respectively. Finally, the present results suggest that though both classes of drivers can cause geomagnetic storm but magnetic cloud is more geo-effective than complex ejecta. Keywords: Interplanetary magnetic field, Intense geomagnetic storm, Moderate geomagnetic Storm, Fast solar wind speed.

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**10** [1453295]

**Prediction of the Earth's magnetic field using neural network**

Olawumi Rophiat Kaka[1, 2], Elijah Oyeyemi[2, 3], and Babatunde Rabiu[2, 4]

[1]Physics, Afe Babalola University, Ekiti, Nigeria
[2]Space Physics Laboratory, Federal University of Technology, Akure, Nigeria
[3]Physics, University of Lagos, Lagos, Nigeria
[4]Enginering, National Space Research and Development Agency, NASRDA, Abuja, Nigeria

Considering the usefulness and the great importance of the Earth's magnetic field e.g., shielding some of the energetic particles from the Sun in reaching the Earth, in navigation of the air craft and oceaning, etc. Then there is a necessity to monitor the present state of the Earth's Magnetic Field and be able to use the data to predict the future of the state of the Earth's Magnetic Field. In this research, the artificial neural work was used to predict the Earth's Magnetic Field following the success recorded with different researchers using neural networks to predict some of the space activities. The primary source of data used for this research is the long data record of hourly values of H amassed by the Algeria INTERMAGNET observatory, Tamanrasset (TAM) with longitude 5.53ºW and latitude 67.21ºN and f10.7 data were obtained from OMNIWEB. The database covers a 16 year data ranging from the years 1993 to 2009, which include all periods of calm and disturbed magnetic activities. The multilayer feed forward network with a back propagation algorithm was used in this research with the input parameters: the horizontal component of the Earth magnetic field (H) is used to represent the main source while the solar radio flux at 10.7 cm (f10.7) wave length wave length is used to represent the external source of the Earth's Magnetic Field, day of the year, (DN), Universal Time (UT), a 2-month running mean of the sunspot number (R2), a 2-day running mean of the 3-hour planetary magnetic index Ap (A16), solar zenith angle (CHI), geographic latitude (q). The results obtained here compare well with the observed values. It is concluded that it would indeed be feasible to use a neural network model to predict the Earth's magnetic field.

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**11** [1453046]

**Extreme geoelectric field event scenarios for geomagnetically induced current application**

Chigomezyo M. Ngwira[1, 2] and Antti Pulkkinen[1, 2]

[1]Heliophysics, NASA Goddard Space Flight Center, Greenbelt, MD, USA
[2]Physics, Catholic University of America, Washington, DC, USA

During geomagnetic storms, intense time-varying currents are produced in the magnetosphere and ionosphere which result in rapid variation of the geomagnetic field. A geoelectric field is induced at the Earth's surface as defined by Faraday's law of induction, which in-turn drives currents in man-made technological conductor networks, such as power transmission systems. Society today has become highly reliant on electricity in order to meet essential needs. Therefore, the threat of severe societal consequences has accelerated recent interest in extreme geomagnetic storm impact on high-voltage power transmission systems. As a result, extreme geomagnetic event characterization is of fundamental importance for quantifying the technological impacts and societal consequences of extreme space weather. This paper reports on the global behavior of the horizontal geomagnetic field, its rate of change dB/dt, and the induced geoelectric field during severe/extreme geomagnetic events. This includes: (1) an investigation of the latitude threshold boundary, (2) results from some previous geomagnetically induced currents (GIC) studies in South Africa, and (3) the influence of the equatorial electrojet (EEJ) on the occurrence of enhanced geoelectric fields over geomagnetic equatorial ground stations. We show that geoelectric fields around the EEJ belt can be an order of magnitude larger than stations outside the belt. This is an important implication for power networks located in this region. Also, the present paper seeks to enhance interest and solicit partnership with African scientist towards research on GIC which has important societal applications.

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**12** [1453370]

**Estimating the geoeffectiveness of halo CMEs from associated solar and IP parameters using neural networks**

Jean Uwamahoro[1], Lee Anne McKinnell[2], John Bosco Habarulema[2]

[1]Mathematics and Physics, Kigali Institute of Education, Kigali, Rwanda
[2]Space Science, South African National Space Agency, Hermanus, South Africa

Estimating the geoeffectiveness of solar events is of significant importance for space weather modeling and prediction. This paper describes the development of a neural network based model for estimating the probability occurrence of geomagnetic

storms following halo coronal mass ejection (CME) and related interplanetary (IP) events. This model incorporates both solar and IP variable inputs that characterize geoeffective halo CMEs. Solar inputs include numeric values of the halo CME angular width (AW), the CME speed Vcme, and the comprehensive flare index (cfi) which represents the flaring activity associated with halo CMEs. IP parameters used as inputs are the numeric peak values of the solar wind speed (Vsw) and the southward Z-component of the interplanetary magnetic field (IMF) or (Bs). IP inputs were considered within a 5 day time window after a halo CME eruption. The neural network (NN) model training and testing datasets were constructed based on 1202 halo CMEs (both full and partial halo and their properties) observed between 1997 and 2006. The performance of the developed NN model was tested using a validation dataset (not part of the training dataset) covering the years 2000 and 2005. Under the condition of halo CME occurrence, this model could capture 100% of the subsequent intense geomagnetic storms (Dst < or = -100 nT). For moderate storms (-100< Dst <= -50), the model is successful up to 75%. This model's estimate of the storm occurrence rate from halo CMEs is estimated at a probability of 86%.

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**13** [1476544]

**Space climate change and the ionosphere**

Jan Laštovička[1] and Dalia Buresova[1]

[1]Aeronomy, Institute of Atmospheric Physics, Academy of Sciences of the Czech Republic, Prague, Czech Republic

On long time scales, not only changes of space weather but also changes of space climate play a role. Long-term changes (time scales longer than solar cycle) and trends in the ionosphere reflect increasing concentration of greenhouse gases in the atmosphere, but they reflect also impact of other trend drives, namely of secular change of the Earth's magnetic field, space weather phenomena represented by geomagnetic activity (the only space weather parameter available throughout the last 50-60 years in the form of geomagnetic activity indices), solar activity, and stratospheric ozone change (for the lower ionosphere). It will be shown that the role of space weather phenomena in long-term trends in the ionosphere is changing with time. Whereas before about 1970 the long-term trends/changes in the ionosphere were controlled by geomagnetic activity changes, in more recent years the geomagnetic control was lost starting with the *E*-region ionosphere and since about 2000 long-term trends in the ionosphere are no more dominantly controlled by geomagnetic activity. Secular changes of the Earth magnetic field play important role only regionally, particularly in the low-latitude Southern America. In computing long-term ionospheric trends we have to correct for solar activity due to a dominant solar cycle effect and, therefore, it is difficult to estimate impact of long-term changes (not related to solar cycles) on the ionosphere. These long-term changes of the ionosphere affect long-term changes of ionospheric radio wave propagation conditions, possibly also GNSS/GPS signals.

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**14** [1452014]

**The importance of shock waves in the solar coronal magnetic loop during flares and the effects of high-energetic particles on the ionosphere**

Umit Deniz Goker[1] and Abebe Kebede[2]

[1]Physics, Bogazici University, Istanbul, Turkey
[2]Physics, North Carolina A&T State University, Greensboro, NC, USA

Following our previous work on the coronal mass ejections (Goker, 2012), this communication explores the effects of High-Energetic Particles in the Ionosphere. The previous work includes the magnetohydrodynamic (MHD) study of shock waves in the current sheet of a solar coronal magnetic loop. The formation of shock wave and its effect on the magnetic reconnection were investigated using Lagrangian Remap Code (LareXd). For the coronal magnetic loop, we constructed the slow shock structure because of the dominant characteristics of this type of shock. Physical parameters such as viscosity and heat conduction in the MHD equations were considered. These parameters were used to catch the different characteristics of jumps in this medium. Thus, we could determine the characteristics of shock waves during the coronal mass ejections. These results have been applied to the structure of the magnetic reconnection and the solar wind. By calculating the speed of the solar wind, we could determine the intensity and the amount of charged particles blasted off during the flare. These charged particles also change the characteristics of aurora depending on the intensity of shock waves from the coronal mass ejections and the chemical structure of the particles in the solar wind. A variety of data archives for the auroral structures from different space instruments were used. The data were analysed using a code developed by us and constructed using MATLAB Programming Language. This work shows the relationship between the intensity of shock wave and the auroral structures in detail.

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**15** [1451903]

**Self-organized theory model of solar flares: New frontiers from small-scale structures**

Alexei Osokin[1]

[1]Sternberg Astronomical Institute of Moscow University, Moscow, Russian Federation

A further development of Solar flares model based on Self-organized critical (SOC) theory worked out by the authors is presented. It is shown, that models based on SOC - theory approach to the study of rapid energy dissipation in magnetic plasma may be of equal importance with the localized, small - scale Magnetohydrodynamic (MHD) simulation. However refined SOC models are needed to establish a more physical connection between the model evolution rules and the observations. The authors present a new model in the frame of which not only statistical results, but also basic for the model elements and processes, such as magnetic tubes are matched against the observational data. This approach allows further development of the model by introduction of specifications corresponding to a more refined physical image of the phenomenon. We show that: i) continuous emersion and interactions (dissipation, reconnecting) of the tubes may occur as a self-organized criticality process, producing avalanches; ii) By taking into account flares inertia, we can construct and explain the flares statistic indices variation; iii) The model allows to determine certain physical parameters for small-scale magnetic tubes. This result is unusual for stochastic models; iv ) we used the system that builds its own spatial structure, similar different polarity zones on the Sun. The zone that divides them (the one, we might call 'the neutral line') proves to be, like in the case of the physical Sun that of flares generation and of maximal energy output. This work was supported by the RFBR, projects 11-02-00264 and 11-02-00631.

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**16** [1449570]

**Magnetospheric and ionospheric sources of geomagnetic field variations**

Enoch Oluwaseun Elemo[1] and Akeem Babatunde Rabiu[2, 3]

[1]Basic Space and Atmospheric Sciences, African Regional Centre for Space Science and Technology Education in English (ARCSSTE-E), Ile-Ife, Nigeria
[2]Engineering and Space Systems, National Space Research and Development Agency, Abuja, Nigeria
[3]Space Physics Laboratory, Federal University of Technology, Akure, Nigeria

Abstract This study investigated the magnetospheric and ionospheric sources of geomagnetic field variation using the data set that consists of the hourly values of the geomagnetic element: horizontal intensity H, recorded at the Geomagnetic Observatory (Long. 4.670 and Lat. 8.50) of the Department of Physics, University of Ilorin, Ilorin, Nigeria for the months of August, October, and December in the year 2008. The study attributed the daytime variation to the ionospheric sources while various reasons were given to explain these night-time variations, which include convective drift currents in the magnetosphere and the asymmetric rings currents in the magnetospheric currents, this variation due to disturbances indicate possible non-ionospheric origin and a partial ring current in the right side magnetosphere. The mean monthly hourly variation showed seasonal variation with the Sq (H) maximizes in equinox with least variation in June solstice. Moreover, the mean ration of seasonal contributions of magnetospheric to ionospheric sources revealed that the greatest contributions from both magnetospheric and ionospheric sources at the E season with the least at J season.

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**17** [1449900]

**Coronal mass ejections and July 2005's heliospheric phenomena**

Alexei Osokin[1]

[1]Sternberg Astronomical Institute of Moscow University, Moscow, Russian Federation

The Forbush-effect that was observed on the periphery of interplanetary disturbances in July 2005 is discussed. The intensity of galactic cosmic rays has decreased by about 2% on July 16 and then Forbush effect reached 8% at end of day July 17 in many ground monitors. The perturbation was small in the near-Earth space, and it could not provide the value Forbush effect. We discuss observations of two solar flares (M9.1 and X1.2 - see fig.) that were occurred near the western solar limb in July 14, 2005. There is the fact that the second flare's CME was characterized by a speed of about 2300 km / s at the beginning of ejection, i.e., Post Impulsive Event. Brushing the remains of previous ejections, the CME has formed steep western front of the interplanetary disturbances, in which the giant Forbush effect has been in the west line of the Sun-Earth. This work was supported by the RFBR, projects 11-02-00264 and 11-02-00631.

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**18** [1439190]

**Relation between night airglow OI 630 nm and GPS-TEC**

Dadaso Jaypal Shetti[1]

Physics, Smt. Ksturbai Walchand College, Sangli, Maharashtra, India.

Ground based photometric observations of OI 630.0 nm emission line have been carried out from Kolhapur station (Geog. Lat. 16.8 N, Geo. Long 74.2 E) and d(TEC)/dT observations from Hyderabad (17.410 N, 78.550 E) station, India . The signature of MTM and the plasma bubble has been found in both night airglow (OI630.0 nm) and d(TEC)/dt observations. It is suggested that *F*-region temperature should be simultaneously measured both at equator as well as at Kolhapur to confirm the signature of MTM. The nocturnal variations observed in the atomic oxygen airglow emission at low latitude are well correlated with the dynamical variations seen in the *F*-region ionospheric parameters such as d(TEC)/dT, for both quiet and disturbed days. Total Electron Content (TEC) and OI 630 nm airglow emission both these phenomena are dependent on the electron density of the ionosphere *F* region, it is useful to find relationship between the two parameters under geomagnetically quiet and disturbed conditions at one location

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**19** [1452735]

**Seasonal dependence of planetary waves observed in the ionospheric equatorial region**

Anthea J. Coster[1], Larisa Goncharenko[1], Shunrong Zhang[1], and Jonathan Wurtz[2]

[1]MIT Haystack Observatory, Westford, MA, USA
[2]University of New Hampshire, Durham, NH, USA

This talk focuses on an investigation of the signatures of planetary waves in the Earth's ionosphere. Planetary waves are large slow-moving, 'planetary-scale' waves that can wrap around the entire Earth. They are generated in the troposphere (the lowest part of the atmosphere which extends from the ground to 10-15 km) or in the mesosphere (the region between ~60-90 km above the ground) by variety of forces and exist due to the Earth's rotation and the conservation of absolute vorticity. Time- varying or dissipating planetary waves can be a strong source of variation in multiple atmospheric parameters on time scales from 2 to 20 days. As these waves propagate upwards, the interaction of the neutral atmosphere with ionospheric plasma produces signatures that can be observed by analyzing total electron content (TEC) data. A database covering the years 2007-2011 of GPS derived TEC measurements was used for analyzing the seasonal characteristics of planetary waves. This global database includes GPS-derived TEC data from the COSMIC satellites and from the GPS ground-based network. The results of this analysis for the equatorial and mid-latitude regions will be described.

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**20** [1452517]

**Mapping the East-African equatorial ionosphere by interpolating GPS data using Universal Kriging**

Melessew Nigussie[1], Sandro Maria Radicella[2], Baylie Damtie[1], and Endawoke Yizengaw[3]

[1]Physics, Washera Geospace and Radar Science Laboratory, Bahir Dar University, Bahir Dar, Ethiopia
[2]ICT for Development Laboratory, The Abdus Salam International Center for Theoretical Physics (ICTP), Trieste, Italy
[3]Institute for Scientific Research, Boston College, Chestnut Hill, MA, USA

In different parts of the world, regional ionospheric maps have been developed to mitigate the impact of the ionosphere on radio signal. However, the East-African equatorial ionosphere has not yet mapped may be due to lack of enough Global Positioning System (GPS) receivers. The Universal Kriging (UK) interpolation technique has been used to map the vertical total electron content (vTEC) estimated by fifteen ground-based GPS receivers that have been deployed recently in the region. The vTEC may be represented by the deterministic and stochastic models, which can be obtained by applying the Regularized Least Square (RLS) and Universal Kriging estimation techniques, respectively. By combining these models the instantaneous vTEC maps of the East-African can be obtained continuously, showing the large scale structure of the ionosphere like equatorial ionospheric anomaly, during quiet and disturbed conditions. In this paper, we will show different case studies for different days and demonstrate the Universal Kriging interpolation technique is the best way to image the characteristics of the ionosphere of the regions that are devoid of ground based instrument, like East-Africa region. In addition, we have shown the maps of the estimate of variances associated with maps of estimate of vTEC.

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**21** [1512688]

**Global specification of the post-sunset Equatorial Ionization Anomaly**

Patrick Dandenault[1], Kenneth Dymond[1], Clayton Coker[1], Scott Budzien[1], Andrew Nicholas[1], Damien Chua[1], Sarah McDonald[1], Christopher Metzler[1], Peter Walker[2], Ludger Scherliess[3], Robert Schunk[3], Larry Gardner[3], and Lie Zhu[3]

[1]Naval Research Laboratory, Washington, DC, USA
[2]Computational Physics, Inc., Springfield, VA, USA
[3]Center for Atmospheric and Space Sciences, Utah State University, Logan, UT, USA

The Special Sensor Ultraviolet Limb Imager (SSULI) on the Defense Meteorological Satellite Program (DMSP) is used to specify the post-sunset Equatorial Ionization Anomaly. Ultraviolet emission profiles of 135.6 nm and 91.1 nm emissions from O++e recombination are measured in successive altitude scans along the orbit of the satellite. The overlapping sample geometry provides for a high resolution reconstruction of the ionosphere in altitude and latitude for each pass of the satellite. Emission profiles are ingested by the Global Assimilation of Ionospheric Measurements (GAIM) space weather model, which was developed by Utah State University and is run operationally at the Air Force Weather Agency (AFWA). The resulting specification of the equatorial ionosphere reveals significant variability in the post-sunset anomaly, which is reflective of the driving space weather processes, namely, electric fields and neutral winds. Significant longitudinal and day-to-day variability in the magnitude (or even existence) of the post-sunset anomaly reveal the influence of atmospheric tides and waves as well as geomagnetic disturbances on the pre-reversal enhancement of the electric field. Significant asymmetry between anomaly crests reveals the influence of atmospheric tides and waves on meridional neutral winds. A neutral wind parallel to the magnetic field line pushes plasma up (or down) the field lines, which raises (or lowers) the altitude of the crests and modifies the horizontal location and magnitude of the crests. The variability in the post-sunset anomaly is one of the largest sources of error in ionospheric specification models. The SSULI instrument provides critical data towards the reduction of this specification error and the determination of key driver parameters used in ionospheric forecasting. Acknowledgements: This research was supported by the USAF Space and Missile Systems Center (SMC), the Naval Research Laboratory (NRL) Base Program, and the Office of Naval Research (ONR).

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**22** [1513424]

**The peculiarities of ionospheric disturbances at low solar activity period**

Iurii Cherniak[1], Irina Zakharenkova[1], Irk Shagimuratov[1], Andrzej Krankowski[2], Ivan Galkin[3], Nina Korenkova[1], and Vladimir Leschenko[1]

[1]West Department of IZMIRAN, Kaliningrad, Russian Federation
[2]University of Warmia and Mazury, Olsztyn, Poland
[3]University of Massachusetts Lowell, Lowell, MA, USA

The extended solar minimum conditions and the beginning of the new 24th solar cycle give us an opportunity to investigate the ionosphere with extremely low electron density values. The ionospheric response accompanied with geomagnetic disturbances occurred on October 2008, July 2009, May 2010 caused the appreciable ionospheric response on the background of extremely low electron density in the ionosphere. It was carried out the joint analysis by using the multi-instrumental diagnostic facilities data. It was processed the ionospheric measurements data provided by European, American, Japanese, and Australian ionosonde networks and GPS TEC products, generated by International GNSS Service. The peak electron density ($foF_2$) variations, shape of the electron density profiles and global GPS TEC distribution were analyzed. The global ionospheric maps of TEC were used in order to estimate large scale storm effects, ionosonde data gives possibilities to estimate the local peculiarities of the ionosphere disturbances. Additionally for detailed analysis of the height ionospheric structure, we combined ionosonde-derived data with the electron density profiles retrieved from FORMOSAT-3/COSMIC radio occultation measurements. The moderate geomagnetic disturbances with similar magnitude (Kp ~ 6) lead to the different ionospheric response (positive and negative) over European, American, Japan and Australian areas. The global pattern and local temporal and quantitative characteristics of the ionosphere disturbances during selected geomagnetic storms were revealed. Additionally it was carried out the comparison of ionosonde derived $foF_2$ values with IRI-2007 model, that have the storm-time option. It was obtained the qualitative agreement between the ionosonde-derived $foF_2$ values and model calculations for cases of negative ionospheric storms. The best agreement between model and observations results corresponds to the Northern Hemisphere mid-latitude stations. We acknowledge the European Digital Upper Atmosphere Server (DIAS), Australian IPS Radio and Space service and the National Institute of Information and Communications Technology (NICT) in Japan for providing ionosonde data. The authors would like to thank B. W. Reinisch and the Center of Atmospheric Research, University of Massachusetts Lowell for the ionogram data of DIDBase. We are also grateful to International GNSS Service (IGS) for GPS TEC products.

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**23** [1426539]

**Comparison between GPS-TEC observations over Lagos and IRI predictions during solar minimum**

Oluwaloseyi Comfort Adejuyigbe[1] and Andrew Oke-Ovie Akala[1]

[1]Physics, University of Lagos, Akoka, Lagos, Nigeria

GPS TEC observations over Lagos (6.52º N, 3.4º E, 3.04º S magnetic latitude), Nigeria during solar minimum (2009) were compared with the TEC derived from IRI-2007 model, using the three coefficients of topside electron density–IRI-2001; IRI01-corr; and NeQuick. The major source of errors that is limiting the accuracy of GNSS is ionospheric effects. For Galileo single frequency users, plans are on deck to mitigate range delay errors by a global algorithm based on the NeQuick option of IRI via ingestion mechanism. Year 2009 has one of the deepest minimum over the last eight solar cycles. Thus, the data for the year at Lagos presents an opportunity to weigh the performance of IRI model under a deep solar minimum, which may in turn help to define the lowest range error margin for GNSS users at the African equatorial region. The data were grouped into daily and seasonal sets. Receiver and satellites biases were obtained from the Data Centre of the Bern University, Switzerland, and they were carefully removed from the TEC data. In order to eliminate multipath effects from the data, we used elevation cut-off angle of 30º. Overall, for TEC derived from both observation and models, the diurnal variations in TEC recorded the maximum during 1400–1600 LT hours and minimum during 0400–0600 LT hours. Seasonally, the March Equinox recorded the maximum, while June Solstice. IRI-2001; IRI01-corr options grossly over-estimated TEC over Lagos, while a reasonable agreement is found between GPS derived TEC and those derived from the NeQuick option, especially, during the daytime. During the early morning hours (0000–0500 LT), the NeQuick derived TEC deviated slightly from observations.

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**24** [1453221]

**Solar quiet daily variations at Medea**

Fatma Anad[1], Christine Amory-Mazaudier[2], Seid Bourouis[1], Abdeslam Abtout[1], and Endawoke Yizengaw[3]

[1]Géophysique, CRAAG, Algiers, Algérie
[2]Laboratoire de Physique des Plasmas, CNRS, UPMC, Saint-Maur-des-Fossés, France
[3]Institute for Scientific Research, Boston College, Chestnut Hill, MA, USA

The magnetic station of Medea, (AMBER network) located in the northern part of Algeria (2.72° E, 36.29° N), provided continuous recordings of the geomagnetic field since July 2008. The horizontal component (H) and east component (Y) of the earth magnetic field, recorded from 2009 to 2011, are used to calculate and analyze the diurnal and seasonal solar quiet variations (Sq (H) and Sq (Y)) during magnetic quiet days. The magnetic quiet days are select with a daily magnetic index am < 20 nT. The preliminary results show that Sq (H) shows a seasonal variation. The analysis of the Sq (H) shows that the station of Medea is near the focus of the Sq system in winter, below the focus in spring and oscillates in summer for the years 2009 and 2010. For 2011, Sq (H) exhibits the same characteristic except for the months of November, December, and January, for these months Medea is below the focus of the Sq system. Changes in the East component Sq (Y) are roughly consistent with the model of an infinite plane layer above a plane earth, generally used to represent the Sq, except for the winter season. The amplitudes of the seasonal variations Sq (H) and Sq (Y) are larger at the June solstice than at the December one. The seasonal component Sq (Y) in March and October are shifted in phase in relation to components in April and September. We explain these variations in terms of relative position of Medea to the focus of the Sq current system and the ionospheric dynamo.

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**25** [1453895]

**Latitudinal variations and Equatorial Ionization Anomaly over African stations**

Segun Olawale Segun[1], Adeniyi Jacob Olusegun[2], Sandro Radicella [3], Babatunde Rabiu[4, 5], and Patricia Doherty[6]

[1]Physical Sciences, Bells University, Ogun, Nigeria
[2]Physics, University of Ilorin, Ilorin, Nigeria
[3]Telecommunications/ICT for Development Laboratory, The Abdus Salam International Center for Theoretical Physics (ICTP), Trieste, Italy
[4]Engineering and Space Systems, National Space Research and Development Agency, Abuja, Nigeria
[5]Physics, Federal University of Technology, Akure, Nigeria
[6]Institute for Scientific Research, Boston College, Chestnut Hill, MA, USA

The transportation of plasma from the equatorial trough to the crest has been one of the basic of physical mechanisms responsible for the total electron content (TEC) variability apart photo-ionization at the low latitude regions. African stations during quiet days of September 2008 to August 2009 within the equator through the low latitude to the crest and beyond were employed in this study. The 4-months; March, June, October and December mean total electron content (TEC) over these stations; Addis-Ababa, Nairobi, Dare-salaam, Lusaka, Maputo, Durban and Hermanus have been investigated. The monthly mean TEC variability over Lusaka were observed to have higher magnitudes than the other stations during the forenoon periods in the month of March, June and December with the months of October as exception. The acclaimed larger magnitude of TEC throughout monthly mean diurnal period over the crest than the trough was not observed in June, October and December. In the month of March, this larger magnitude was observed from 0100 UT 1400 UT and decays afterward while TEC over Lusaka is increasing. Further effort are made on the simultaneous records of the solar quiet fields deduced from each station to estimate their equatorial electrojet (EEJ) strengths with respect to the overhead electric field over Addis-Ababa. The EEJ strength (EES) and the integrated EEJ (IEEJ) deduced were further investigated for possible relationship between the latitudinal TEC magnitudes and equatorial ionization anomaly (EIA) build-ups. In view of these, other months will be investigated so that adequate morphology regarding these relationships could be established

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**26** [1426539]

**Comparison of equatorial TEC at African and American longitudes during the minimum and ascending phases of solar cycle 24**

Andrew Oke-Ovie Akala[1]

[1]Physics, University of Lagos, Akoka, Lagos, Nigeria

This study compares equatorial total electron content (TEC) at African and American longitudes during the minimum (2009, 2010) and ascending (2011) phases of solar cycle 24. GPS-TEC data, which were observed at the same local time at two equatorial stations on both longitudes: Lagos (6.52ºN, 3.4ºE, 3.04ºS magnetic latitude), Nigeria; and Pucallpa (8.38ºS, 74.57ºW, 4.25ºN magnetic latitude), Peru were used for the investigation. These data were grouped into daily, seasonal and solar activity sets. Receiver and satellites biases were obtained from the Data Centre of the Bern University, Switzerland, and they have been carefully removed from the TEC data. Furthermore, in order to eliminate multipath effects from the data, elevation angle cut-off of 30º was adopted. The hourly averages of each data set were determined. The day-to-day variation in vertical TEC (VTEC) recorded the maximum during 1400–1600 LT hours and minimum during 0400–0600 LT hours at both longitudes. Seasonally, during solar minimum, maximum VTEC values were observed during March Equinox and minimum during Solstices. However, during the ascending phase of the solar activity, the maximum values were recorded during the December Solstice and minimum during the June Solstice. VTEC also increased with solar activity at both longitudes. On longitude by longitude comparison, the African sector recorded higher VTEC values over the American sector.

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**27** [1414321]

**PLASMON: Progress in characterising the plasmasphere**

Andrew Collier[1, 2], Janos Lichtenberger[3], Mark Clilverd[4], Anders Jorgensen[5], Craig Rodger[6], Massimo Vellante[7], Reiner Friedel[8], Balazs Heilig[9], Bob Holzworth[10], Tero Raita[11], and Jan Reda[12]

[1]South African National Space Agency (SANSA), Hermanus, South Africa
[2]UKZN, Durban, KwaZulu-Natal, South Africa
[3]Eotvos Lorand University, Budapest, Hungary
[4]British Antarctic Survey, Cambridge, UK
[5]New Mexico Institute of Mining and Technology, Socorro, NM, USA
[6]University of Otago, Dunedin, New Zealand
[7]University of L'Aquila, L'Aquila, Italy
[8]Los Alamos National Laboratory, Los Alamos, NM, USA
[9]Eotvos Lorand Geophysical Institute, Budapest, Hungary
[10]University of Washington, Seattle, WA, USA
[11]University of Oulu, Oulu, Finland
[12]Polish Academy of Sciences, Warsaw, Poland

Current models of the plasmasphere do not encompass all of the necessary structure or physics. Observations of the plasmasphere are also sparse. PLASMON will provide regular measurements of plasmaspheric electron and mass densities across all longitudes and incorporate them into a data assimilative model. This model will be a vast improvement over any previous plasmaspheric models. This poster will document the progress made during the first year of the PLASMON project. At present almost all of the hardware is in place and we are gathering data.

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**28** [1450219]

**Impact of effective Earth radius factor (k-factor) on wireless link over Akure, Nigeria**

Adekunle Titus Adediji[1]

[1]Physics, Federal University of Technology, Akure, Nigeria

For point to point line-of-sight communications, wireless links are widely employed. The propagation loss on a terrestrial line-of-sight wireless link is influenced by atmospheric and seasonal conditions. The reliability of the link is also affected by k-factor values. The value of k-factor is taken as 4/3 where specific data is not available; however, this value may only be used for gross planning. In reality, it is important to determine its average and effective value for adequate path engineering because its value depends on local climatic conditions and it is terrain specific. In this study, k-factor values for entire seasonal cycle 2007-2009 in Akure have been analyzed. The study has been carried out to observe the distribution of k-factor and study its impact on terrestrial point to point line-of-sight wireless link over Akure. Keywords: Line-of-sight, k-factor, refractive index, wireless link, troposphere.

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**29** [1453307]

**Spatio-temporal characteristics of worldwide Sq (H)**

Temitope Pascal Owolabi[1, 4], Babatunde Rabiu[2, 4], Gbenga Moses Olayanju[3]

[1]African Regional Center for Space Science and Technology Education in English (ARCSSTE-E), Ile Ife, Nigeria
[2]National Space Research and Development Agency, Abuja, Nigeria
[3]Geophysics, Federal University of Technology, Akure, Nigeria
[4]Physics, Federal University of Technology, Akure, Nigeria

The study of the spatio-temporal characteristics of worldwide Sq (H) was carried out using 64 geomagnetic stations for four different seasons namely; Winter (November, December, January and February), Summer (May, June, July, August), Autumn (September, October) and Spring (March, April) for the year 1996. The data derived from the geomagnetic stations spread across the globe were analyzed for the study of worldwide Sq (H). The results show that the geomagnetic stations at high latitudes N/S has the highest magnitude of Sq (H) of about 420 nT while the equatorial region experienced an abnormal enhancement in Sq (H) magnitude between 220-320 nT. This may be as a result of equatorial electrojet effect. It was observed that high magnitudes in Sq (H) nT at the high latitudes were pronounced at eastern part of the globe based on

the contour plots from latitudinal and longitudinal profiles obtained and shows the asymmetrical nature in the north, south, east and western parts of the globe.

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**30** [1452807]

**First results of and a plan for worldwide continuous electric field measurements**

Ronald R. Ilma[1], Michael C. Kelley[1], Ambelu Tebabal[2], Patrick Alken[3], and Baylie Damtie[2]

[1]School of Electrical and Computer Engineering, Cornell University, Ithaca, NY, USA
[2]Physics, Washera Geospace and Radar Science Laboratory, Bahir Dar University, Bahir Dar, Ethiopia
[3]National Geophysical Data Center, NOAA, Boulder, CO, USA

*Anderson et al*. [2002, 2004] discussed the quantitative relationship between the strength of the equatorial electrojet (EEJ) with the vertical **E × B** drift velocity of the ionospheric *F* region, and a neural network-based method to use ground-based magnetometer data to determine the field. The basic idea was articulated first by *Gonzales* [1979]. The idea is to use one magnetometer on the equator and one off the equator by at least 10 degrees of latitude. Both will see the ring current magnetic field but only one will see completely the electrojet. By subtracting them, the EEJ current can be determined, which is proportional to the zonal electric field. This sounds easier than it actually is since the local earth conductivity matters, as does the variable properties of the upper atmosphere. *Anderson et al*. [2004] developed a neural network program to train the data set by using days when he knew the electric field from observations at the Jicamarca Radio Observatory in Peru. We will do the same by training data from the African and Peruvian sectors, with the zonal electric field deduced from the CHAMP satellite data [see *Alken and Maus*, 2010]. We will present the African sector CHAMP data for eight years and compare it to the Scherliess and Fejer vertical drifts model and to our initial African data.

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**31** [1415777]

**Modelling of geomagnetically induced currents during geomagnetic storms using geoelectric fields and auroral electrojet indices**

Elijah Olukayode Falayi[1, 2]

[1]Physics and Telecommunication, Tai Solarin University of Education, Ijebu Ode, Nigeria
[2]Space Science Center, University of Sussex, Brighton, UK

The effects of space weather on ground based technology mostly occur due to the varying geomagnetic field during geomagnetic storms, producing geomagnetically induced current (GIC). Space weather storms involve intense and rapidly varying electric currents in the ionosphere, which create geoelectric and geomagnetic fields at the Earth's surface. In this study, we have investigated some intense geomagnetic storms: September 18th, 2000; March 31st, 2001; October 21st, 2001; November 6th and 24th, 2001; October 29th and 31st, 2003 and November 9th, 2004. The electric field for each day has been computed using ground conductivity and geomagnetic recordings. The conductivity models are determined by least square fit between the observed and predicted GIC values. Our results show that GIC are strongly correlated with the geoelectric field, and also with eastward and westward auroral electrojet indices and time derivatives of the horizontal geomagnetic field. Root mean square error statistical test has been employed to evaluate the accuracy of the models used.

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**32** [1449607]

**Ionospheric response to earthquake through lower and upper atmosphere coupling**

Yongqiang Hao[1], Zuo Xiao[1], and Donghe Zhang[1]

[1]Institute of Space Physics and Applied Technology, Peking University, Beijing, China

Evidence of atmospheric waves coupling between lower and upper atmosphere excited by Japan's Tohoku earthquake was provided by infrasonic detection on the ground and remote sensing of the ionospheric disturbances (Doppler shift sounding and GPS/TEC). However, corresponding variations were also found to appear in geomagnetic field which is rarely reported before. We checked ground-based measurements in Japan and China, and found that the variations showed up in almost all the stations in turn, according to the distance to the epicenter. But, to different major earthquake events of recent years in this region, the geomagnetic field responded in very different ways, meaning that the ionospheric currents were differently disturbed in each case. Our analysis indicated that whether the response is detectable strongly depends on both the seismic surface waveforms, and the ionospheric currents condition (local time and latitude).

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**33** [1453565]

**Atmosphere dynamic balance model (ADB-model) and related troposphere general circulations' cells behind the formation of tropical monsoons**

César Biouele Mbane[1]

[1]University of Yaoundé I, Yaoundé, Cameroon

Tropical monsoons, occasionally also known as tropical wet climates or tropical and trade-wind littoral climates, are found in regions where there is a complete seasonal reversal of winds. Given the fact that our understanding of physical processes behind the formation of tropical monsoons is very incomplete and only based on weather mean conditions measured or observed near the ground (i.e., pressure, precipitations, and wind fields), we want to make a contribution to a better description of physic processes behind complete seasonal reversal of easterly (or westerly) winds in regions where tropical monsoons are observed by using the impacts of thermoelastic properties of saturated water vapor on atmosphere passive convection. Our results are based on Mbanes' fundamental relationship of Atmosphere dynamic balance which leads to ADB-model and appropriate plots of both troposphere general circulations' cells and related easterly (or westerly) winds generated by Coriolis force near the surface of the earth. Key words: ADB-model, General Circulation cells, seasonal reversal of winds, tropical monsoons.

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**34** [1453573]

**Assessment of ambient temperature of oil and gas producing communities in the Niger delta**

Moses Member Mark Ekpa[1]

[1]Physics and Astronomy, University of Nigeria, Nsukka, Nigeria

The paper is aimed at determining the effect of ambient temperature increase due to oil and gas activities in the oil and gas producing communities, its effect on the health of the people. Thermometer was used for data collection; the measurement of the temperature was done thrice a day, for two months. Analysis of the result shows that the temperature in the affected communities is higher than normal environment in other communities that oil and gas activities are not taking place. The findings also shows that the high temperature has a relationship with the prevalent cases of skin cancer, eye irritation, respiratory problem, etc. The paper went further to proffer solution to the prevalent health problem and the role of atmosphere in the distribution of temperature in the area.

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**35** [1453853]

**Inter-comparison of atmospheric precipitable water from ground-based GPS measurement and regional climate model experiment over Eastern Africa**

Gizaw Mengistu Tsidu[1], Yohannes Getachew[1], and Gereab Kidanu Zewdie[1]

[1]Physics, Addis Ababa University, Addis Ababa, Ethiopia

Drought and floods represent climate hazards that can cause great damage in terms of human suffering and loses on every sector of the economy. Both can be traced in terms of the analysis of water vapor cycles in the atmosphere. It is known since long time that an increase in water vapor enhances the greenhouse effect and gives rise to further warming. According to the Intergovernmental Panel on Climate Change (IPCC) reports water vapor feedback acting alone approximately doubles the warming from what it would be for fixed water vapor. It acts also to amplify other feedbacks in general circulation models, such as cloud feedback and albedo feedback. On longer time scales, water vapor changes are thought to contribute to an important positive feedback mechanism for climate change. Warming of the surface, particularly the sea surface, leads to enhanced evaporation. Due to fact that water vapor is a greenhouse gas, enhanced water vapor in the lower troposphere results in further warming, allowing a higher water vapor concentration, thereby creating a positive feedback. Thus, an understanding of the mechanisms distributing precipitable water vapor (PWV) through the atmosphere and of water vapor's effects on atmospheric radiation and circulation is vital to estimating long-term changes in climate. The column content of water vapor (or Precipitable Water – PWV) can be obtained from the GPS electromagnetic signal's non-hydrostatic tropospheric path delay and satellites such as MODIS. In the last decade, different works showed the feasibility of GPS system to obtain water vapor measurements by means of space-borne GPS receivers (water vapor profiles) or by means of ground-based GPS receivers (PWV). The potential for GPS to detect PWV has been well demonstrated. Agreements at the level of 1–2 mm of PWV between GPS, radiosonde, and microwave water vapor radiometers (WVR) have been reported in previous research. Since the infrared satellite techniques only work in the absence of significant cloud

cover and radiosonde measurements are made mainly over the land and are hardly available over the Eastern Africa region, the availability of relative large number of GPS ground receivers over the Eastern Africa region may serve to establish more accurate estimation of vertically integrated water vapor in the atmosphere over the region. Atmospheric precipitable water is derived from ground-based GPS receivers network using GAMIT software and the results are compared with that from ERA-Interim reanalysis dataset. Seasonal and diurnal variations of the two datasets are analyzed. It has also been found that general circulation model has dry bias over lowlands and wet bias over highlands while the correlations between the two datasets generally exceed 0.8 at different time scales. Moreover, the differences between PWV derived using empirical global pressure and temperature (GPT) model and the numerical weather model-based Vienna Mapping Function are also described.

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**36** [1453373]

### Equatorial $F_1$ layer and modelling of the height of its occurrence

Olalekan David Ayokunnu[1], and Jacob Olusegun Adeniyi[2]

[1]Physics, The Polytechnic, Ibadan, Nigeria
[2]Physics, University of Ilorin, Ilorin, Nigeria

The Radicella-Mosert (1991) formula for the prediction of the peak of height $F_1$ layer ($h_mF_1$) was verified. The values of $h_mF_1$ given by this formula are lower than the observed values. The model was modified in order to improve the predictions of $h_mF_1$. The data used throughout this work are those of years of low solar activity with an average sun spot number. The data are for Korhogo, Côte d'Ivoire, 1995, with geographical latitude and longitude 9.3ºN 5.4ºW respectively and dip 0.67ºS. The modified model was tested with data from Ouagadougou, 1995 (12.4ºN, 1.5ºW), an equatorial region and was found to describe the values of $h_mF_1$ better than Radicella-Mosert formula. A further tests were carried out on the modified formula, using data from Ouagadougou, 1994 and Ilorin, Nigeria, 2010 (8.5ºN, 4.5ºE and magnetic dip 4.1ºS).

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**37** [1452595]

### Challenges from low level tropical fluctuations of space weather

Shelton Y. Beedoe[1]

[1]Physics, University of Liberia, Monrovia, Liberia

There are huge fluctuations in space weather over the West African country of Liberia. It is not yet investigated if the sources can be linked to the specific nature of the rain forest tropical zone that characterizes the region or high altitude fluctuations can be linked. An important goal is to involve students (and recent graduates who are teaching assistants) within the Physics Department at the University of Liberia in the study of space whether effects on the tropical rain forest. A discussion on the observed changes of weather and pictorial presentation will be made.

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**38** [1449333]

### Planetary waves during a moderate geomagnetic storm

Teferi Dejene Demissie[1], Nora Kleinknecht[1], Marianne Daae[1], and Patrick Espy[1]

[1]Physics, Norwegian University of Science and Technology (NTNU), Trondheim, Norway

Nightly averaged measurements of the ozone mixing ratio profile obtained from Troll station (72°1'S, 2°32'E) in Antarctica have been used to investigate the presence and vertical profile of the 2-day planetary wave in stratosphere and mesosphere (50 to 80 km) during a moderate geomagnetic storm in July 2009. Nightly averaged mesospheric temperature derived from the hydroxyl nightglow at Rothera station (67°34'S, 68°08'W) and Dst index are used to characterize the moderate geomagnetic storm. The variations of planetary waves with the changes in ozone mixing ratio and temperature are discussed, and the phase and amplitude variation of the 2-day wave before, during and after the moderate geomagnetic storm are presented.

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**39** [1449531]

**West African weather system in the development of tropical cyclones**

Tairu Salami[1]

Weather Forecasting Services, Nigerian Meteorological Agency, Egbe, Lagos, Nigeria

Tropical cyclones have their origins from areas of low atmospheric pressure over warm waters in the tropics or subtropics. We have carefully studied the interconnection between the West African Weather Systems (WAWS) and their subsequent development into Tropical Cyclones. Between 2004 and 2005, we studied the interconnection and the teleconnection between the WAWS and the various occurrences of Tropical Cyclones and their eventual development into Hurricanes. We noted that critical synoptic characteristic and the environmental properties of the Systems; the thermodynamic conditions of the storms trajectory and the conditions of the ocean are all closely linked. It is therefore believed that proper understanding and monitoring of these systems will play a very vital role in early detection of potential WAWS that may develop into Tropical Cyclones and even Hurricanes. More practical issues will be presented. It was recorded that over the period 1992-2001, weather and climate-related disasters especially those of Tropical Cyclones origin killed about 622,000 people, affected more than two billion, left millions more homeless, devastated.

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**40** [1449116]

**First observation of mesospheric and thermospheric winds by a Fabry-Perot interferometer in China**

Wei Yuan[1], Jiyao Xu[1], Qian Wu[2], RuiPing Ma[1], GuoYing Jiang[1], Hong Gao[1], Xiao Liu[1], Sunzheng Chen[1]

[1]Center for Space Science & Applied Research, Beijing, China

[2]High Altitude Observatory, National Center for Atmospheric Research, Boulder, CO, USA

A Fabry-Perot interferometer, funded by the Meridian Project in China, was deployed at the Xinglong station (40.2°N, 117.4°E) of the National Astronomical Observatories in Hebei Province, China. The instrument has been operating since April 2010, measuring mesospheric and thermospheric winds. The first observational data of winds at three heights in the mesosphere and thermosphere were analyzed, demonstrating the capacity of this instrument to aid basic scientific research. The wavelengths of three airglow emissions were OH892.0, OI 557.7, and OI 630.0 nm, which corresponded to heights of 87, 98, and 250 km, respectively. Three 38-day data sets of horizontal winds, from April 5, 2010 to May 12, 2010, show clear day-to-day variations at the same height. The minimum and maximum meridional winds at heights of 87, 98, and 250 km were –16.5 to 8.7 m/s, –24.4 to 15.9 m/s, and –43.6 to 1.5 m/s. Measurements of zonal winds were –5.4 to 7.6 m/s, 2.3 to 23.0 m/s, and –22.6 to 49.3 m/s. The average data from the observations was consistent with the data from HWM93. The wind data at heights of 87 and 98 km suggest a semi-diurnal oscillation, clearly consistent with HWM93 results. Conversely there was a clear discrepancy between the observations and the model at 250 km. In general, this Fabry-Perot interferometer is a useful ground-based instrument for measuring mesospheric and thermospheric winds at middle latitudes.

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**41** [1453203]

**Using space based GNSS technology for atmospheric temperature and moisture analysis in Australia.**

Birtukan S. Biadglgne[1], John Le Marshall[2], Kefei Zhang[3], Witold Rohm[3], Falin Wu[3], Toby Manning[3], and Yuan Yubin[3]

[1]Climate & Water, Australian Bureau of Meteorology, Melbourne, VIC, Australia
[2]Centre for Australian Weather and Climate Research, Australian Bureau of Meteorology, Melbourne, VIC, Australia
[3]School of Mathematical and Geospatial Sciences, RMIT University, Melbourne, VIC, Australia

Monitoring environmental and climate change from space requires high precision and accuracy earth observations. In recent years, the revolution in GPS technology has resulted in a powerful, inexpensive new technique with capabilities of providing high temporal and spatial resolution data for sounding the atmosphere in all weather and over both land and water. GPS meteorology provides a record of high quality measurements of atmospheric parameters (temperature, pressure, specific humidity) essential for meteorological, climate, environmental and disaster prevention applications. Atmospheric information is retrieved using GPS technology by two distinct measurement techniques, namely, GPS radio occultation (GPS RO) and 'ground-based GPS' measurements. GPS RO is a satellite-to-satellite, limb sounding technique based on measuring the bending of GPS radio signals in the atmosphere. The GPS radio signals are bent or refracted when propagating through the Earth's atmosphere. This information can then be used, assuming a spherical symmetry, to yield refractive index profile and subsequently temperature profile of the atmosphere. The second measurement technique is ground based GPS. This technique is the ground based version of the above mentioned space born system. The Global

Positioning System (GPS) signals experience a propagation delay when passing through the atmosphere to a receiver near the surface of the Earth. The time delay for a signal to propagate from transmitter to a receiver is converted to provide an estimate of the total integrated water vapour in the vertical column above a receiver on the Earth's surface. An accuracy of ~1 mm can be obtained using the technique. In Australia, the space based (RO) and ground-based GPS measurement technique for meteorology (NWP), and climate monitoring has been assessed through research and demonstrated operational activities. Its positive impact on operational weather forecast models, temperature profiling capability, and its agreement with radiosonde sounding measurements indicates the technique's potential capability in meteorological applications. Since 2006, The Bureau of Meteorology has collaborated with RMIT on GPS RO and GPS Ground based research and experimental development. This paper presents comparison of atmospheric profiles of temperature and water vapour derived from LEO satellites with radiosonde measurements from selected locations in Australia, and comparison of ground base GPS derived water vapour with radiosonde datasets obtained from the Australian Bureau of Meteorology (BOM) upper air archive. Statistical and visual comparison shows that the difference between radiosonde observations and the data retrieved from GNSS are well within acceptable limits, confirming its usability as a meteorology data source.

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**42** [1453861]

**A modified SHAO-C tropospheric delay correction model for Ethiopia**

Gizaw Mengistu Tsidu[1] and Yohannes Getachew[1]

Physics, Addis Ababa University, Addis Ababa, Ethiopia

The troposphere affects electromagnetic signal propagation causing signal path bending and the alteration of the electromagnetic wave velocity. Tropospheric delay can introduce a considerable error in satellite positioning if it is not properly estimated. The GPS signal delay can vary from 2 to 20 m depending on the elevation angles between the receiver and the satellite. In this work, the spatial and temporal variations of the zenith tropospheric delay (ZTD), especially their dependence on altitude and latitude over Ethiopia, are analyzed using ECMWF (European Centre for Medium-Range Weather Forecast) pressure-level atmospheric data and compared with ZTD time series for 5-year period from 2007-2011 measured at several GPS stations from the Crustal Movement Observation Network of over Great Rift Valley regions of Eastern Africa which are managed by UNAVCO. A modified version of tropospheric delay correction model, SHAO-C used in China, is established for Ethiopia. ZTD is modeled directly by a cosine function together with an initial value and an amplitude at a reference height in each grid, and the variation of ZTD along altitude and latitude is fitted with a second-order polynomials. The coefficients of the modified SHAO-C are generated using the ECMWF ERA-Interim data at 0.75x0.75 degree latitude-longitude grid, featuring regional characteristics in order to facilitate a wide range of navigation and other surveying applications. The altitude is obtained from high resolution digital elevation model (DEM). The results are assessed for fulfilling the requirements of most GNSS navigation or positioning applications in terms of the tropospheric delay correction.

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**43** [1453308]

**Morphological studies on ionospheric VHF scintillations over an Indian low latitude station during a solar cycle period (2001-2010)**

Venkatesh Kavutarapu[1], Paluri Venkata Sri Rama Rao[1], and Prasad S. Dasari[1]

[1]Physics, Andhra University, Visakhapatnam, Andhra Pradesh, India

The amplitude scintillations data recorded at 244 MHz from the geostationary satellite, FLEETSAT (73ºE) at a low latitude station, Waltair (17.7ºN, 83.3ºE) during the ten year period of high to low solar activity from 2001 to 2010 is considered to study the occurrence characteristics of the VHF scintillations. A close association between the intense scintillations on VHF signals during pre-midnight hours, associated with range type of spread-*F* on ionograms and a relatively weak and slow fading scintillations during post-midnight hours associated with frequency type of spread-*F* is observed during the relatively high sunspot years from 2001 to 2004, whereas during the low sunspot years from 2005 to 2010 the scintillation activity as well as spread-*F* activity are found to be minimum. During both the high and low sunspot years, it is observed that the maximum scintillation activity occurs during equinoctial months followed by winter with the minimum occurrence during summer months. The annual mean percentage occurrence of scintillations is found to be clearly associated with the variations in the annual mean sunspot number. The nocturnal variations in the occurrence of scintillations show the onset of scintillation activity starts from 19:00 hrs LT with maximum of occurrence around 21:00 hrs LT. A clear semiannual variation in the occurrence of scintillations is observed during pre-midnight hours with two peaks in equinoctial months of March/April and September/October. The number of scintillation patches observed is found to be more during pre-midnight hours compared to those during post-midnight hours. The most probable scintillation patch duration lies around 30 minutes.

Further, it is found that the number of scintillation patches with durations of 60 minutes and more decreases with the increase in the patch duration. It is also observed in general that the scintillation activity is inhibited during geomagnetic disturbed days.

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**44** [1451968]

**Diurnal variation of total electron content at Makerere University during 2010**

Florence Mutonyi D'ujanga[1] and Benon Fred Twinamasiko[1]

[1]Physics, Makerere University, Kampala, Uganda

Diurnal variations in the total electron content (TEC) at Makerere University (00º19'N, 32º40'E, Geo Dip -22º), Uganda, have been investigated using a NovAtel GSV400B GPS receiver for the year 2010. The highest TEC values occurred from 13h00 to 17h00 local time (LT) throughout the year, with the highest values being exhibited during equinoctial months. In addition, there was some correlation between this high TEC and the moderate storms that occurred in 2010. These high TEC values have been attributed to the solar EUV ionization coupled with the upward vertical **E × B** drift. Nighttime enhancements were also found to be seasonally dependent, attaining maximum values during equinoctial months. Observed TEC depletions were found to correlate with an increase in the $S_4$ index and have been identified as a manifestation of the plasma density depletions of the equatorial origin.

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**45** [1452337]

**Low latitude plasma density depletions over South America and Africa near solar minimum**

Edgardo Pacheco[1], Endawoke Yizengaw[1], Vadym Paznukhov[1], Cesar Valladares[1], and Charles Carrano[1]

Institute for Scientific Research, Boston College, Chestnut Hill, USA

The equatorial and low-latitude ionospheric irregularities have been of great interest for the scientific community. However, there are significant gaps in the global understanding of the physics behind the formation of ionospheric irregularities/bubbles; especially the cause of its longitudinal variability is still not completely understood. In this paper, using the global positioning system (GPS) total electron content (TEC) data, we present the longitudinal variability of the plasma density depletion, believed to be the signature of the bubbles, near the magnetic equator and 20 degrees south of the magnetic equator over the South American and African regions. We also performed the statistical distribution of plasma bubbles occurrence probability as a function bubble depth (in TEC unit), local time coverage, time extent, and seasons. We utilize the GPS TEC measurements from the LISN, SCINDA, and IGS networks to investigate the occurrence probability and characteristics of the low-latitude density irregularities/bubbles at different longitudes near solar minimum during 2011. Furthermore, we independently performed, using GPS and UHF measurements, the longitudinal variability of the occurrence probability of the scintillations and associate it with the longitudinal variability of ionospheric irregularities/bubbles over the same regions.

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**46** [1453586]

**Characterization of variability of total electron content (TEC) over Malindi**

George Ochieng Ondede[2, 1], Paul Baki[2], Sandro M. Radicella[3]

[1]Physics and Material Science, Maseno University, Maseno, Nyanza, Kenya
[2]Technical and Applied Physics, The Kenya Polytechnic University College, Nairobi, Kenya
[3]ICT for Development Laboratory, The Abdus Salam International Center for Theoretical Physics (ICTP), Trieste, Italy

The Ionosphere affects communication such as for television, radio, and Global Navigation Satellite System (GNSS). Its dynamics depend largely on solar activity. The attenuation of radio signals as they propagate through the ionosphere can be determined through a parameter called the Total Electron Content (TEC), which is a measure of the number of electrons along a line of sight. The variability of TEC is critical around the dip equatorial region especially within 15 degree North and South where we experience anomalously enhanced Total Electron Content in the ionosphere. This study focused on the characterization of the variability of TEC over Malindi, Kenya (03.03ºN, 40.13ºE), which lies within the dip equatorial region, with goal of coming up with a morphological description of TEC that would be useful in the understanding of the space weather conditions over Kenya. The objectives of the study were to obtain the plots of TEC against time for each day of the four months, January, April, July and October of the years 1999, 2000, 2001 and 2002 and to characterize the variability of the TEC during the period of study. The Global positioning System GPS data was obtained from the Malindi

station, being one International GNSS Service (IGS) station with the highest data availability in Kenya. The plots of TEC against time of the day were obtained for the entire period and then characterized according to time of the day and selected months of the years. From the research, it was evident that the TEC variability depended on the solar activity. The diurnal variability was greatest during the early morning and late evening hours of the local time and minimum during the midday and midnight. The monthly variability was greatest in April, moderate in October and least in January and July. There was observed enhanced nighttime variability just before midnight as well. The observations were so because the two months, April and October just came a few days after the equinoxes when the sun was directly over the equator while the months of January and July just came after the solstices. Of the four years studied, 2000 and 2001 experienced the highest level of TEC variability. The year 2001 was the peak season in the solar cycle. The enhanced nighttime variability was because of an enormous nighttime electron content increase. The information would be available to the aviation industry, the marine industry, the communication service providers, and many other establishments whose operations depended on the space weather conditions.

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**47** [1451355]

**Longitudinal variability of EEJ from new equatorial observations in India**

Phani Chandrasekhar Nelapatla[1, 2], Kusumita Arora[1], and Nandini Nagarajan[1]

[1]INTERMAGNET Geomagnetic Observatory, National Geophysical Research Institute, Hyderabad, Andhra Pradesh, India
[2]Geophysics, Andhra University, Vishakhapatnam, Andhra Pradesh, India

Recent magnetic observations from satellites enabled the estimation of East-West current distribution indicating that intensity of the Equatorial Electrojet (EEJ) varies strongly from day-to-day. The data from various satellite and ground based observatories led to models of the EEJ day-to-day variability as a function of longitude, local time, season and solar flux [1].These models indicate short longitudinal correlation lengths of 15 degree and finding a temporal correlation length of 2.4 hours [2; 3]. Such findings provide fresh impetus for real time observation of the EEJ along the dip equator. The data from new two remote equatorial sites {Campbell Bay (CBY; dip: -0.02, 93 deg.E) Great Nicobar & Vencode (VEN; dip: 0.08, 77 deg.E), India} (separated by 15 deg.E) along with low-latitude sites Hyderabad (HYB; dip; 0.20, 78 deg.E) and Port Blair (PBR; dip: 0.08, 92 deg.E) shown in Fig (a) are used to monitor variability of the EEJ in the present study. The average peak current density exhibits a clear dependence on longitude with peaks showing up first at CBY followed by VEN. 5-minute averages of ΔX1 (VEN-HYB) and ΔX2 (CBY-PBR) are used in the present study for D-months (Nov, Dec-2010; Jan, Feb, Nov, Dec-11, Jan & Feb-12). Analysis of the data of Quiet and Disturbed days shows large day-to-day variability between the two longitudes. The noon time peak is found to be larger at 93 deg. than 77 deg. during the entire period which fits with the EEJ climatological model [2]. Instances of Counter Electrojet (CEJ) during this period have been noted. Some instances of the CEJ correspond to the turning of Interplanetary Magnetic Field (Bz) from South to North. Degree of longitudinal variability can be seen in Fig (b) where ΔX1 and ΔX2 shows the CEJ intensities and compared with Bz on 11th Dec 2010. Two interesting observations are drawn during this period of study. 1) The CEJ effect is identical between the two longitudes on particular days, results more negative depression at 77 deg. compared to 93 deg. in all instances. 2) The observed CEJ on some days is not evident in CBY which is at VEN; what is evident at CBY is not at VEN. The Real Time Ionospheric Model & Interplanetary Electric Field are compared to distinguish between instances of prompt penetration and CEJ. For this data set, instances of CEJ and penetration are identified and classified according to their possible causes. Continued observations may be able to produce patterns which can be explained by wind models and also yield information on the coupling of the electric currents and magnetic events. Keywords: Equatorial Electrojet and Counter Electrojet.

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**48** [1452653]

**Variation of total electron content [TEC] and ionospheric scintillations their effects on GNSS over Akure, Nigeria**

Sola Rufus Fayose[1] and Babatunde Rabiu[2, 3]

[1]Physics and Electronics, Adekunle Ajasin University, Akungba Akoko, Nigeria
[2]Engineering and Space Systems, National Space Research and Development Agency, Abuja, Nigeria
[3]Space Physics Laboratory, Federal University of Technology, Akure, Nigeria

The effect of Space weather is usually linked to disturbances in the ionosphere (gradients in the total electron content (TEC) and Scintillations). This has significant effect especially for GPS users causing degradation in range measurements, loss of lock by the receiver of the GPS signal. For differential GPS (DGPS) or real time kinematic (RTK) users, differences over

the baseline as small as 2 TEC units, where one TEC unit is 1016 electrons/$m^2$, can be problematic in resolving ambiguities. Though quite a lot has been done in the developed nations in this respect, there is a dearth of such information for the developing region. This paper therefore presents the variation of total electron content (TEC) over a tropical in at Akure, Nigeria (7.15 N, 5.12 E) using GPS data collected over a period of one year.

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**49** [1453224]

**Altitudinal variations of ionospheric irregularities over Indian longitudinal sector using satellite-based observations**

Potula Sree Brahmanandam[1, 2] and Y. H. Chu[1]

[1]Institute of Space Science, National Central University, Chung-Li, Taiwan
[2]ECE, K L University, Vaddeswaram, India

It is known that no consensus has so far been established among community on the generation mechanism of ionospheric plasma blobs and their relationship with plasma bubbles at different altitudes. On the other hand, it has been well accepted through plentiful of observational evidences are that the plasma blobs always appear at higher magnetic latitudes i.e., ~ between ±050 and ±200 from the magnetic equator. By effectively using the unique combination of Challenging Mini satellite Payload (CHAMP), Republic of China Satellite (ROCSAT-1), and Defense Meteorological Satellite Program (DMSP) satellites located at ~400 km, 650 km, and 850 km respectively, a case study is carried-out on the altitudinal variations of ionospheric irregularities during the post-sunset periods at the Indian longitude between 14 and 17 October 2001. It became possible for us to study the width of plasma bubble and plasma blobs in the longitudinal (zonal) direction at different altitudes along with the temporal variations of ion velocity components in horizontal (Vy) and vertical (Vz) directions probed by the ROCSAT-1 and DMSP satellites. The width of plasma bubbles/blobs is the scale size of the bubble/blob in the zonal direction, or the distance between west and east wall/boundary of the bubble and the sharp decrease/increase of the ion density from its background value can be considered to determine the boundary of the plasma bubble/blob [*Huang et al.*, 2011]. The dominant features noticed in Vy and Vz components are their anti-correlation relationship at ROCSAT-1 satellite altitude, which often called as mirroring effect [*Behnke and Harper*, 1973]. The most important observation from this study is that plasma bubbles are found to be observed immediately after post-sunset hours, while plasma blobs observed after three hours' time till pre-sunrise hours at higher altitudes ~ between ±050 and ±200 from the magnetic equator, which implying that the plasma blobs emanate from plasma bubbles that generated at the bottomside of ionospheric *F* layer shortly after sunset. It is believed that the polarization electric fields generated inside the plasma bubbles will play a role in the generation of wider plasma bubbles and higher altitude plasma blobs. Key words: Plasma Bubble, Plasma Blob, Polarization electric fields, and wide-plasma bubbles.

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2. Huang, C. S., O. de la Beaujardière, P. A. Roddy, D. E. Hunton, R. F. Pfaff, C. E. Valladares, and J. O. Ballenthin (2011), Evolution of equatorial ionospheric plasma bubbles and formation of broad plasma depletions measured by the C/NOFS satellite during deep solar minimum, *J. Geophys. Res.*, 116, A03309, doi:10.1029/2010JA015982.

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**50** [1447405]

**Total electron content as index of total ionospheric response to magnetic activity at two stations within Equatorial Anomaly**

Rasheedat B. Abdulrahim[1, 2] and Babatunde Rabiu[1]

[1]Research and Development, National Space Research and Development Agency/Centre for Satellite Technology Development, Abuja, Nigeria
[2]National Space Research and Development Agency/Centre for Satellite Technology, Abuja, Nigeria

GPS measurements recorded at two stations closely located along same latitude but separated by almost longitudes of 5 degree - Yola (9º14'N, 12º28'E) and Abuja (9º12'N, 7º11'E), Nigeria, were analyzed to obtain the total electron content (TEC) values. The station of study falls within the equatorial anomaly region. The TEC was used to as index to investigate the local ionospheric response to magnetic activity. Different magnetic activities such as low (Dst > -20 nT); medium (-20 nT > -50 nT); high (-50 nT >DA-100 nT), and extreme (Dst < -100 nT) were identified with specific ranges of TEC values. The variability of this TEC index with hours and seasons were investigated. TEC index has some levels of correlation with existing magnetic indices. Measured TEC could serve as proxy for monitoring ionospheric responses to magnetic activity.

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**51** [1452568]

**Spatiotemporal variability of Ionospheric TEC over equatorial low latitude Indian Sub-Continental region during solar and geomagnetic events: An investigation with ground based GPS data analysis.**

Sampad Kumar Panda[1] and Shirishkumar S. Gedam[1]

Centre of Studies in Resources Engineering (CSRE), Indian institute of Technology Bombay, Mumbai, Maharastra, India

The Indian sub-continental region covers the equatorial zone in the South-Asian longitudes with the magnetic equator passing through underneath of the country near Trivandrum and equatorial ionization anomaly (EIA) crest approximately lying in the center around the line joining Kolkata and Ahmedabad. Being present near equatorial and low latitude region, the ionosphere above it is significantly different from middle and high latitude ionosphere exhibiting many unique characteristics in density and temperature like plasma fountain, ionization anomaly, wind and temperature anomaly, scintillations etc. The horizontal orientation of the geomagnetic field lines at the equator and the shift between the geographic and geomagnetic equator is the main reason for observation of these features and their longitudinal variation [*Bhuyan et al.*, 2005]. During the space weather events like solar flares, geomagnetic storms and severe scintillation conditions, the equatorial ionosphere becomes highly disturbed with rapid fluctuation of TEC causing severe phase fluctuations of received signals near the equatorial region. The geomagnetic storm is a significant space weather phenomenon resulted from the activities of the global magnetosphere–ionosphere–thermosphere system due to interplanetary magnetic field driven by solar wind move southward and continues for extended period of time. During geomagnetic storms the electron density may either enhance (positive ionospheric storm) or decline (negative ionospheric storm), and this significant disturbed behavior is commonly known as the ionospheric storm (Buonsanto, 1999). With the opportunity of full constellation GPS satellites wrapping around the globe, now it is possible to inspect regional even global ionosphere from signature on the signals. During the decline phase of 23rd solar cycle, there were many large intense solar flares causing interplanetary magnetic field to be most disturbed leading to intense geomagnetic storms. From the simultaneous observations of carrier phase and pseudorange measurements in a dual frequency GPS receiver, the epoch-wise 2-sigma iterated mean vertical Total Electron Content (VTEC) is calculated at each of the stations showing significant changes in ionospheric electron density during the events. The spatio-temporal variation of TEC during the occurrences are compared with previous and successive quiet days and correlated with interplanetary magnetic field (IMF-Bz) and geomagnetic indices (Dst & Kp indices) to investigate the effects. The results are also evaluated by taking Faraday rotation data elements of Geostationary Operational Environmental Satellite (GOES) and routinely published Global Ionosphere Maps (GIM) by International GPS Service (IGS) Ionosphere Working Group (Iono_WG). The auroral electrojet strength (AE), solar sun spot numbers are recorded to strengthen the results of the analysis the events occurred in the past years. The results of major events occurred in the previous solar cycles will be shown by observing the available GPS data as well as ancillary datasets.

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**52** [1453277]

**A comparison of IRI-TEC predictions with GPS-TEC measurements over Nsukka, Nigeria**

Bonaventure Iheanyichukwu Okere[1, 2], Daniel Izukanachi Okoh[1, 2], Perpetua Chinelo Okonkwo[1, 2], Pius Nwankwo Okeke[1, 2]

[1]Radio Astronomy, Centre for Basic Space Science, University of Nigeria, Nsukka, Nigeria
[2]Physics and Astronomy, University of Nigeria Nsukka, Nigeria

The International Reference Ionosphere (IRI) model has been widely adopted as the international standard for specifying ionospheric parameters. An evaluation on the performance of the IRI model over Nsukka, Nigeria (6.87ºN, 7.38ºE) is presented in this work. We compare TEC values for 2010 from the IRI model with corresponding TEC data from the SCINDA-GPS receiver installed at Nsukka so as to evaluate the performance of the model over the region. The work shows that data from these equipment is proposed for use in TEC modelling over the African continent together with the IRI model. And knowledge on the performance of the IRI over various regions of the continent will inform the extent to which the model will be used. Our results show very good diurnal correlations (above 85%) between the IRI-TEC prediction and the GPS-TEC measurements for the year examined.

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**53** [1453200]

**Multi-instrument study of ionospheric irregularities over Indian and Indonesian longitude sectors during November 2011**

Potula Sree Brahmanandam[1, 2] and Phani Chandrasekhar Nelapatla[3]

[1]Institute of Space Science, Chung-Li, Taiwan
[2]ECE, K L University, Vaddeswaram, India
[3]Geomagnetic Observatory, CSIR- National Geophysical Research Institute, Hyderabad, India

This multi-instrument study reports on the results of amplitude scintillations at 250 MHz recorded at Vaddeswaram, VDD (Geographic lat. 16.31ºN, Geographic long. 80.3ºE, Dip 18ºN), a typical low-latitude station in India, vertical drifts (E x B drifts) and diurnal variations of h'F (virtual height of the bottomside *F* region) as observed using a digital ionosonde (DPS-4D) from an Indian equatorial station Trivandrum, TRV (Geographic lat. 8.5ºN, Geographic long. 77ºE, Dip 0.5ºN) along with equatorial electrojet (EEJ) ground strength measured using magnetometers during 05-08 November 2011. The interesting observations of this study are that the higher **E × B** drifts, occurrence of long-duration range-type spread *F* at TRV (>4.5 hours) and scintillations at VDD (>3.5 hours), the presence of plasma depletions in total electron content (TEC) data initially at Tirunelveli, TRL (Geographic lat. 8.5ºN, Geographic long. 77ºE, Dip 0.5ºN), an equatorial station, followed by at Bangalore, BLR (Geographic lat. 13.02ºN, Geographic long. 77.57ºE, Dip 6.0ºN), a low-latitude station, and later at Calcutta, CLC (Geographic lat. 22.58ºN, Geographic long. 88.38ºE, Dip 320 N), an anomaly crest station, along with wide-plasma bubbles (longitudinal/zonal widths of them are higher than 150 km) starting from 73ºE to 90ºE longitudes during post-midnight times as observed by the Communication/Navigation Outage Forecasting System (C/NOFS) satellite on 06 November 2011. The secondary peak around 1600 LT in EEJ strength followed by a high upward drift velocity (more than 60 m/s) with a significant raise of the *F* region up to 470 km over the magnetic equator on 06 November indicating that the daytime EEJ ground strength might have played a crucial role on the *F*-region electrodynamics so as to initiate the ionospheric irregularities, scintillations and wide-band plasma bubbles. In addition, except on 06 November the rest of the days (05, 07 and 08 November) did not show any field-aligned-irregularities (FAI) scattered from 3-meter irregularities as measured by the 47 MHz Equatorial Atmospheric Radar (EAR) located at Kototabang (0.20ºS, 100.3ºE, Dip 10.36ºS) in West Sumatra, Indonesia, implying that the electrodynamics during post sunset time over Indian and Indonesian longitudes is strong enough to produce ionospheric irregularities on 06 November 2011. The present study reinforces the notion that the nighttime equatorial upper atmospheric phenomena may be influenced by those that occur during the presunset period [*Prakash et al*., 2009]. Keywords: Range spread-*F*, Scintillations, C/NOFS satellite, and equatorial electrojet strength.
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**54** [1453292]

**International Reference Ionosphere (IRI) and global positioning system (GPS) Total Electron Content (TEC) variations over Ilorin, Nigeria**

Perpetua Chinelo Okonkwo[1], Joseph C Ugwuanyi[1], Daniel Izukanachi Okoh[1], Bonaventure Okere[1]

[1]Physics and Astronomy, University of Nigeria. Nsukka, Nigeria

Diurnal and day-to-day variations of Vertical Total Electron Content (VTEC) over an equatorial region (Ilorin, Nigeria; Geographic 8.50ºN, 4.55ºE; Geomagnetic 10.60ºN, 78.41ºE) is presented in this paper using data from the IRI model and from the AFRL-SCINDA (Air Force Research Laboratory - Scintillation Network Decision Aid) GPS receiver installed at the Ilorin station. A comparison between VTEC data from the two sources is also presented since a major concern in the work is to use available GPS-TEC data for year 2010 to evaluate the performance of the IRI model in TEC prediction over the region, and to therefore inform a proposed use of the IRI model in TEC modeling over the African region. Our results show generally good comparisons between the IRI TEC predictions and the GPS TEC measurements, results from the comparisons on diurnal basis were, as expected, better than those on day-to-day basis. The work also indicated that the lower TEC thresholds of the IRI predictions for the days observed occurred at around 04:00 UT while for the GPS measurements occurred at around 05:00 UT. Key words: Total electron content; GPS TEC; IRI TEC; International Reference Ionosphere; Ilorin ionosphere; AFRL-SCINDA GPS.

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**55** [1453350]

**Effects of the ionospheric activity on the positioning accuracy**

Rui M. S. Fernandes[1], Sanit Arunpold[2], Nitin Tripathi[2], Durairaju Kumaran Raju[3], Machiel Simon Bos[4], Keith Groves[5], and Ronald Caton[6]

[1]SEGAL, University of Beira Interior/IDL, Covilha, Portugal
[2]AIT, Bangkok, Thailand
[3]TMSI, NUS, Singapore, Singapore
[4]CIIMAR, Porto, Portugal
[5] Institute for Scientific Research, Boston College, Chestnut Hill, MA, USA
[6]Space Vehicles Directorate, Air Force Research Laboratory, Kirtland AFB, NM, USA

The TIRA (Towards Ionospheric Research in Asia) project has the goal to contribute for the development of Ionospheric studies in South-East Asia by using space-geodetic systems, in particular by analyzing data acquired using dedicated or available GNSS (Global Navigation Satellite Systems) networks. It is contributing directly for the current activities carried out in the framework of the SCINDA (Scintillation Network Decision Aid) project, which is being implemented by AFRL (Air Force Research Laboratory) in South-East Asia. TIRA is investigating the effects of scintillation in dense GNSS networks. Additionally, TIRA is playing a major role in the densification and maintenance of the network of SCINDA GNSS stations being currently installed in the region. Finally, TIRA intends to improve the scientific knowledge on ionosphere research and GNSS data processing of the partners that are collaborating with AFRL in the region. In this work, we present the initial results of the investigation being carried out concerning the effect of ionospheric activity in positioning using dense networks of stations. We used data from the Singaporean SiReNT network, which currently is formed by seven stations distributed over an area of approximately 50 km by 25 km. We compare the positioning solutions in single mode (using the GIPSY-OASIS software package with the Precise Point Positioning strategy) and in differential mode (using TBC, a commercial software). We also compare the results obtained using a dedicated software (RINEX_HO) developed to correct the GPS observables for second- and third-order ionosphere effects. We show that the improvement is marginal for most positioning applications, namely for surveying, but that can slightly improve the accuracy of the derived time-series.

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**56** [1453946]

**Space science education in the 21st century: The place of educationists and researchers**

Theodora Olufunke Bello[1] and Etim Okon Offiong[2]

[1]Institute of Education, Obafemi Awolowo University, Ile-Ife, Niger
[2]African Regional Center for Space Science and Technology Education in English (ARCSSTE-E), Ile-Ife, Nigeria

Space science and technology has been widely used to enable man to understand the earth better. The knowledge of it has remained the driving force behind most developed and developing economies because of its application in surveying and mapping, food security, health, disaster management, air, land and sea navigation, emergency response and wild life management. However, the necessary manpower with the required skills to bring about the realization of these applications are lacking especially in developing countries. The United Nations through her Office for Outer Space Affairs (UNOOSA) has set up four regional centers to develop indigenous capacity in space science and technology. Courses in Remote Sensing / Geographic Information Systems, Satellite Communications, Satellite Meteorology and Global Climate, and Basic Space / Atmospheric Physics are run by these centres. With the successes recorded so far, this paper attempts to review the impact the training has had on African scientists with the view to providing answers to the foregoing questions as well as pointing researchers to frontline research concerns: What opportunities are there for cooperation and collaboration between the GNSS research team and the regional centers in Africa? How can capacity building for researchers in Africa be improved? How can researchers harness available technological innovations in the industry especially in resource-challenged environment?

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**57** [1452997]

**Using Vpython and PhET simulations to teach ionospheric physics in Africa.**

Anthony Musumba Mwene[1], Martin Mason[2], and Dan Burns[3]

[1]Physics, Bismarck State College, Bismarck, ND, USA
[2]Physics, Mount San Antonio College, Ontario, CA, USA
[3]Physics, Los Gatos High School, Los Gatos, CA, USA

Vpython is an open source program, multi-platform and freely available. Vpython has been used extensively in US institutions to teach Introductory Physics courses because it eases students to programming by allowing students to write code that has a lot of physics with a few lines. There are a number of institutions that use Python for upper level computational courses. We seek to encourage and introduce Vpython to teach space science and astronomy in Africa. University of Cape Town in South Africa makes extensive use of Vpython in Undergraduate Physics courses. Dr. Akpojotor of Delta State University in Nigeria has also used Python for Undergraduate and Postgraduate training. Vpython is a great visualization tool that gets students involved in physics and programming in their formative undergraduate years.

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LONGITUDE AND HEMISPHERIC DEPENDENCE OF SPACE WEATHER

12–16 November 2012 | Addis Ababa, Ethiopia

# Participants

| *Last Name* | *First Name* | *Affiliation* | *Country* | *E-mail* | *Page(s)* |
|---|---|---|---|---|---|
| Abdulrahim | Rasheedat | National Space Res. & Dev. Agency | Nigeria | *bourlarnley@gmail.com* | 52 |
| Abebe | Alemau | Ethiopian Ministry of Science and Technology, Addis Ababa | Ethiopia | *alemuabebe2002@yahoo.com* | ii,38 |
| Abraha | Gebregiorgis | Addis Ababa Univ., Addis Ababa | Ethiopia | *ggabraha@yahoo.com.hk* | |
| Adediji | Adekunle | Federal Univ. of Technology, Akure | Nigeria | *kunleadediji2002@yahoo.co.uk* | 44 |
| Adejuyigbe | Oluwaloseyi | Univ. of Lagos, Lagos | Nigeria | *comiforte@yahoo.com* | 42 |
| Adekoya | John | Olabisi Onabanjo Univ., Ago Iwoye | Nigeria | *adekoyabolarinwa@yahoo.com* | 34 |
| Adeniyi | Jacob | Univ. of Ilorin, Ilorin | Nigeria | *segun47@yahoo.com* | ii,5,7,8,17,22,44,47 |
| Akala | Andrew | Univ. of Lagos, Lagos | Nigeria | *akalaovie2004@yahoo.com* | 3,16,22,36,42,43 |
| Alken | Patrick | Univ. of Colorado, Boulder, CO | USA | *alken@colorado.edu* | 5,23,45 |
| Amaeshi | Larry | Univ. of Lagos, Lagos | Nigeria | *larryamma@yahoo.co.uk* | 2,12 |
| Amory-Mazaudier | Christine | LPP/Polytechnique/UPMC/CNRS, Saint-Maur-des-Fossés | France | *christine.amory@lpp.polytechnique.fr* | 2,5,8,10,17,24,42 |
| Anad | Fatma | CRAAG, Algiers | Algérie | *f_anad@yahoo.fr* | 8,42 |
| Anderson | David | CIRES, Univ. of Colorado (NOAA/SWPC), Boulder, CO | USA | *david.anderson@noaa.gov* | 21 |
| Anderson | Phillip | Univ. of Texas at Dallas, TX | USA | *phillip.anderson1@utdallas.edu* | 20 |
| Arunpold | Sanit | AIT, Bangkok | Thailand | *sanit.arunpold@gmail.com* | 55 |
| Ayalew | Eliase | Addis Ababa Univ., Addis Ababa | Ethiopia | *eliaseayalew@ymail.com* | |
| Ayalew | Tibebu G. | Bahir Dar Univ., Bahir Dar | Ethiopia | *tib2010get@gmail.com* | |
| Ayokunnu | Olalekan D. | The Polytechnic, Ibadan | Nigeria | *davilek@yahoo.com* | 22,47 |
| Bailey | Scott | Virginia Tech, Blacksburg, VA | USA | *baileys@vt.edu* | 20 |
| Baki | Paul | Kenya Polytechnic Univ. College, Nairobi | Kenya | *paulbaki@gmail.com* | 29,50 |
| Basu | Sunanda | Boston College/Inst. Sci. Res., MA | USA | *sunanda.basu@bc.edu* | ii,1,8,9,15 |
| Beedoe | Shelton | Univ. of Liberia, Monrovia | Liberia | *drbeedoe@yahoo.com* | 47 |
| Bello | Theodora | Obafemi Awolowo Univ., Ile-Ife | Nigeria | *bledore@oauife.edu.ng* | 11,55 |
| Behnke | Richard | National Science Foundation | USA | *rbehnke@nsf.gov* | 1 |
| Berhane | Tsega | Addis Ababa University | Ethiopia | *selameykulu@gmail.com* | |
| Biadglgne | Birtukan | Australian Bureau of Meteorology | Australia | *bxb@bom.gov.au* | 48 |
| Brahmanandam | Potula | Institute of Space Sci., Chung-Li | Taiwan | *anand.potula@gmail.com* | 52,54 |
| Budzien | Scott | Naval Research Laboratory | USA | *budzien@nrl.navy.mil* | 41 |
| Buresova | Dalia | Inst. of Atmospheric Physics, Academy of Sciences, Prague | Czech Republic | *buresd@ufa.cas.cz* | 12,38 |
| Burrell | Angeline | Univ. of Texas at Dallas, TX | USA | *agb073000@utdallas.edu* | 3,14 |
| Caton | Ronald | AFRL/RVBXP, Kirtland AFB, NM | USA | *Ronald.Caton@kirtland.af.mil* | 5,7,28,31,55 |
| Chau | Jorge | Radio Observatorio de Jicamarca, Instituto Geofísico del Perú, Lima | Peru | *jorge.chau@jro.igp.gob.pe* | 6,24,25 |

| | | | | | |
|---|---|---|---|---|---|
| Cherniak | Iurii | West Department of Izmiran | Russian Federation | *tcherniak@ukr.net* | 41 |
| Chukwuma | Victor | Olabisi Onabanjo Univ, Ago Iwoye | Nigeria | *victorchukwuma@yahoo.com* | 3,15,34,35,36 |
| Cilliers | Pierre | SANSA Space Science, Hermanus | South Africa | *pjcilliers@sansa.org.za* | |
| Collier | Andrew | SANSA / UKZN, Hermanus | South Africa | *collierab@gmail.com* | 44 |
| Coster | Anthea | MIT Haystack Obs., Westford, MA | USA | *ajc@haystack.mit.edu* | 3,4,18 24,40 |
| Dandenault | Patrick | Naval Research Laboratory, Washington, DC | USA | *patrick.dandenault@nrl.navy.mil* | 41 |
| Damtie | Baylie | Washera Geospace and Radar Sci. Lab., Bahir Dar Univ., Bahir Dar | Ethiopia | | ii,3,10 27,40,45 |
| de Jesus | Rodolfo | Universidade do Vale do Paraíba, São José dos Campos, São Paulo | Brazil | *jesus.rodolfo@hotmail.com* | 35 |
| de la Beaujardière | Odile | AFRL/RVBXP, Kirtland AFB, NM | USA | *odile.delabeaujardiere@us.af.mil* | 7,25,29 |
| Delay | Bonnie | Boston College/Inst. Sci. Res. | USA | *delay@bc.edu* | |
| Demissie | Teferi | Norwegian Univ. of Science and Technology (NTNU), Trondheim | Norway | *teferi.demissie@ntnu.no* | 47 |
| Doherty | Patricia | Boston College/Inst. Sci. Res., MA | USA | *Patricia.Doherty@bc.edu* | ii,2,8,10 15,29,43 |
| Doumbia | Vafi | Université de Cocody à Abidjan | Côte d'Ivoire | *vafid@yahoo.fr* | 4,5,24 |
| Ekpa | Moses | Univ. of Nigeria, Nsukka | Nigeria | *ekpamoses@yahoo.com* | 46 |
| Elemo | Enoch | African Regional Centre for Space Sci. &Tech. Edu. in English, Ile-Ife | Nigeria | *enochelemo@yahoo.com* | 39 |
| Ezigbalike | Chukwudozie | UN Economic Commission for Africa, Addis Ababa | Ethiopia | *dozie@ezigbalike.com* | |
| Falayi | Elijah | Tai Solarin Univ. of Education, Ijagun | Nigeria | *olukayodefalayi@yahoo.com* | 11,45 |
| Fayose | Sola | Adekunle Ajasin Univ. | Nigeria | *sola.fayose@gmail.com* | 51 |
| Foster | John | MIT Haystack Obs., Westford, MA | USA | *jfoster@haystack.mit.edu* | 3,7,18 |
| Fritts | David | GATS/Boulder, Boulder, CO | USA | *dave@cora.nwra.com* | |
| Fuller-Rowell | Timothy | CIRES, Univ. of Colorado (NOAA/SWPC), Boulder, CO | USA | *tim.fuller-rowell@noaa.gov* | ii,2,8 26 |
| Gebremedhin | Asmelash | Addis Ababa Univ., Addis Ababa | Ethiopia | *asmea.mulu@gmail.com* | |
| Getachew | Yohannes | Addis Ababa Univ., Addis Ababa | Ethiopia | *john.yohannes@gmail.com* | 46,49 |
| Gogie | Tsegaye K. | Bahir Dar Univ., Bahir Dar | Ethiopia | *tsegaye8684@yahoo.com* | |
| Goker | Umit | Bogazici Univ. | Turkey | *deniz.goker@boun.edu.tr* | 35,38 |
| Goncharenko | Larisa | MIT Haystack Obs., Westford, MA | USA | *lpg@haystack.mit.edu* | 6,24,25 40 |
| Gopalswamy | Natchimuthuk | NASA Goddard Space Flight Center, Greenbelt, MD | USA | *natchimuthuk.gopalswamy-1@nasa.gov* | 1 |
| Groves | Keith | Boston College/Inst. Sci. Res., MA | USA | *keith.groves@bc.edu* | ii,7,8 15,28,55 |
| Guhathakurta | Madhulika | NASA Headquarters, Greenbelt, MD | USA | *Madhulika.Guhathakurta@nasa.gov* | 1 |
| Güyer | Sinan | Yildiz Technical Univ., Istanbul | Turkey | *sinanguyer@gmail.com* | 35 |
| Hao | Yongqiang | Peking Univ. | China | *yong.hao@gmail.com* | 45 |
| Heelis | Roderick | Univ. of Texas at Dallas, TX | USA | *heelis@utdallas.edu* | ii,3,14 15,24 |
| Holzworth | Robert | Univ. of Washington, Seattle, WA | USA | *bobholz@washington.edu* | 25,30,44 |
| Huba | Joseph | Naval Research Lab., Cheverly, MD | USA | *huba@ppd.nrl.navy.mil* | 7,24,30 |
| Ilma | Ronald | Cornell Univ., Ithaca, NY | USA | *rri5@cornell.edu* | 45 |
| Jakowski | Norbert | German Aerospace Center, Neustrelitz | Germany | *norbert.jakowski@dlr.de* | 3,7,8 16 |
| Joshua | Benjamin | Kebbi State Univ. of Science and Technology, Aliero | Nigeria | *wisdomworld04@yahoo.com* | 4,17 |
| Kaka | Olawumi | Afe Babalola Univ., Ekiti | Nigeria | *poloy2k2@yahoo.com* | 37 |

| | | | | | |
|---|---|---|---|---|---|
| Kavutarapu | Venkatesh | Andhra Univ., Visakhapatnam | India | *venkatkau@gmail.com* | 22,50 |
| Kelley | Michael | Cornell Univ., Ithaca, NY | USA | *mikek@ece.cornell.edu* | ii,25,29 43 |
| Klenzing | Jeffrey | NASA Goddard Space Flight Center, Greenbelt, MD | USA | *jeffrey.klenzing@nasa.gov* | 5,24 |
| Laštovička | Jan | Inst. of Atmospheric Physics, Academy of Sciences, Prague | Czech Republic | *jla@ufa.cas.cz* | 2,12,38 |
| Loughmiller | Pamela | Tembo Space Dynamics | USA | *pL53@cornell.edu* | 6,25 |
| Maeda | George | Intl. Ctr. for Space Weather Sci. & Education/Kyushu Univ., Fukuoka | Japan | *maeda@serc.kyushu-u.ac.jp* | 7,32 |
| Mahrous | Ayman | Space Weather Monitoring Ctr., Cairo | Egypt | *amahrous@helwan.edu.eg* | 4,6,20 |
| Mbane | César | Univ. of Yaoundé I, Yaoundé | Cameroon | *cesar.mbane@yahoo.fr* | 7,45 |
| McKinnell | Lee-Anne | SANSA Space Science, Hermanus | South Africa | *lmckinnell@sansa.org.za* | ii,2,3,8 9,37 |
| Meberatu | Alem | Adigrat Univ., Adigrat | Ethiopia | *alemmeb@gmail.com* | |
| Medard | Mene | Université de Cocody à Abidjan | Côte d'Ivoire | *medardmene@yahoo.fr* | 33 |
| Mengesha | Alemayehu | Bule Hora University, Bule Hora | Ethiopia | *alexye7@gmail.com* | |
| Mengistu | Gizaw | Addis Ababa University, Addis Ababa | Ethiopia | *gizaw_mengistu@gmx.net* | ii,1,2,3 10,13,46 49 |
| Meriwether | John | Clemson Univ., Clemson, SC | USA | *meriwej@clemson.edu* | 6,26 |
| Moldwin | Mark | Univ. of Michigan-AOSS, Ann Arbor, MI | USA | *mmoldwin@umich.edu* | 2,4,5 11,18,21 |
| Mwene | Anthony | Bismarck State Col., Bismarck, ND | USA | *musumba@gmail.com* | 56 |
| Nair | Manoj | CIRES, Univ. of Colorado (NOAA/NGDC), Boulder, CO | USA | *manoj.c.nair@noaa.gov* | 3,14 |
| Nedie | Abiyu | Univ. of Alberta, Edmonton | Canada | *nedie@ualberta.ca* | 33 |
| Nelapatla C. | Phani | National Geophysical Research Institute, Hyderabad | India | *phaninelapatla@gmail.com* | 51,54 |
| Ngwira | Chigomezyo | NASA Goddard Space Flight Ctr., MD/ Catholic Univ. America, Washington, DC | USA | *chigomezyo.ngwira@nasa.gov* | 4,19,37 |
| Nigussie | Melessew | Washera Geospace and Radar Sci. Lab., Bahir Dar Univ., Bahir Dar | Ethiopia | *melessewnigussie@yahoo.com* | 6,27,40 |
| Nonguierma | Andre | UN Economic Commission of Africa, Addis Ababa | Ethiopia | *ANonquierma@uneca.org* | 8 |
| Obrou | Olivier | Université de Cocody à Abidjan | Côte d'Ivoire | *olivier.obrou@fulbrightmail.org* | 4,19,33 |
| Ogunmodimu | Olugbenga | Lancaster Univ., Lancaster | UK | *gbengadimu@gmail.com* | 6,26 |
| Okere | Bonaventure | University of Nigeria, Nsukka | Nigeria | *ibokere2001@yahoo.com* | 19,53,54 |
| Okonkwo | Perpetua | Univ. of Nigeria, Nsukka | Nigeria | *peepyyy@yahoo.com* | 53,54 |
| Olusesan | Bakare | Olabisi Onabanjo Univ., Ago Iwoye | Nigeria | *sesanbakare12@yahoo.com* | 34,36 |
| Olwendo | Joseph | Pwani Univ. College, Mombasa | Kenya | *castrajoseph@yahoo.com* | 7,29 |
| Ondede | George | Maseno University, Nyanza | Kenya | *georgeochieng08@yahoo.com* | 50 |
| Osokin | Alexei | Sternberg Astronomical Institute of Moscow Univ. | Russian Federation | *arno@sai.msu.ru* | 39 |
| Ouattara | Frédéric | École Normale Supérieure de l'Université de Koudougou, Koudougou | Burkina Faso | *fojals@yahoo.fr* | 3,5,17 |
| Owolabi | Temitope | African Regional Centre for Space Sci. & Tech. Edu. in English, Ile-Ife | Nigeria | *topepascal2003@yahoo.com* | 44 |
| Oyekola | Oyedemi | | | | |
| Oyeyemi | Elijah | Univ. of Lagos, Lagos | Nigeria | *e_oyeyemi@yahoo.co.uk* | 5,16,22 37 |
| Pacheco | Edgardo | Boston College/Inst. Sci. Res., MA | USA | *pacheced@bc.edu* | 23,50 |

| | | | | | |
|---|---|---|---|---|---|
| Panda | Sampad | Indian Institute of Technology Bombay, Mumbai | India | *sampadpanda@gmail.com* | 53 |
| Parris | Richard | Air Force Research Laboratory | USA | *richard.parris@kirtland.af.mil* | 31 |
| Paxton | Larry | The Johns Hopkins Univ./Applied Physics Lab.,, Laurel, MD | USA | *larry.paxton@jhuapl.edu* | 2,13,23 |
| Rabiu | Babatunde | National Space Res. & Dev. Agency, Abuja/Federal Univ. of Technology, Akure | Nigeria | *tunderabiu@yahoo.com* | 2,11,16 37,39,43 44,51,52 |
| Radicella | Sandro | The Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste | Italy | *rsandro@ictp.it* | ii,1,8 27,40,43 47,50 |
| Rao | Paluri | Andhra Univ., Visakhapatnam | India | *palurivsrao@gmail.com* | 5,22,49 |
| Rui | Fernandes | Univ. of Beira Interior, Covilha | Portugal | *rmanuel@di.ubi.pt* | 48,55 |
| Salami | Tairu | Nigerian Meteorological Agency | Nigeria | *adesat2002@yahoo.com* | 48 |
| Scherliess | Ludger | Utah State Univ./CASS, Logan, UT | USA | *ludger.scherliess@usu.edu* | 4,19,41 |
| Segun | Segun | Bells Univ. | Nigeria | *oloriebimpjch2002@yahoo.co.uk* | 43 |
| Shetti | Dadaso | Smt. Ksturbai Walchand College | India | *shettidj2002@yahoo.co.in* | 40 |
| Sibanda | Patrick | Univ. of Zambia, Lusaka | Zambia | *sibanda@umich.edu* | 4,18 |
| Skone | Susan | Univ. of Calgary, Calgary | Canada | *shskone@ucalgary.ca* | 7,31 |
| Somoye | Emmanuel | Lagos State Univ., Lagos | Nigeria | *femi2000somoye@yahoo.com* | 16,36 |
| Ssessanga | Nicholas | South African National Space Agency | South Africa | *nssessanga@sansa.org.za* | 7,31 |
| Stromme | Anja | National Science Foundation | USA | *astromme@nsf.gov* | |
| Talaat | Elsayed | The Johns Hopkins Univ./Applied Physics Lab., Laurel, MD | USA | *elsayed.talaat@jhuapl.edu* | 5,23 |
| Tessema | Solomon | Entoto Observatory and Kotebe College, Addis Ababa | Ethiopia | *tessemabelay@gmail.com* | ii,2,7, 8,10 |
| Tiefu | Bogalech | Addis Ababa Univ., Addis Ababa | Ethiopia | *tbogalech@gmail.com* | |
| Tikuye | Birehanu | Woldie Univ. | Ethiopia | *baplightgreat@gmail.com* | |
| Tripathi | Sharad | Barkatullah Univ., Bhopal | India | *risingsharad@gmail.com* | 4,20,55 |
| Troshichev | Oleg | Arctic & Antarctic Research Institute, Saint-Petersburg | Russian Federation | *olegtro@aari.nw.ru* | 2,13 |
| Uwamahoro | Jean | Kigali Institute of Education | Rwanda | *mahorojpacis@gmail.com* | 37 |
| Valladares | Cesar | Boston College/Inst. Sci. Res., MA | USA | *cesar.valladares@bc.edu* | 4,6,15 25,28,50 |
| Vogel | Augustus | Office of Naval research, Global | USA | *augustus.vogel.civ@mail.mil* | |
| Wemimo | David | Olabisi Onabanjo Univ., Ago Iwoye | Nigeria | *wemidavid@yahoo.com* | 34 |
| Wondem | Atalay | Addis Ababa Univ., Addis Ababa | Ethiopia | *atawon@yahoo.com* | 8,32 |
| Woods | Thomas | Univ. of Colorado/Lab. for Atmospheric & Space Phys., Boulder, CO | USA | *tom.woods@lasp.colorado.edu* | 4,18 |
| Workayehu | Abiyot B. | Bahir Dar Univ., Bahir Dar | Ethiopia | *abbydis25@yahoo.com* | |
| Yirdaw | Ambelu Tebabal | Bahir Dar Univ., Bahir Dar | Ethiopia | *ambelut2003@yahoo.com* | |
| Yizengaw | Endawoke | Boston College/Inst. Sci. Res., MA | USA | *kassie@bc.edu* | ii,2,5,10 11,15,18 23,27,32 40,42,50 |
| Yuan | Wei | Ctr for Space Sci. & Applied Res. | China | *wyuan@spaceweather.ac.cn* | 48 |
| Zewdie | Gebreab | Addis Ababa Univ., Addis Ababa | Ethiopia | *hygbki21@gmail.com* | 46 |
| Zhang | Donghe | Peking Univ., Beijing | China | *zhangdh@pku.edu.cn* | 6,28,45 |

Notes:

AGU CHAPMAN CONFERENCE
Addis Ababa, Ethiopia | 12–16 November 2012

# Longitude and Hemispheric Dependence of Space Weather

*Bete Giyorgisin, Lalibela, Ethiopia* *St George EOT Church, Lalibela, Ethiopia*