Commission G
2005 – 2008 triennium report

Chair: Prof Paul S Cannon, UK

1 In Memoriam

The following friends and colleagues from the URSI Commission G Community passed away during the triennium:

- Jean-Paul Villain (France)
- A P Mitra (India)
- Pietro Dominici (Italy)
- Tor Hagfors (Norway)
- Lyudmila Logvinova (Russia).
- Roy Piggott (UK)
- Paul Argo (USA).

2 Chair's Comments

General

I would like to give my thanks to the National Representatives. Moreover I would like to thank the GA conveners and WG leaders for their unstinting and timely help, and to thank my vice-chair Michael Rietveld and my immediate past-chair Christian Hanuise for their excellent advice.

Funding

The URSI board provides to the Commission Chairs a sum of money at the start of each triennium, to be administered for the good of the community. During this triennium a sum of EUR9635 was made available. Approximately EUR5500 was spent in supporting various meetings, typically with 500 or 1000 Euros. The remaining EUR4135 has been used to support seven scientists, from a number of countries, to attend the General Assembly – this being our flagship meeting.

In addition – see below – USD5000 were made available to support the attendance of students at the meeting. After consultation, the Chair decided to make 5 awards, each of USD1000 to those students who submitted to the Student Paper Competition.

Electronic Communication:

The Commission now has a website hosted by URSI http://www.ursi.org/G/Homepage.htm, which is basic but hopefully sufficient – it is at least easy to maintain and keep up-to-date. My thanks go to Inge Heleu at URSI for posting updates as required.

Commission G also has an electronic mailing list, maintained by Dr Wilkinson (ursi-commission-g@ips.gov.au). Any member of the community can post to this mailing

list. The mailing list membership is moderated by the Commission Chair. Currently, there are 416 addresses in the mailing list, which is a drop of ~300 from the report three years ago. This is probably due to it being used more and thereby dormant and unused email accounts have been identified. *There is an urgent need to increase the distribution, possibly through active use of national data bases.*

Chicago GA

Programme: Commission G has ~250 papers at the GA – an excellent turn out. The support is all the more gratifying given the plethora of other meetings being held this year. The Commission G tutorial paper is to be given by Dr Brian Wilson, on the subject of Data Assimilation, a new and exciting area for our community.

Paper Submission Process: This triennium URSI introduced a centralised paper submission process. This has certainly been a success and the Chair would like to register his thanks for the provision of this system

URSI Long Range Planning Committee

The LRPC decided to concentrate its attention on (i) enhancing the participation in URSI by new generations of young students and scientists, (ii) new topical initiatives and areas, and (iii) strengthening of Commissions that are not very active. The student paper competition has been introduced to progress (i). In respect to (ii), the Chair, Co-Chair and National Representatives of Commission G identified important emerging issues in two categories, Applied Science and Systems, and Science. The former include radar remote sensing from space and of space, high integrity GNSS navigation systems, assimilative models of electron density and scintillation, and engineering out the affects of the ionosphere in low frequency radio astronomy. The Science topics include increased emphasis on planetary ionospheres, anthropogenic effects (ionospheric modification by HF heaters and climate change), and plasmaspheric physics and models. As usual, significant opportunities for interaction exist with Commission F, H, and J.

Working Groups

Commission G working groups are the primary focus for active collaborative research. During the triennium 2005-2008, URSI Commission G has been active through a number of WGs - reports from these WGs are provided below,

WG G4 (Ionospheric Research to Support Radio Systems) has recommended that it should be disbanded – all other WGS recommend that they continue. WG G1 (Ionosonde Network Advisory Group) will be electing new officers at their meeting at the next GA.

3 Vice-Chairs Comments

The primary responsibility of the vice-chair is soliciting, and editing papers for the Radio Science Bulletin. In this triennium two papers have been published and a third is being prepared. This is a minimum number, averaging nearly one per year, and a greater number of papers is clearly desirable. Approximately one in three solicited

authors agreed to prepare a paper so some redundancy is needed. The support of the wider community is required to suggest topics and authors to the next vice-chair. Thanks go to Dr Ross Stone (Editor) and to Dr Phil Wilkinson, (Associate Editor) for the final preparation of the papers.

The papers published were: "Space Weather Impacts of the Subauroral Polarization Stream", by *Anthea Coster and John Foster*, RSB 321, June 2007 and "The impact of high resolution radar on meteor studies: the EISCAT perspective", by *Asta Pellinen-Wannberg, Gudmund Wannberg, Johan Kero, Csilla Szasz and Assar Westman,* RSB no 324, March 2008.

In addition to the review papers, Commission G has also sponsored a collection of papers on the subject of ionopsheric raytracing to remember the pioneering work of Jennifer Haselgrove. These papers will be published in the June and September 2008 of RSB.

4 Working Groups Reports

The following Working Groups reports have been prepared by the Working Group Chairs in cooperation with their co-chairs.

4.1 G1: Ionosonde Network Advisory Group

Chair: T. Bullett (USA), Vice-Chair: L-A McKinnell (SA), INAG Editor: P. Wilkinson (Australia)

INAG has maintained a constant membership of around 280. The main medium for contacting INAG members remains the Bulletin. During the last three years three Bulletins (INAG-66, 67 and 68) were produced, with a total of 11 articles. Most of these were in INAG's traditional roles of announcements regarding ionosonde stations and brokering agreements on data exchange formats.

Ionosonde owners and operators still practice commendable levels of data sharing, although international fiscal and intellectual property pressures endanger this foundation. Ionosonde data continue to have widespread use in publications and presentations. There were about 30 journal articles and 50 presentations featuring ionosondes over this triennium.

As a result of INAG initiative, ionosonde data users have online access to raw ionogram data at WDC-A. In addition to the standard scaled ionogram characteristics, the raw ionograms in native formats are available from NGDC at Boulder.

There has been a great deal of development of new generation ionosondes and data analysis software. While ionosondes that digitize at an intermediate frequency or baseband, such as the CADI, DPS-4 and the new AIS continue to be the most popular, this triennium saw the operation of the first fully digital ionosondes, which digitize at the radio frequency. These include the VIPIR (dynasonde) and DPS-4D.

The scientific possibilities afforded by these fully digital ionosondes are astounding. So are the volumes of raw data which they produce. Single high resolution raw ionograms from an 8 receiver system can approach 1 GByte. Some preliminary work on handling and exchanging raw data has begun, but more effort in this area is clearly needed. At the January 2008 US National Commission Radio Science meeting in Boulder, some of the lessons learned by the Incoherent Scatter Radar community were presented to INAG members by Dr. Frank Lind of MIT Haystack Observatory.

New ionogram automatic scaling software has also been developed. Adding to the familiar ARTIST and AUTOSCALE options are "Autoscala" (INGV), Dynasonde21 (Dynasonde Solutions) and Expert System for Ionogram Reduction (Space Environment Corp.). With these new choices comes an increasing need for standardization. To this end, INAG has endorsed the SAOXML data exchange format for information derived from ionograms. This format was described in INAG-66.

4.2 Studies of the ionosphere using beacon satellites

Chair: R. Leitinger (Austria), Vice-Chairs: P. Doherty (USA); and P.V.S. Rama Rao (India)

The Beacon Satellite Group (BSG) is interdisciplinary, servicing science, research, applications, and engineering interests.

The Working Group was active in its traditional fields, namely compilation, exchange and dissemination of information, contact with and exchange of experience with various organisations of relevance (ITU-R study group 3, the European COST Actions, augmentation systems for GPS based satellite navigation, international and national advisory bodies, GPS data retrieval and archiving organisations, and others), providing advice on request. The work was partly carried out by correspondence, and partly through attendance of conferences and other meetings.

Among the most important activities of the BSG are the Beacon Satellite Symposia. After a forerunner organised at the Max-Planck-Institut für Aeronomie at Lindau/Harz, Germany, in 1970 the series started in 1972 with the first Symposium at Graz/Austria and continued at time intervals between two and four years. Keeping the three year rhythm the next meeting is planned for 2010. The proposed venue is the University Politecnia de Catalunya, UPC/gAGE, in Barcelona, Spain. This local host for this meeting will be Dr. Manuel Hernandes-Pajares, a member of the BSG.

The most recent Beacon Satellite Symposium held at Boston College from June 11-15, 2007 again ranks among the most successful ones. The details of this symposium are listed below:

Scientific Committee

- Ms. Patricia Doherty, Boston College, USA (Patricia.Doherty@bc.edu)
- Prof. P.V.S. Rama Rao, Andhra University, Visakhapatnam, India (palurirao@yahoo.com)
- Prof. Sandro Radicella, ICTP, Trieste, Italy (rsandro@ictp.trieste.it)

Local Organizing Committee

- Ms. Patricia Doherty, Boston College, USA
- Dr. Cesar Valladares, Boston College, USA
- Dr. Michael Mendillo, Boston University, USA

The statistics on the Beacon Symposium are as follows:

- Number of participants: 110
- Number of countries represented: 24
- Number of sessions: 15 (14 oral sessions and 1 poster sessions)
- Number of papers presented: 116 (86 oral presentations, 30 posters)
- Number of sponsors with substantial monetary support: 5 (Boston College, NSF, NASA, FAA, AFRL)

During the opening ceremony the participants were welcomed by Ms. Patricia Doherty and Prof. P.V.S. Rama Rao on behalf of the Beacon Satellite Studies group. Ms. Doherty and Prof. Sandro Radicella also extended a greeting from the group chair, Dr. Reinhart Leitinger. Dr. Leitinger suffered a stroke in March 2006 and continues to work toward recovery. His message included his wishes for a successful symposium with his hope to join us at a future meeting. The opening ceremonies continued with a formal welcome from Boston College by Dr. Arnie Shore, Associate Vice Provost for Research. Dr. Shore's warm welcome was combined with gratitude for bringing this unique scientific group to Boston College. Dr. Jules Aarons then presented an entertaining history of his experience studying the effects of the ionosphere on Beacon Signals.

BSS 2007 included sessions on new science initiatives with Beacon Satellites; where discussions on upcoming satellite missions, sensing instruments and multi-instrument networks generated much anticipation for a new era of studies using Beacon satellites. Other sessions addressed the specific topics of TEC and scintillation measurements and models; low-latitude equatorial depletions; space weather effects on Beacon signals and navigation augmentation systems; radio occultation techniques; tomographic imaging; remote sensing and general discussions. Social events included a welcome reception; a cocktail party at The Castle sponsored by Boston University and a symposium dinner where Prof. Paul Cannon, Chair of URSI Commission G, addressed the participants with rousing support for the activities of the Beacon Satellite Group.

The Beacon Satellite Group is pleased and very grateful that due to substantial financial support from the NSF, NASA, FAA, AFRL and Boston College, it was possible to waive registration fees for students and provide travel support for over 22 participants from developing countries. This enabled participation for a wide audience with good representation from South America, India, Africa, Russia and other countries. Boston College also provided inexpensive accommodation for all participants. Although many young scientists were able to attend, the Beacon Satellite Group misses a "real" young scientist programme of URSI and urges Commission G to support such a program at the next symposium.

The Working Group wishes to continue its activities as an URSI Commission G Working Group in the future and has endorsed its present leadership. Since traditional

and new activities are well within the terms of reference of the Working Group, it does not suggest a change of these terms.

4.3 G3: Incoherent scatter

Chair: W. Swartz (USA), Vice-Chair: I. Haggstrom (Sweden)

4.3.1 Introduction

The global network of incoherent scatter radars (ISR) provides observations of fundamental properties of the atmosphere, ionosphere, and magnetosphere. Coordinating "World Day" (WD) experiments conducted by the ISRs and associated instrumentation is the major activity of the URSI Incoherent Scatter Working Group (ISWG). The ISWG publishes schedules of the World Days as part of the International Geophysical Calendar. Links to the current schedule as well as previous years schedules may also be found at: http://people.ece.cornell.edu/wes/URSI_ISWG.

In view of the ongoing activities in this field we ask URSI to keep this working group active.

4.3.2 World Days Facts

This report will include some facts about the World Days, how to request World Days for satisfying certain scientific objectives, and descriptions of the experiments carried out in the past three years and planned for the remainder of 2008.

- World Days provide for coordinated operations of two or more of the incoherent scatter radars (ISRs) for common scientific objectives. (Experiments that require only one radar should be set up separately and directly with those in charge of that ISR.)
- Note that the use of the ISRs is open to all qualified scientists, and the data are freely disseminated to a broad community of users for research and in the development and validation of models and instrumentation.
- World Days should be scattered throughout the calendar year.
- World Day data is to be promptly submitted to the CEDAR database and/or made available through other online databases as appropriate.

4.3.2 Process for Requesting World Day experiments

- Radar observing time is allocated (1) to individuals or groups through either formal or informal requests to the institutions responsible for operating the facilities, and (2) for World Day observations coordinated through a plan developed annually by the URSI Incoherent Scatter Working Group (ISWG).
- The high demand for ISR observations, in particular for extended and multi-radar operations, requires certain procedures to help ensure that the highest priority scientific research is addressed by the coordinated World Day schedule within the limits imposed by the cost and technical restrictions of ISR operations.

- The process begins with the development of a baseline schedule of general-purpose experiments that fall within the operating constraints of the radars. The baseline World Day schedule for 2009 and its updates will be available at http://people.ece.cornell.edu/wes/URSI_ISWG/2009WDschedule.htm or similar addresses in the future.
- If you are planning extended duration and/or multiple facility ISR experiments, you should review the baseline schedule carefully to determine whether your observational requirements can be met by the provisional baseline observations. If not, and if your experiment cannot be easily accommodated through requests to individual radar facilities, you will need to submit a proposal for additional or modified operations to the Chair of the ISWG (W. E. Swartz prior to the URSI GA in August 2008, or to I. Haggstrom afterwards). Instructions for preparing your request and a sample proposal are available at: http://people.ece.cornell.edu/wes/URSI_ISWG/SampleWDproposal.doc
- If you are unsure whether or not your experiment requires the submission of a proposal, please contact the ISWG Chair or any staff member of an ISR facility.
- When proposals are received, the ISWG Chair will initiate an interactive review process, enabling experimenters to provide additional input or arguments as needed. Every effort will be made to accommodate all requests.
- The ISWG will meet during the summer of each year to review all the proposals with the aid of external reviewers solicited by the Chair as appropriate. The group will then determine how the global network of ISRs can best satisfy the approved observational requests and will ensure that the experimental configurations, numbers of radars involved, time distribution and total time allocated are appropriate for the specified science goals. This process will normally take place at, or during, the annual CEDAR meeting. The proposer's presence during this discussion is not required.
- Please feel free to consult with any facility staff member for clarification on this process for requesting ISR observing time within the World Day program.

4.3.3 Observations

International Polar Year: Continuation of year-long observations with the Jicamarca, Poker Flat, EISCAT Svalbard ISRs

Key Objectives:

- To provide an unprecedented data set with multiple applications.
- To provide correlative data for other instrumentation and models committed to the IPY.

Background Conditions: Anything that comes along.
ISRs Needed: ESR, and others as resources permit.
Parameters to Measure: Standard.
Contacts: Tony van Eyken.

TEC Mapping: ISR/GPS Coordinated Observations of Electron Density Variations

Key Objectives:

- To study latitudinal variations of the ionosphere in the American longitude sector.
- To examine time and latitudinal variations of electron content in the plasmasphere.
- To test the GPS TEC mapping function.

Background Conditions: A range of magnetic activity is preferred but not required. A summer week (5 days) with some magnetic activity to complement the measurements of 2007 March 1-5 (which was magnetically quiet). We plan similar experiments for years ahead so that we can pick up different months for different years.
ISRs Needed: All.
Parameters to Measure: Standard ISR basic parameters, e.g., Ne, Ti, Te and line-of-sight ion velocity Vo.
Inferred parameters, such as meridional thermospheric winds and local electric fields, are desirable at least for Millstone Hill.
Good height coverage and height/range resolution is needed. The idea is to have a good ISR profile for both the bottomside and topside. Our intent is to determine the plasmaspheric content from the difference between the GPS TEC and the integrated ISR electron content. Because of this, the value of the F2 peak, and of the electron density above and below it, are very important for our analysis. Using a single very long pulse to make ISR measurements may result in significant smearing effects and would cause measurements below 200 km to be unusable for our study. We suggest either a short pulse with a long dwell (integration) time or a long pulse with interleaved Alternating Code. A time resolution of up to 30 min is acceptable.
We will use Millstone Hill's zenith and MISA data, taken almost simultaneously, to test how the slant TEC is mapped to the vertical TEC. So both local measurements and wide coverage are requested. The elevation scan is preferred.
For high latitude sites, we prefer elevation scans towards the South. First, that would generate line-of-sight TEC that can be compared with GPS TEC (few GPS satellites are overhead or in the north at high latitudes). Second, in the American Sector, combined Millstone and Sondrestrom data could provide good latitudinal coverage over subauroral and auroral areas.
For other sites, vertical observations would be fine. We ask for high altitude measurements from Arecibo.
Contacts: Shun-Rong Zhang, Anthea Coster.

C/NOFS: Communications / Navigation Outage Forecasting System

The primary purpose of C/NOFS is to forecast the presence of ionospheric irregularities that adversely impact communication and navigation systems through
(1) improved understanding of the physical processes active in the background ionosphere and thermosphere in which plasma instabilities grow;
(2) the identification of those mechanisms that trigger or quench the plasma irregularities responsible for signal degradation; and
(3) determining how the plasma irregularities affect the propagation of electro-magnetic waves.
A satellite was launched in April, 2008 into a low inclination (13°), elliptical (~ 400 x 700 km) orbit that is solely dedicated to the C/NOFS objectives. It is equipped with sensors that measure ambient and fluctuating electron densities, ion and electron

temperatures, AC and DC electric fields, magnetic fields, neutral winds, ionospheric scintillations, and electron content along the lines of sight between C/NOFS and the Global Positioning System (GPS) satellite constellation. The orbit has a 45-day repeating precession. Complementary ground-based measurements including the Jicamarca and Altair radars are critical to the success of the mission. Coordination with the World Days periods starting in August 2008 will be expected. (Requests for additional UAF radar time beyond the currently scheduled World Days are to be made directly to the respective observatory staffs once orbital characteristics are known.)
Contacts: Odile de La Bedaujardiere, David Hysell, Wes Swartz

QP TIDs: Coordinated Study of Quasi-Periodic Medium-Scale Traveling Ionospheric Disturbances with Extended Latitude Coverage

Key Objectives:

- To determine whether gravity-wave induced medium-scale traveling ionospheric disturbances (MSTIDs) consistently observed at high geomagnetic latitudes under quiet geomagnetic conditions are at all related to the continuum of quasi-periodic thermospheric waves observed at both Arecibo and Millstone, and perhaps at AMISR Poker Flat.
- To Firmly establish the geophysical parameter range over which these quasi-periodic MSTIDs—that currently appear to defy theoretical explanation—exist.

Background Conditions:

- Low to moderate geomagnetic activity, New Moon.

ISRs Needed: All except Jicamarca, for three 48-hour runs.
Parameters to Measure: Continuous or near-continuous vertical power profiles through the *E* and *F* regions (100-800 km) with the best time resolution possible. We must have 5 minute or better time resolution power profiles in order to properly filter the data to separate small amplitude waves from the normal variations of the ionosphere.
Secondary Parameters to Measure: Dual-beam ion velocities commensurate with the primary objective. .
Contacts: J.D. Mathews, F.T. Djuth, D. Livneh, I. Seker, M.P. Sulzer, C.A. Tepley, S.M. Smith, W.A. Bristow, J.C. Foster, and M. Nicolls.

Strat-Warming: Dynamics and Temperature of the Lower Thermosphere During Sudden Stratospheric Warming

Key Objectives:

- To measure neutral wind (zonal and meridional components) and electron and ion temperatures in the lower thermosphere before and during sudden stratospheric warming.
- To compare variations in temperature and winds to average variations observed by ISRs during the winter.
- To compare variations in temperatures and winds to mesospheric response as given by MF and meteor radars and lidars.
- To extend studies of stratospheric warming effects to the lower thermosphere and investigate possible coupling with the ionosphere.

- To examine the mechanisms responsible for variations in lower thermospheric dynamics and temperatures and investigate to what degree they can be related to sudden stratospheric warming.

Background Conditions: The observations need to be made before and during the sudden stratospheric warming. A 10-day campaign is requested, based on an alert to be issued either in January or February.
ISRs Needed: All, although the response at Arecibo and Jicamarca may be weak.
Parameters to Measure: LTCS mode - electron and ion temperatures from lowest possible altitude throughout the *F*-region, zonal and meridional components of neutral wind in the lower thermosphere (95-140km), F-region meridional wind. Temporal resolution can be sacrificed and data integration period increased in order to obtain data at lower altitudes.
Contacts: Larisa P. Goncharenko, Irfan Azeem, William Wardr.

Synoptic:
Key Objectives: These synoptic experiments are intended to emphasize wide coverage of the *F*-region, with some augmented coverage of the topside or *E*-region to fill in areas of the data bases that have relatively little data.
Contacts: Wes Swartz, Jan Sojka.

LTCS (Lower Thermosphere Coupling Study): Tidal Variability
Contact: Larisa P. Goncharenko

M-I Coupling (Magnetosphere-Ionosphere Coupling): Storm and Substorm Effects on the Middle- and Low-Latitude Ionosphere
Contact: Chaosong Huang

GPS-Radar (Global Plasma Structuring-Radar Experiment): Thermal plasma coupling between low, mid, and high latitudes
Contact: John Foster

Meteoric Ions (Global observations of ionization created by the Perseids and Leonids)
Contact: Ingemar Haggstrom

CPEA (Coupling Processes in the Equatorial Atmosphere)
Contacts: Shoichiro Fukao, Project Leader, Sunanda Basu, Janet Kozyra

MST (Studies of the Mesosphere, Stratosphere, and Troposphere)
Contacts: Gerald Lehmacher, Erhan Kudeki, Jorge L. Chau

World Month (Searching for Long Period Effects)
Contacts: Tony van Eyken, Larisa P. Goncharenko, and Wes Swartz

4.4 G4: Ionospheric Research to support radio systems

Chair: M. Angling (United Kingdom); Vice-Chair: C. Coleman (Australia)

URSI Commission G Working Group 4: Ionospheric Research to Support Radio Systems was formed at the Maastricht General Assembly. The intention was that the group should have wide objectives, and should seek to maintain an overview of ionospheric research related to radio systems. A website for the working group is located at: http://www.ips.gov.au/IPSHosted/wg4/index.html. In addition to a general information role, the group has attempted to sponsor two projects that were felt of general importance. The areas selected were data assimilation and propagation predictions for digital radio.

The data assimilation project aimed to provide a consistent set of input and test data that could be used to facilitate comparative testing between models. There has been little uptake of this idea. Apart from the initial studies identified in the report given to the last GA, the only known use of this test set has been by QinetiQ and AFRL in an unpublished study.

With regards the other project, a model of ionospheric scatter has been formulated and a method developed to estimate the effect of multipath and Doppler on digital waveforms. The model is largely based in existing ITU recommendations applicable to self interference. A draft amendment to ITU-R Rec533 has been submitted to ITU. This has been achieved largely through the personal efforts of Les Barclay with some assistance from IPS and QinetiQ.

The group has not been as active as hoped and it is not clear that this is likely to change in the near future. It is therefore recommended that the group should be shut down, whilst noting that its technical area remains well covered by the Ionospheric Effects Symposium and the IET Ionospheric Radio Systems and Techniques conference.

4.5 GF: Middle atmosphere

Co-Chair for Commission G: J. Röttger (Germany), Co-Chair for Commission F: C.H. Liu (China, SRS)

The International School on Atmosphere Radar at the National Central University in Taiwan ISAR-NCU over three weeks in October 2007 demonstrated the wide student interest in learning about MST and incoherent scatter radar. Lecturers from several countries were present with the students mainly from developing countries. A report was published in the URSI Radio Science Bulletin and we appreciated sponsoring and financial support by URSI.

A further school of this kind, ISAR-NCU 2008, is being prepared on remote sensing by passive and active sounding methods using radio waves for studies of the ionosphere and atmosphere. This school will be held at the National Central University in Chung-Li, Taiwan in October 2008. The majority of funding will come from Taiwan and some further support and sponsoring by URSI has been applied for.

This school is again directed towards students from developing countries and the Asia Pacific region.

In December 2007 the 11th MST radar workshop MST-11 was held in Tirupati, India. More than 100 participants attended. The proceedings have been published by the National Atmosphere Research Laboratory of India in Gadanki and a short journal publication is on its way in Annales Geophysicae. The next MST radar workshop MST-12 is planned for May 2009 in Canada.

The existence and performance of the URSI Joint Working Group GF was very helpful in the preparation and for the final decision in Germany to remain in the EISCAT Scientific Association. The membership was transferred end of 2006 from the Max-Planck-Gesellschaft to the Deutsche Forschungsgemeinschaft.

In view of the ongoing activities in this field we ask URSI to keep this working group active.

4.6 GH: Active experiments in plasmas

Co-Chair for Commission G: K Groves (USA), Co-Chair for Commission H: B. Thide (Sweden)

The 2005-08 period has been an exciting time for active experiments in space, marked by the completion and first utilization of a new world class high power, high frequency (HF) heating facility and significant progress in understanding heating physics driven by experimental results. As a result, the Active Experiments in Plasmas community has been, literally, active.

A relatively new heating facility established near Gakona, Alaska under the High Frequency Active Auroral Research Program (HAARP) by the U.S. Air Force Research Laboratory and the Naval Research Laboratory was completed in July 2007. Since the facility's completion more than 1000 hours of reliable operations have been performed, primarily to investigate HF-induced generation of ELF/VLF radiation. The HAARP facility consists of 144 crossed-dipole antenna elements fed independently by 20 kW transmitters producing a peak effective radiated power (ERP) of 3.6 GW across a broad range of frequencies (2.8-10 MHz). Because each element is powered and controlled independently, the system offers extremely flexible control of transmitted phase, amplitude and frequency opening up vast new possibilities for waveform selection and excitation of plasma wave modes. Additional information concerning the HAARP facility can be found at www.haarp.alaska.edu.

Prior to completion (2006 to mid-2007) the facility was operated at lower power in a number of campaigns to investigate the heating characteristics as a function of magnetic aspect angle and frequency. Particularly interesting results were obtained heating near the 2nd gyro-harmonic of the local magnetic field where dramatic enhancements of optical emissions were observed. The first international campaign with the new facility was conducted during the period from Feb-Mar 2008. Focused

on the generation of artificial irregularities, it consisted of approximately 35 experiments conducted by a similar number of investigators from the US and the international community. Preliminary analysis shows that spectacular optical emissions were observed and many new results are anticipated. A second campaign period is anticipated in October 2008; specific dates will be announced to the community when they are established.

Additionally, an effort to restore a two-frequency heater capability at Arecibo Observatory in Puerto Rico is funded and underway. The Arecibo heater will deploy a sub-reflector screen and use the 270 meter dish as the primary reflector and should achieve better performance at both 5.1 MHz and 8.175 MHz, approximately 80 MW ERP, than the previous Arecibo heating facility near Islote,. Coupled with the sensitive incoherent scatter radar at the facility it promises to enable exciting new high resolution studies on the micro-physics of high power wave-plasma interactions in space at mid-latitudes.

A number of new investigations in 2006-08 were conducted with the EISCAT heating facility located at Tromsø, Norway by participants from numerous countries including the UK, Finland, Norway, Sweden, Germany, Japan, Russia and Ukraine. Topics studied include the dependence of Langmuir turbulence signatures on geomagnetic field aspect angle as observed by the EISCAT incoherent scatter radars, the excitation of short-scale irregularities associated with upper hybrid processes using coherent backscatter radar (CUTLASS) and short-wave broadcast station carriers, as well as the interaction of powerful HF pump waves with natural phenomena such as auroral processes, magnetic pulsations, ion outflow, and polar mesospheric summertime echoes (PMSE). Indeed, a new 50 MHz coherent backscatter radar was installed to further support these studies at longer wavelengths. A major campaign was conducted in 2006 to investigate the directional dependence of stimulated electromagnetic emissions (SEE) using HF interferometry. Opportunities to perform new optical experiments were limited to some extent by the occurrence of solar minimum during the 2005-08 period, but these activities are expected to increase significantly during the next three years.

The Sura heating facility near Vasilsursk, Russia reports a number of new results from campaigns conducted in 2006 and 2007. Studies combining in situ observations from the Demeter satellite and ground-based tomographic reconstructions have demonstrated large scale HF-induced density variations mapping hundreds of kilometers along the geomagnetic field. Both negative and positive density perturbations were observed, ranging from ±10-20% in relative amplitude. Propagation effects detected by satellite-based VLF observations corroborate the formation of these HF-induced large-scale ducts. These results merit further theoretical and modeling investigation to provide quantitative descriptions of ducting phenomena.

Some of these results were presented at the VII International Suzdal URSI Symposium on Modification of the Ionosphere by Powerful Radio Waves held near Moscow in October 2007. The meeting was well-attended, with approximately 25

oral and 30 poster presentations covering a wide range of heating-related topics as well as phenomena driven by intense natural electric field sources, such as lightning. Much progress in understanding nonlinear thermal parametric instabilities and their role in plasma heating, structuring and electron acceleration was reported, as was further insight into the nature of wave-plasma interactions at magnetic zenith and gyroharmonics and the critical contributions of upper- and lower-hybrid waves to HF-induced turbulence and striation-formation.

Given the on-going development of new facilities and the recent impressive results from existing heaters, expectations for future progress in understanding high power HF-space plasma interactions are very high. The 2005-08 time period has been very productive and it is anticipated that there will be many new significant results in the next reporting period.

The Active Experiments in Plasmas group wishes to continue as an URSI Working Group in the forthcoming triennium.

4.7 FG: Atmospheric Remote Sensing using Satellite Navigation Systems

Co-Chairs: Dr. Bertram Arbesser-Rastburg (F) and Dr. Cathryn Mitchell (G)

We considered holding a special conference as had been held in Matera in 2003. However, due to the large number of meetings already scheduled in the period 2006-2007 we opted for a special session at the International Beacon Satellite Symposium, 2007 held in Boston, USA.

The session welcomed papers that had an applications emphasis or had connections between the ionosphere and troposphere. It promoted very lively discussions, particularly relating to the precise techniques that are used in GPS receivers to measure scintillations.

Details of the papers given are below.

10:50 AM	Study of Equatorial Spread F Irregularities at Indian Low Latitude Using Multi-Technique Observations	K.N. Iyer, H.P. Joshi, Mallini Aggarwal, A.K. Patra and Smitha V. Thampi
11:10 AM	A Review of Ionospheric and Tropospheric Scintillation and its Effect on Global Navigation Satellite Systems at L- and C-Band	R. Watson, C.N. Mitchell and M.J. van de Kamp
11:30 AM	The Coherent Ionospheric Doppler Receivers: Past, Present and Future	J. York, C. Slack, T. Garner, T.L. Gaussiran II and D. Munton
11:50 AM	Precise Ionospheric Measurements with GPS	S. Ganguly, L. Dyrud, A. Jovancevic and A. Brown
12:10 PM	Investigations of GPS Scintillations Using Digital Storage Receivers	P. Kintner and A. Cerruti

Future: The importance of the working group topic is on the increase. There are now potentially four navigation systems (GPS, GLONASS, Galileo and COMPASS) that will come into increasing importance in the next few years. A special conference for the working group will be considered in the next period, probably in early 2010.

In view of the ongoing activities in this field we ask URSI to keep this working group active.

4.8 URSI/COSPAR on International Reference Ionosphere (IRI)

Chair: B.W. Reinisch (USA), Vice Chair for COSPAR : Martin Friedrich (Austria), Vice Chair for URSI: Lida Triskova (Czech Republic); Secretary: D. Bilitza (USA),

The main event during the reporting period was the release of the new and improved version of the model, IRI-2007. This latest version includes several new options and new parameters: (a) two new options for the topside electron density profile (a correction based on topside sounder data developed by Bilitza, USA and the NeQuick-model of Radicella, Italy and Leitinger, Austria), (b) a Neural-Network model for the electron density in the auroral E-region based on the work of McKinnell, South Africa and Friedrich, Austria using EISCAT incoherent scatter radar measurements and rocket data, (c) plasmaspheric electron temperatures are included for the first time (Akebono model of Kutiev, Bulgaria and Oyama, Japan), (d) a much improved model for the topside ion composition (Triskova and Truhlik, Czech Republic), and for the first time a specification of spread F probability (de Souza, Brazil).

During the 2006 General Assembly of the Committee on Space Research (COSPAR) in Beijing, China, a special IRI-related session was held entitled “Modeling the Solar Activity Variations of Ionospheric Parameters (session C4.2)”. Close to 60 papers were presented during the 2-day session including oral and poster presentations. Of special interest is the good correlation of topside parameters with indicators of solar variation like the F10.7 radio flux when allowing for a 1-2 day delay.

A special IRI workshop was held in October of 2006 in Buenos Aires, Argentina focusing on an improved representation of total electron content (TEC) with IRI. The meeting was exceptionally well organized by Dr. M. Mosert and her team from CASLEO, San Juan with help from the ionospheric groups from the Universidads Nacional of Tucuman and La Plata. Excellent global coverage was represented by participants from Argentina, Czech Republic, Italy, USA, Spain, Russia, Austria, Peru, Cuba, South Africa, Brazil, Nigeria, and Mexico, making use of many different data sources: ionosondes, GPS, incoherent scatter radars, TIMED, DMSP, Hinotori, Akebono, and a few other satellites. Presentations showed how on one hand the data from the Global Navigation Satellite Systems (GNSS) can benefit the representation of TEC with IRI both in terms of model improvements as well as real-time updating, and on the other hand showed how usage of the IRI model helps to initiate and fine-

tune the GNSS data mapping techniques. A more detailed description can be found at http://iri.gsfc.nasa.gov/docs/iri_06_report.html.

For its 2007 Workshop the IRI team joined forces with the European Cooperation for the Mitigation of Ionospheric Effects on Radio Systems (COST 296) one of the major pan-European projects in ionospheric physics supported by the European Cooperation in the Field of Scientific and Technical Research (COST). The special focus of this combined IRI/COST workshop was a better representation of the forcing from below and from above in ionospheric models with special emphasis on the IRI model and regional European models. Naturally the workshop had a strong orientation towards application of ionospheric models and specifically on their effects on radio systems. The 1-week meeting was held in Prague, Czech Republic in July 2007, expertly organized by the Local Organizing Committee of the Institute of Atmospheric Physics (Drs. Lastovicka, Buresova, Sauli, Truhlik, Triskova) and attended by 103 participants from Africa, Asia, Europe, and North and South America giving 67 oral and 50 poster papers. An article summarizing workshop results was published in the Space Weather journal (Bilitza, D., B. Reinisch, and J. Lastovicka (2008), Progress in Observation-Based Ionospheric Modeling, Space Weather, 6, S02002, doi:10.1029/ 2007SW000359).

All three IRI meetings received financial support from a number of international and national organizations including travel support from URSI for key speakers.

Refereed papers from the IRI meetings are slated for publication in the Journal of Advances in Space Research. A combined issue with ~30 papers from the Beijing and Buenos Aires meetings is now complete and will be published in the near future. Editing work is under way for selected papers from the Prague meeting which will be published in two issues because of the large number of contributions. Two JASR issues with papers from earlier IRI workshops were published during this reporting period: (1) Bilitza D., B. Reinisch, (eds.), Advances in Specifying Plasma Temperatures and Ion composition in the Ionosphere, Advances in Space Research, Volume 37, Number 5, 2006. (2) Reinisch B., D. Bilitza, and D. Altadill (eds.), New Satellite and Ground Data for IRI and Comparison with Regional Models, Advances in Space Research, Volume 39, Number 5, 2007.

In view of the ongoing activities in this field we ask URSI to keep this working group active.

4.9 Other Working Groups

Other Working Groups in which Commission G is active are reported on the lead Commission reports. These include:

- Inter-commission Working Group on Solar Power Satellites
  Co-Chair for Commission G: M. Rietveld (Norway)
- EGH: Seismo Electromagnetics (Lithosphere-Atmosphere-Ionosphere Coupling)

Co-Chair for Commission G: S. Pulinets (Russia)

- URSI/IAGA Inter-union working group on VLF/ELF Remote Sensing of the Ionosphere and Magnetosphere (VERSIM)
  Co-Chair for URSI Commissions G and H: Janos Lichtenberger (Hungary)

5. Sponsored meetings

5.1 Mode A sponsorship

Commission G offered Mode A (no additional funds) support to the following meetings:

- Advanced School on Space Weather, ICTP, Trieste, Italy, 2 May 2006
- Characterising the Ionosphere, Fairbanks, Alaska, USA, 12-16 June 2006
- IRST - Ionospheric Radio Systems and Techniques, 18-21 July 2006, London, UK A EUR 0
- ISROSES - International Symposium on Recent Observations and Simulations of the Sun-Earth System, Varna, Bulgaria, 17-22 September 2006
- EuCAP 2006 - European Conference on Antennas and Propagation, Nice, France, 6-10 November 2006
- Workshop on the future of ionospheric research for satellite navigation and positioning: its relevance for developing countries, ICTP, Trieste, , 27 November - 8 December 2006
- STIINTE - Solar-Terrestrial Interactions : Instrumentation and Techniques, Sinaia, Romania, 4-16 June 2007
- BSS 2007 - Beacon Satellite Symposium 2007, Boston College, Chestnut Hill, MA, USA 11-15 June 2007
- Rarotonga Energetic Particle Workshop 2007, Rarotonga (Cook Islands), 5-10 August 2007
- STAMMS2 - Spatio-Temporal Analysis of Multimoint Measurements in Space, Orléand, France, 24-28 September 2007
- From Planets to Dark Energy: the Modern Radio Universe, Manchester, UK, 1-5 October 2007
- Scientific and Fundamental Aspects of the Galileo Programme, Toulouse, France, 2-4 October 2007
- IES2008 - 12th International Ionospheric Effects Symposium, Alexandria, Virginia, USA, 6-8 May 2008
- 37th COSPAR Scientific Assembly, Montreal, Canada, 13-20 July 2008

3.2 Mode B sponsorship

Meetings sponsored under Mode B received (limited) funding from Commission G, and other Commissions in some cases.

- Joint URSI-COSPAR session on the IRI (3 half-day sessions), 16-23 July, Beijing, China, 2006
- Vertical coupling in the atmosphere / ionosphere system, Varna, Bulgaria, 18-22 September 2006
- ISAR-NCU - International School of Atmospheric Radar, Chung-Li, Taiwan, 9-27 October 2006
- IRI Workshop 2006 - New Measurements for Improved IRI TEC Representation, Buenos Aires, Argentina, 16-20 October 2006
- MST 11, International Workshop on Technical and Scientific Aspects of MST Radar, Gadanki, Tirupati, India, 11-15 December 2007
- IRI/COST296 Workshop on Ionosphere Modelling, Forcing and Telecommunications, Prague, Czech Republic, 10-14 July 2007
- 10th International VLF Seminar, Zvenigorod, Moscow Region, Russia, 12-15 November 2007
- ISEA-12, Heraklion, Crete, Greece