CAWSES: Climate and Weather for Sun-Earth System– II http://www.cawses.org/wiki/index.php/Main_Page
Task Group4 : What is the geospace response to variable inputs from the lower atmosphere?

TG4 Newsletter Vol. 12, July 2013

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Article 1

Space Science Instrumentation in Africa: Past, Present, and Future

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Introduction: Understanding the physics behind space weather impacts and improving the forecasting are major objectives of the space science community. The equatorial ionosphere in particular is one of the most complex region and is a host to numerous instabilities and interactions. Radio waves, either transmitted through the ionosphere, for satellite communication and navigation, or reflected off the ionosphere for HF and radar applications, are all impacted by these ionospheric dynamics and variability.

Why Africa?: Satellites observations show unique (wider and deeper) ionospheric irregularities/bubbles occur in the African sector more frequently than in any other longitudes, but it has not been confirmed or validated with ground-based observations due to lack of ground-based instruments. This causes the scientific community to raise an important question: Are ionospheric space weather effects the same longitudinally? If not, why? In order to address these questions, filling the gaps of ground-based instruments, primarily in the African sector, is crucial.

Space Science Training in Africa: Space science training to local personnel is essential to have sustainable instrument operation in African countries. During the past few years, a significant number of workshops and summer schools have been hosted in different parts of Africa under the umbrella of the UN-sponsored IHY/ISWI programs. Because of all these coordinated efforts, several African universities understand the importance and application of space weather and introduced space science courses into their curriculum. Recently, in recognition of the unprecedented development

Figure 1. The IHY-2009 workshop participants. The workshop, held in Livingstone, Zambia in June 2009, primarily organized by Tim Fuller-Rowell and Lee-Ann McKinnell.

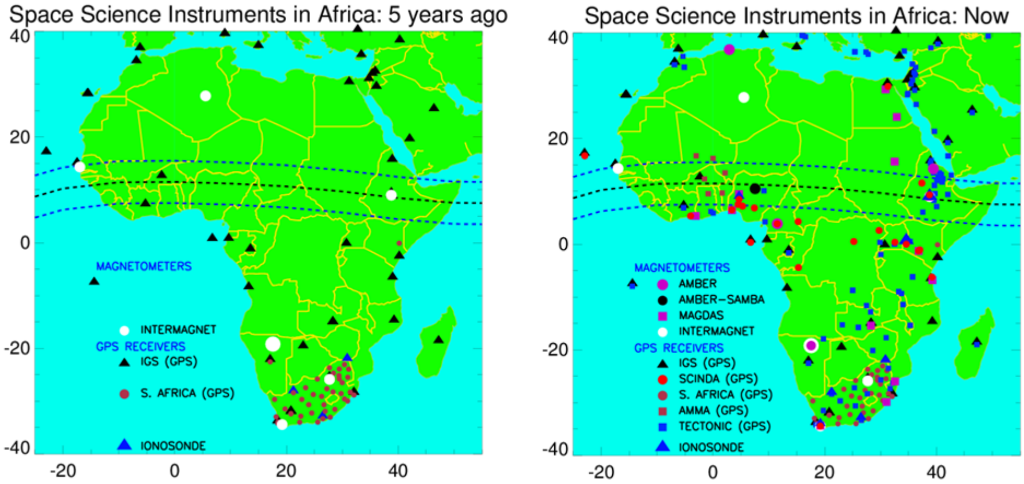

Figure 2. Ground-based instrument coverage in African five years ago (left panel), and now (right panel).

of the space science research activities in Africa, AGU held one of its prestigious Chapman space science conferences in Africa for the first time. It was held in Addis Ababa, Ethiopia during 12-16 November 2012.

Space Science Instruments in Africa: Space-related observations over Africa have been sparse, but there has been a concerted effort over the past five years to develop the observational infrastructure. During the past couple of years, a very few small instruments (see Fig. 2) have been deployed in the region, which are still far from enough to understand the most dynamic ionosphere in the region.

Planned AMISR in Africa: The formation of the unique equatorial ionospheric irregularities in the African sector obviously cannot be answered with only those small scale instruments that are already deployed. Therefore, in order to have a more complete understanding, a group of scientists from the United States, Africa, South America and Europe are planning to develop a single Advanced Modular Incoherent Scatter Radar (AMISR) that will be deployed in Bahir Dar, Ethiopia. The planned AMISR in Africa, combined with those small scale instruments, will provide detail information that will greatly increase our understanding of equatorial electrodynamics. No other instrument provides detail information about ionospheric dynamics.

AMISR in Africa Scientific Benefits : To date, our current understanding of equatorial electrodynamics is primarily based on observations from the Jicamarca ISR instrument (even though satellite observations tell us that there are longitudinal differences). Jicamarca is located in the region where there is a fairly large excursion between the geomagnetic and geographic equator. However, AMISR in Africa, which will be deployed in the region where there is only a very small excursion between the geomagnetic and geographic equators, will provide great opportunities for new science investigations by addressing so many critical scientific problems about the unique ionospheric irregularities in the Africa sector. It will also have a direct impact in advancing space science research in Africa by establishing and advancing sustainable research/training infrastructure within Africa.

AMISR in Africa Societal Benefits: The planned AMISR in Africa will play a vital role in the future socioeconomic development of Africa by sparking interest in the next African generation to do science and technology, which is the backbone for economic development of any country. It will also attract scientists worldwide and rapidly position Africa at the top of global ionospheric research center, and create strong international collaborations. For the United States, the planned AMISR in Africa will serve as a vehicle to create opportunities for graduate and undergraduate students to participate in different phases of the development and deployment process, providing them with high quality international research experiences.

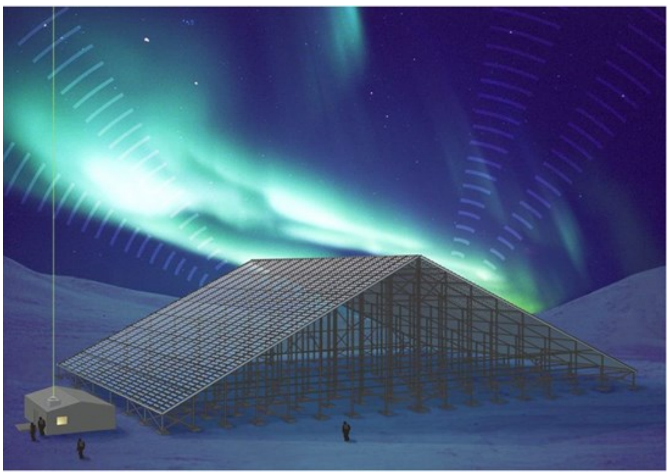

Figure 3. A cartoon plot that shows full AMISR panels setup.

Article 2

Global-scale Observations of the Limb and Disk (GOLD) - A New Perspective on the Thermosphere-Ionosphere System

Richard Eastes

Richard Eastes[1], Alan Burns[2] and Bill McClintock[3] for the GOLD Team
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The Global-scale Observations of the Limb and Disk (GOLD) mission has been selected as a mission of opportunity by NASA's Explorer program. GOLD will make unprecedented observations of the thermosphere-ionosphere (TI) system that will be available to the TI community through the mission's data center at the University of Central Florida, the lead institution for the mission. These data will be used to address a fundamental question for heliophysics science: What is the global-scale response of the thermosphere and ionosphere to forcing in the integrated Sun-Earth system?

The mission will fly a Far UltraViolet (FUV) imager to make simultaneous observations of the neutral temperature and composition, near 160 km, over the visible disk in the daytime. At night the observations will study plasma instabilities in the equatorial ionosphere. The instrument, shown in Figure 1, will be built by the University of Colorado's Laboratory for Atmospheric and Space Physics (LASP). It is planned for launch to a geostationary orbit in 2017 on a communications satellite, which will be owned and operated by SES Government Solutions.

GOLD will address four specific questions:
1. How do geomagnetic storms alter the temperature and composition structure of the thermosphere?
2. What is the global-scale response of the thermosphere to solar extreme-ultraviolet variability?
3. How significant are the effects of atmospheric waves and tides propagating from below on the thermospheric temperature structure?

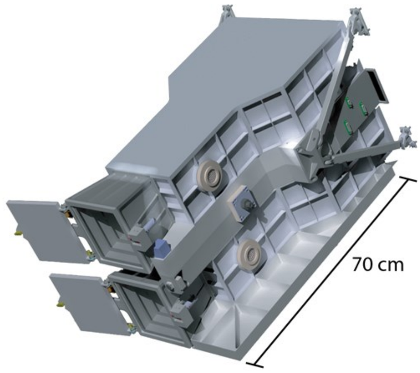

Figure 1: Drawing of the GOLD instrument with covers open on each of the two identical channels.

4. How does the structure of the equatorial ionosphere influence the formation and evolution of equatorial plasma density irregularities?

GOLD's imaging of the temperature and composition in Earth's upper atmosphere revisits the same locations every half-hour, allowing changes in time to be separated from changes in geographic location. This imaging gives GOLD a new perspective on fundamental questions and provides new insights to the upper atmosphere's response to forcing from the Sun and the lower atmosphere. It will also explore a new, cost effective way for scientific instruments to access geosynchronous orbit – as hosted payloads on commercial satellites. A model calculation of the storm-time changes that GOLD will be able to follow is shown in Figure 2.

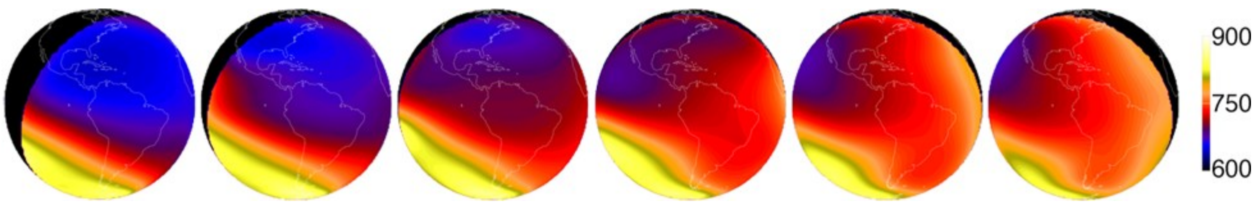

Figure 2: Modeled thermospheric temperature (K) progression at one-hour intervals, during a geomagnetic storm, near 160 km altitude, as sampled by GOLD from geostationary orbit.

Article 3

Ionospheric Connection Explorer Selected by NASA

Thomas Immel
Senior Fellow at Space Sciences Laboratory at the University of California Berkeley, is the Principal Investigator of the ICON Science Mission.

Thomas Immel

NASA has selected a new mission – the Ionospheric Connection Explorer (ICON) – for launch in 2017. Led by The University of California, Berkeley, ICON will provide the best evidence of the ways in which the Earth's atmosphere drives "space weather". ICON will achieve this breakthrough by measuring the key parameters governing the development and fate of the dense plasma in the low-latitude ionosphere. One key objective of the ICON mission is to address the response of geospace to planetary-scale wave forcing entering space from the lower and middle atmosphere. ICON's combination of remote and in situ sensing on a single spacecraft platform is the key aspect that will allow it to quantify the forcing from below simultaneously with the response in Earth's plasma environment.

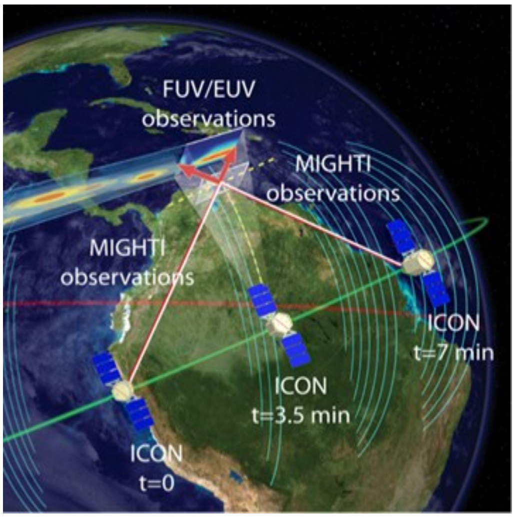

Figure 2: Doppler observations made at at t=0 and t=7 minutes provide vector winds along the limb, while the UV instruments measure ionospheric conductivity and composition along the same track. In situ ion drifts measured at t=3.5 minutes are connected by arched magnetic field lines to the remote wind observations. ICON measures the key parameters of the I-T system continuously via this elegant observational strategy.

ICON is designed to measure all the geophysical parameters that regulate the coupling between the atmosphere and ionosphere: the neutral winds, temperature and composition to determine the properties of the atmospheric wave forcing, and the ionospheric response (ion drift and density structuring). ICON does this with a scientific payload consisting of 4 instruments, shown in Figure 1. These include both remote sensing optical (MIGHTI, EUV, FUV) and in situ plasma observations (IVM). The revolutionary concept of ICON is that it combines these remote and in situ observations to observe dynamical drivers propagating upward through the boundary of space while simultaneously detecting their effects at the spacecraft. This is achieved through ICON's observing scenario, shown in Figure 2. From its low inclination (27 degree) 550 km altitude circular orbit, ICON makes measurements of conditions in the ionosphere and thermosphere (winds, conductivity and neutral composition and temperature) that are connected magnetically to the in situ measurements of ion drift and plasma density made at ICON. ICON can therefore, for the first time, determine the processes that control the equatorial ionospheric dynamo electric fields, and thereby understand how lower atmospheric processes drive changes in Earth's space environment.

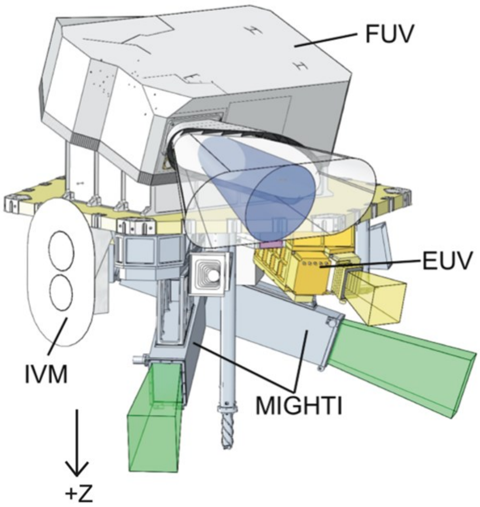

Figure 1: ICON's scientific payload, showing instrument fields of view. ICON carries 4 instruments: MIGHTI for neutral winds and temperatures, EUV for daytime ionosphere, FUV for daytime neutral composition and nighttime ionospheric specification, and IVM for in situ plasma motion.

The development of the ICON payload and spacecraft is now underway and the mission is on-course for launch in early 2017.

Article 4

The 1st Antarctic Gravity Wave Instrument Network: ANGWIN Workshop

National Institute for Polar Research (NIPR), Tokyo, Japan, March 13-15, 2013

Mitsumu K. Ejiri[1], Mike. J. Taylor[2], Takuji Nakamura[1], Tracy Moffat-Griffin[3], Damian Murphy[4], and Hisao Takahashi[5] (Authors' Affiliations are listed below)

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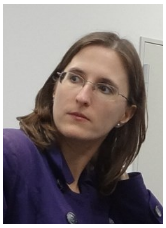

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Gravity waves have long been known as a key driver of the general circulation and temperature structure of the lower, middle and upper atmosphere through their ability to transport large amounts of energy and momentum upwards from copious tropospheric sources. Recent understanding of the effects of gravity waves within the troposphere, middle atmosphere and coupled thermosphere/ionosphere system has been significantly improved by theoretical, observational and modeling studies, and their global importance for modeling our atmosphere and its climate has been demonstrated. However, the contributions from gravity waves at polar latitudes are not well understood, due primarily to a paucity of measurements. The ANGWIN network is a "grass roots" international program initiated by a group of scientists focusing on Antarctic research with a goal of developing and utilizing a network of airglow imagers (and other instruments) located at established research stations around the continent. In particular, ANGWIN seeks to quantify the characteristics of mesospheric gravity waves, their dominant sources, propagation and breaking/dissipation over Antarctica to gain new knowledge of their large "continental-scale" effects on the general circulation of the middle and upper atmosphere.

The first international ANGWIN workshop was held on 13-15 March, 2013 at the National Institute of Polar Research (NIPR), Tachikawa, Tokyo Japan. It was very well attended by 41 scientists: 25 from various institutions in Japan, and 16 international scientists from Argentina, Australia, South Korea, Germany, U.K. and USA. The first day was devoted to formal presentations covering the Antarctic and Arctic regions and a wide variety of research topics extending from the troposphere to thermosphere/ionosphere system including various observational, theoretical and modeling studies. Presented there were current status and future plans, novel observational and analysis results, results from more general global aspects using satellite and GCMs, comparisons with ground-based observations, and updates on new imaging results from satellites, each accompanied by enthusiastic discussions. The second and third days focused on Antarctic science and techniques more closely related to ANGWIN and airglow imaging studies. This workshop offered an important opportunity for the airglow imaging community to have extended

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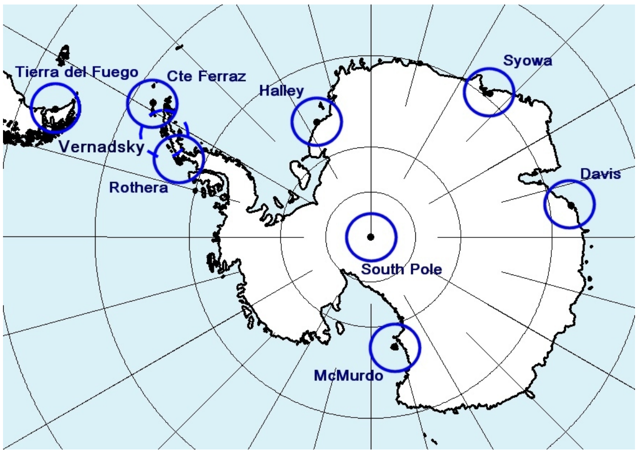

Figure 1. ANGWIN network concept

discussions ranging from the basic principles of the measurements to the details of current analysis techniques. Topics included image processing, noise suppression, instrument function, flat-fielding techniques, methods of extracting gravity wave parameters, auroral contamination issues, and other physical phenomena in the image data and their motions. Further discussions on how to determine and measure gravity wave events and their frequencies of occurrence, energy/momentum fluxes and how to improve current statistical analysis methods also ensued.

In summary, the meeting was a great success with strong attendance by leading scientists in aeronomy and related fields, including many young scientists and students from several countries. The future research directions of ANGWIN (and other airglow programs) were discussed in detail and a new communication of information exchange was established. A strong consensus for continuing ANGWIN science meetings was approved with the next meeting to be held in the USA in 2014. We wish to thank our wonderful hosts at NIPR who made the first ANGWIN meeting a most memorable occasion.

Figure 2. Group photo of the first ANGWIN meeting participants.

Highlights on Young Scientists

Characterization of Equatorial Kelvin Waves using the FORMOSAT-3/COSMIC data

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Uma Das

My research interests are in understanding the dynamical variabilities in the middle and upper atmosphere due to various forcings from above and below. Currently I am working on characterizing the atmospheric equatorial Kelvin waves in the middle and upper atmosphere using FORMOSAT-3/COSMIC GPS RO soundings and data retrievals. COSMIC data, with its high accuracy, vertical resolution, uniform global coverage, and most importantly, the unprecedentedly large number of observations, provides an opportunity to investigate the wave dynamics in the middle atmosphere more accurately.

Many earlier studies showed that Kelvin waves are not observed during the westerly phase of the zonal winds and the amplitudes were significantly enhanced during the descending westerly shear phase of the QBO. However, we observed a special case of Kelvin wave activity during the westerly period of QBO with an easterly shear at ~25 km during November 2008. The top panel of Figure 1 shows the equatorial temperature fluctuations at 20 km during September 2008 to February 2009. The middle panel shows the composites from two dimensional Fourier power spectra at eastward wavenumber one during two month periods and the bottom panel shows the dominant vertical wavelengths during the same period. The wave amplitude during November-December (P2) is constant upto 25 km and later reduces. This shows that the wave is crossing the westerly zone, propagating to higher altitudes, depositing eastward momentum in the region from 26 to 34 km when encountering the next shear level and reducing the easterly wind magnitude by as much as 10 ms^{-1} in the upper stratosphere. This seems to be a combined effect of the generation of the waves below the tropopause, large vertical wavelengths of the Kelvin waves and thin westerly zone resulting in subsequent upward propagation of the waves. This event shows short term effects of the Kelvin waves on the equatorial zonal winds and presents a unique example of wave-mean flow interaction.

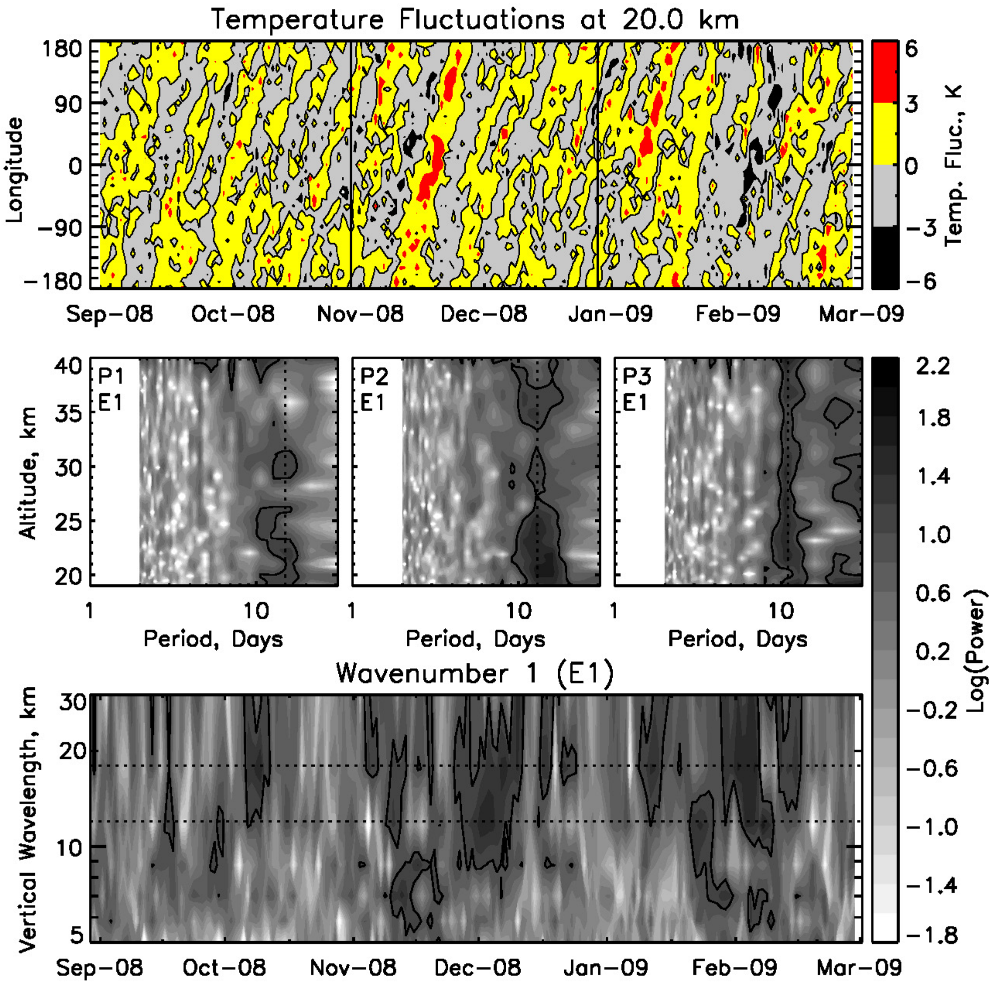

Figure 1. Top: Equatorial temperature fluctuations at 20 km during September 2008 to February 2009. Middle: Composites from two dimensional Fourier power spectra at eastward wavenumber one during two-month periods; Bottom: Dominant vertical wavelengths during the same period.

Short News

Next SCOSTEP program (2014-2018)

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As was already announced by the SCOSTEP newsletter (April 2013 issue), during the ISSI/SCOSTEP forum of May 7-8, 2013 at Bern, next SCOSTEP science program(s) were discussed by 25 participants including the SCOSTEP Bureau members. The new science program was tentatively named as "Variable Sun and Its Terrestrial Impact" (VarSITI) for 2014-2018. A summary of the VarSITI program can be found at http://scostep.apps01.yorku.ca/wp-content/uploads/2010/07/VarSITI.pdf. This new program will be discussed at the Panel 3 session of the International CAWSES-II Symposium in November 18-22, 2013 at Nagoya, Japan.

Upcoming meetings related to CAWSES-II TG4

Conference	Date	Location	Contact Information
International CAWSES-II Symposium	Nov. 18-22, 2013	Nagoya, Japan	http://www.stelab.nagoya-u. ac.jp/cawses2013/

The purpose of this newsletter is to make more communications among scientists related to the CAWSES-II Task Group 4 (particularly between those of the atmosphere and the ionosphere). **The editors would like to invite you to submit the following articles to the TG4 newsletter.**

Our newsletter has four categories of the articles:

1. Articles— ~500 words and four figures (maximum)
   on campaign, ground observations, satellite observations, modeling, workshop/conference/symposium report, etc
2. Highlights on young scientists— ~200 words and two figures
   on the young scientist's own work related to CAWSES-TG4
3. Short news— ~100 words
   announcements of campaign, workshop, etc
4. List of planned workshop

Category 2 (Highlights on young scientists) helps both young scientists and TG4 members to know each other. Please contact the editors for recommendation of young scientists who are willing to write an article on this category.

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This newsletter is also available on the web at http://www.cawses.org/wiki/index.php/Task_4