Commission G

2008-2011 Triennial Report

Chair: Dr. Michael T. Rietveld, Norway

1 In Memoriam

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

- Helmut Kopka (Germany)
- Jules Aarons (USA)
- Vitold Belikovich (Russia)
- Ernie Smith (UK)
- Bill Gordon (USA)
- Ian Axford (New Zealand)
- Henry Rishbeth (UK)
- Paul Kintner (USA)
- Keith Cole (Australia)
- John Titheridge (New Zealand)
- Bill Ellis (Australia)

2 Chair's Comments

General

I would like to thank the GA conveners and WG leaders for their help, and to thank my vice-chair John Mathews and my immediate past-chair Paul Canon for their helpful advice.

I feel that Commission G is an active commission as the reports below show, albeit with an increasing age profile.

URSI wishes to revitalize the contacts between International Telecommunications Union (ITU) and URSI and Commission G should certainly be involved here but I have not succeeded in making progress here. There will be a workshop at the 2011 GASS where URSI scientists who have experience in dealing with ITU, could brainstorm how best to organize a renewed interaction between URSI and ITU.

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 EUR 9000 was made available. Approximately EUR 7500 was spent in supporting various meetings, typically with 500 or 1000 Euros. The remaining EUR 1500 is being used to support scientists, from a number of countries, to attend the General Assembly – this being our flagship meeting.

In addition 3000 EUR were made available to support the attendance of students at the meeting. After consultation, the Chair is deciding how to allocate these funds, with those students who submitted to the Student Paper Competition having high priority.

Electronic Communication:
The Commission website hosted by URSI http://www.ursi.org/G/Homepage.htm, 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 and is used fairly often but hopefully not too much so that people would start to regard it as SPAM. Currently, there are 507 addresses in the mailing list (includes some 5-10% multiple addresses for the same person), which is a welcome increase from ~410 from the report three years ago.

Istanbul GASS
Programme: Commission G has ~220 papers at the GA – an excellent turn out. It is slightly less than at the last GA but the largest number of any commission. One of the three general lectures is to be given by Prof. Asta Pellinen-Wannberg on "The Radio Physics of Meteors: High Resolution Radar Methods offering new Insights", an interesting and active Commission G field. The Commission G tutorial paper is to be given by Dr Martin Füllekrug, on the subject of "Sprites and Energetic Radiation above Thunderstorms", another rapidly developing and exciting area for our community.

Paper Submission Process: The same centralised paper submission process that was used as last time. This has worked well on the whole. The only complication from our view is that caused by the 4-page paper request, which we generally use as an extended abstract, together with a short (<100 word) summary also being required.

URSI Long Range Planning Committee
One of the working documents of the LRPC is a " Review of URSI's Technical Domains, Interactions with Other Societies and Emerging Topic Areas". The Chair, Co-Chair and National Representatives of Commission G helped in a comprehensive update of this document, with the Remote Sensing, Telecommunication and Navigation added to Propagation as our primary areas of interest. Important emerging issues remain in two categories, Applied Science and Systems, and Science. The former include radar remote sensing from space and in 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 2008-2011, URSI Commission G has been active through a number of WGs - reports from these WGs are provided below,

All WGs are active and recommend that they continue, with the possible exception of WG4, where the Chair thinks it is not active enough and he would like to resign.

3 Vice-Chairs Comments

The primary responsibility of the commission vice-chair is soliciting, and editing papers for the Radio Science Bulletin. In this triennium two papers have been published and a third is promised. 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, (Senior Associate Editor) for the final preparation of the papers.

The papers published were: "Meteoric Ionization: The Interpretation of Radar Trail Echoes" by J. Baggaley, RSB No 329, June 2009 and "EISCAT_3D: A Next-Generation European Radar System for Upper-Atmosphere and Geospace Research" by U.G. Wannberg et al., RSB No. 332, March 2010.

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 (2008-2010): L-A McKinnell (SA), Acting Chair (2010-2011): I.A. Galkin (USA), INAG Bulletin Editor: P. Wilkinson (Australia)

INAG has maintained a constant membership of around 280. Common media for INAG member interaction remain its Bulletin and email announcement list. During the last three years three Bulletins (INAG-69, 70 and 71) were produced, with a total of 14 articles. A new tradition for INAG, first introduced in 2008, has become its annual meetings between the URSI General Assemblies, arranged during the US National Commission URSI Conferences in Boulder, CO.

Most of the INAG activities in 2008-2011 concerned its positioning as a global observatory for real-time monitoring of the ionospheric conditions with online public access to the full resolution raw data and derived products. In the past, online access has been commonly provided to the retrospective data, with increased attention to the native-format raw ionogram archiving capabilities at WDC-A and UMLCAR. With advent of the INAG-inspired Global Ionospheric Radio Observatory (GIRO) and its agreements with 42 network sounders to release their data to GIRO within a few minutes of their measurements, a new community of now-casting instruments with publicly distributed sensor data has emerged. With a word of appreciation, INAG welcomes new real-time GIRO participants from Russia, Brazil, China, Korea, and Nigeria, as well as acknowledges long-time participants in the USA, Europe, and South Africa.

Given the real-time capability of the ionosonde network, the triennium is marked by an increased interest in the assimilative modelling and prediction using ionogram-derived data. A Forecasting Ionospheric Real-time Scintillation Tool (FIRST) has become operational at NGDC based on low-latency feeds from Jicamarca and Kwajalein ionosondes. The International Reference Ionosphere (IRI) has started a new project of building an assimilative IRI using GIRO data. The USAF Weather Agency (AFWA) has begun its network-wide NEXt IONosonde (NEXION) program to update their ionosonde instruments that contribute their real-time data to the Global Assimilative Ionospheric Measurements (GAIM) model. The NEXION program plans fielding a total of 30 new 4D ionosonde systems over the next few years. An important step forward for the ionosonde community was the acceptance of the URSI-endorsed standard data model for ionosonde data exchange, SAO.XML (DIAS), and the upcoming Near-Earth Space Data Infrastructure for e-Science (ESPAS) program. The SAO.XML data model was fully accepted in 2008, based on the metadata model engineered for long-term electronic archival of science data.

There has been a continuing development and deployment of new generation ionosondes featuring digital transceivers. In 2011, DSTO in Australia developed a new mono/bistatic FMCW ionosonde which is joining the family of fully-digital ionosondes that also include VIPIR (2008) and Digisonde 4D (2006). With improved precision of the new generation ionosondes comes their capability to conduct synchronized oblique sounding experiments.

4.2 G2: Studies of the ionosphere using beacon satellites

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

Studies of the Ionosphere using Beacon Satellites
Vice-Chairs: P. Doherty (USA); P.V.S. Rama Rao (India) and Honorary Chair: R. Leitinger (Austria)

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, communication and exchange of experience with various organizations of relevance (the European COST Actions, augmentation systems for GPS based satellite navigation, international and national advisory bodies, GPS data retrieval and archiving organizations, the Institute of Navigation, IHY and IPY

activities and others), providing advice on request. The work was partly carried out by correspondence, and partly through attendance at conferences and other meetings.

Among the most important activities of the BSG are the Beacon Satellite Symposia. After a forerunner organized 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 18th meeting is planned for 2013. There are three proposed venues including the University of Bath in the UK, the University of Warmia and Mazury in Olsztyn, Poland and Boston College in the US. The chairs of the BSG are in the process of consulting with group members to decide on a final destination.

The most recent Beacon Satellite Symposium held in June 2010 at the Universitat Politecnica de Catalunya, UPC/gAGE, in Barcelona, Spain was a great success. The local chair for this symposium was Dr. Manuel Hernandez-Pajares. The symposium was attended by over 150 scientists from more than 20 countries. There were 17 sessions covering topics that included TEC Measurements and Models, Scintillation, Space Weather Effects using Beacon Satellite Signals, Ionospheric Imaging Techniques and Results, GPS Radio Occultation Techniques and Studies, Multi-Instrument Ionospheric Techniques and New Science Initiatives with Beacon Satellites.

During the opening ceremony the participants were welcomed by Dr. Manuel Hernandez-Pajares and the BSG chairs, Patricia Doherty and Prof. P.V.S. Rama Rao. P. Doherty also extended a message from Dr. Leitinger to the group. Dr. Leitinger continues to recover from a stroke that he suffered in 2006.

The presentations were of excellent quality and they included some of the latest techniques and analysis results for beacon satellite studies. To showcase these papers, a special issue of Radio Science is in progress. Dr. Manuel Hernandez-Pajares and Patricia Doherty are serving as associate editors of Radio Science for this issue. It is expected that this issue will be released later in 2011. It is important to note that this is the first time that the Beacon Satellite Symposium papers have been showcased in a special issue of a peer reviewed journal.

The Beacon Satellite Group is grateful for the generous support from our sponsors including the Universitat Politecnica de Catalunya, the Spanish Government, Boston College, NSF and the FAA. These supporting funds made it possible to waive registration fees for students and young scientists, and to provide travel support for nearly 20 participants from developing countries.

The Working Group wishes to continue its activities as an URSI Commission G Working Group in the future and has endorsed its present leadership at the 2010 symposium. 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 Working Group

Chair: I. Häggström (Sweden), Vice-Chair: M. McCready (USA)

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 and previous schedules may be found at http://www.eiscat.se/Members/ingemar/skedule.

This report will include general information about World Days, the procedure to request World Days, and descriptions of the experiments carried out since the last report and planned for the remainder of 2011.

World Days provide for coordinated operations of two or more of the incoherent scatter radars (ISRs) for common scientific objectives. The ISRs that participate in this program are listed here from geographic south to north.

Jicamarca, Peru
Arecibo, Puerto Rico
MU Radar, Japan
Millstone Hill, USA
Kharkov, Ukraine
Irkutsk, Russia

Poker Flat (PFISR), USA
Sondrestrom, Greenland
EISCAT Mainland, Scandinavia
Resolute-North (RISR-N), Canada
Svalbard (ESR), Norway

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 via prompt submission to the CEDAR, Madrigal, and/or other databases as appropriate. In view of the ongoing activities in this field, we ask URSI to keep this working group active.

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 costs and technical restrictions of ISR operations.

When proposals are received, the ISWG Chair initiates an interactive review process, enabling experimenters to provide additional input as needed. Every effort is made to accommodate all requests. The ISWG meets during the summer of each year to review all proposals with the aid of external reviewers solicited by the Chair as appropriate. The group then determines how the global network of ISRs can best satisfy the approved observational requests and ensures that the experimental configurations, numbers of radars involved, time distribution and total time allocated are appropriate for the specified science goals. This process normally takes place at the annual CEDAR meeting.

4.3.3 Observations

A description of the coordinated incoherent-scatter radar runs that were performed during the last three years are given here, with a brief description of their goals.

During **2009**, the World Day observations totaled 560 hours for all the ISRs, and an additional 136 hours for the polar radars. They are listed here.

IPY (International Polar Year), three 32-hour runs performed by the EISCAT mainland, ESR, PFISR and Sondrestrom radars to complete the two-years of extra measurements that provided extensive coverage for the International Polar Years, March 2007 through February 2009.

ISRs needed: Polar (EISCAT Mainland, ESR, Sondrestrom, PFISR).

Contacts: A. van Eyken, J. Sojka.

StratWarm (Stratospheric Warming), a 10-day run during a one-month alert window to measure neutral winds and electron and ion temperatures in the lower thermosphere before and during sudden stratospheric warming, and to examine the mechanisms responsible for variations in lower thermospheric dynamics and temperatures. This run was not performed because there was not a stratospheric warming event during the one-month window.

ISRs needed: All, although the response at Arecibo and Jicamarca may be weak.

Contacts: L. Goncharenko, P. Hoffman, S. Azeem, W. Ward.

QP TIDs (Quasi-Periodic Medium-Scale Travelling Ionospheric Disturbances), three 40-hour runs to determine whether gravity-wave induced medium-scale travelling ionospheric disturbances consistently observed at high geomagnetic latitudes under quiet geomagnetic conditions, are related to the continuum of quasi-periodic thermospheric waves observed at both Arecibo and Millstone, and perhaps at PFISR.

ISRs needed: All except Jicamarca.

Contacts: J. Mathews, F. Djuth, D. Livneh, I. Seker, M. Sulzer, C. Tepley, S. Smith, W. Bristow, J. Foster, M. Nicolls.

Synoptic, a 32-hour run to provide measurements of standard ionospheric parameters.

ISRs needed: All.

Contacts: W. Swartz, J. Sojka.

Meteors (Global Measurements of the Meteor Input Function), one 24-hour run to study the sporadic meteor distribution throughout the hemisphere near solstice, and to add to the study of the geographical, season and diurnal behaviour.

ISRs needed: All.

Contacts: J. Plane, D. Janches.

PMSE (Polar Mesospheric Summer Echoes), a 40-hour measurement of this polar phenomenon.

ISRs needed: Polar (EISCAT Mainland, ESR, Sondrestrom, PFISR).

Contact: I.McCrea.

Wind Reversal, a 10-day run during a one-month alert window to measure the temporal development of the equinoctial wind reversal and temperature changes to help examine the factors responsible for circulation change.

ISRs needed: All.

Contacts: L. Goncharenko, P. Hoffman.

TEC Mapping (Total Electron Content), a six-day run of ISR/GPS coordinated observations of electron density variations to study the latitudinal variation of the ionosphere and the plasmasphere boundary layer behavior.

ISR needed: All.

Contacts: S.-R. Zhang, A. Coster.

Solar Wind Effects (Terrestrial effects of solar wind processes), to study the effect of equatorial solar coronal holes, fast solar streams, CMEs and solar flares. This request was combined with the TEC Mapping run.

ISR needed: All.

Contacts: A. Rouillard, C. Davis, I. Finch, I. McCrea.

During **2010**, the World Day observations totalled 653 hours and are listed here.

StratWarm (Stratospheric Warming), a 10-day run during a one-month alert window to measure neutral winds 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; and to examine the mechanisms responsible for variations in lower thermospheric dynamics and temperatures.

ISRs needed: All, although the response at Arecibo and Jicamarca may be weak.

Contacts: L. Goncharenko, P. Hoffman, S. Azeem, W. Ward.

QP TIDs (Quasi-Periodic Medium-Scale Travelling Ionospheric Disturbances), one two-day run to determine whether gravity-wave induced medium-scale travelling ionospheric disturbances consistently observed at high geomagnetic latitudes under quiet geomagnetic conditions are related to the continuum of quasi-periodic thermospheric waves observed at both Arecibo and Millstone, and perhaps at PFISR.

ISRs needed: All except Jicamarca.

Contacts: J. Mathews, F. Djuth, D. Livneh, I. Seker, M. Sulzer, C. Tepley, S. Smith, W. Bristow, J. Foster, M. Nicolls.

Solar Min (Synoptic), six 32-hour synoptic runs to capture the extended solar minimum of the current cycle.

ISRs needed: All.

Contacts: A. van Eyken, J. Sojka, I. Häggström.

Topside, three two-day runs to investigate the latitudinal variability of F-region topside parameters, capitalizing on new data acquisition and analysis schemes. In addition, study of the latitudinal coupling of the topside region on closed field lines, and ion upflow in the high latitude region.

ISRs needed: All.

Contacts: F. Rodrigues, M. Nicolls.

During **2011**, the World Day observations will total 515 hours and are listed here.

Synoptic, two three-day runs to measure basic ionospheric parameters and to capture the end of the extended solar minimum.

ISRs needed: All.

Contacts: J. Sojka, I. Häggström.

Meteors (Global Measurements of the Meteor Input Function), two two-day runs to study the sporadic meteor distribution throughout the hemisphere, and to study sporadic *E*-layer fluctuations not influenced by strong meteor flux variations.

ISRs needed: All.

Contacts: A. Pellinen-Wannberg, C. Szasz, J. Kero, D. Meisel, I. Häggström.

Planetary Waves, a 10-day run to investigate planetary-scale waves in the ionosphere. This will include measurements of the neutral wind throughout the mesosphere-lower thermosphere region, the response of the *F* region to atmospheric waves, and examining the mechanisms responsible for modulating the global-scale structure of the ionosphere at low and middle latitudes.

ISRs needed: All.

Contacts: S. England, Q. Zhou, G. Liu.

4.4 G4: Ionospheric Research to support radio systems

Chair: M. Angling (United Kingdom); Vice-Chair: D. Knepp (USA)

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. Indeed it has proven to be very hard to get different groups to participate in comparative testing of any sort. Some progress has been made by QinetiQ by testing against openly published data. Progress has also been made by AFRL – anonymized results will be published at IES 2011. A comparative testing collaboration has also been proposed by the IRI group, but has not proceeded.

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. The model has now been included in the current version of ITU-R P.Rec533 (10/09). 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. This may be due to the engineering focus – in contrast to the Beacon Satellite Group or INAG.

4.5 GF: Middle atmosphere

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

International Schools on Atmospheric Radar (ISAR) were held in November 2008, 2009 and 2010 at the National Central University (NCU) in Chung-Li, Taiwan. One observes a continuing demand for such schools and training courses, which is proved by the generally large number of students' applications and a reported success, proved by examinations and responses of students. The National Central University has consequently again decided that the next school ISAR-NCU-2011 shall be held over ten days 14-23 November 2011. The venue will again be the National Central University in Chung-Li, Taiwan, which is also the main sponsor of this school.

These schools are aiming to graduate and PhD students, young postdoctoral research scientists and engineers having background or work in the fields of atmospheric or ionospheric science, radar and radio system development and experimental applications. In particular methods applying different ground-based lower, middle and upper atmosphere and ionosphere radar and radio methods are addressed.

All these schools ISAR-NCU were performed under the international heading of the SCOSTEP (Scientific Committee on Solar Terrestrial Physics) program CAWSES (Climate and Weather of the Sun-Earth System) and the URSI Working Group GF on Middle Atmosphere (International Union of Radio Science), co-chaired by C.H. Liu and J. Röttger.

4.6 GH: Active experiments in Space plasmas

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

The 2008-2011 period marked a number of new results using high frequency high power radio waves to actively perturb the natural ionosphere despite the generally low solar flux which limited the electron densities available for experimentation. Perhaps the most dramatic new results obtained during the reporting period were observed at the High-Frequency Active Auroral Research Program (HAARP) HF facility near Gakona, Alaska. For the first time artificial ionization layers have been generated by high power HF radio waves. Initially such layers were believed to be confined to magnetic zenith and vertical heating geometries. Subsequent experimentation has since established that the layers can occur over a broad range of pointing angles (up to 20° zenith angle) by HF frequencies at least as high as the 4^{th} harmonic of the fundamental electron cyclotron frequency. The layers can now be produced reliably using frequency stepping techniques designed to match the resonant frequency as a function of altitude as the layers typically descend, sometimes by 100 km or more, from the initial HF interaction altitude. Nominally it is believed that local ionization of neutrals by accelerated electrons within the interaction region is responsible for extreme increases in electron density. The effects of reduced recombination and/or other chemical processes in the heated environment are not known. Current activities are focused on maintaining the layers in a stable configuration to extend the lifetime beyond a typical period of a few minutes. The results are consistent with numerous DMSP and GPS observations of enhanced electron density on field lines connected to the HF interaction region and more exciting work remains to be done to fully understand the phenomena.

Active investigations of ELF/VLF generation using the "polar electrojet antenna" have been conducted and much progress has been made towards understanding the nature of the source region both from ground- and space-based sensors. An exciting new development is the first demonstration of ELF signals generated by HAARP without the presence of the electrojet, via F-region heating using the so-called Ionospheric Current Drive (ICD) concept. Strong signals at frequencies between .5-50 Hz have been detected at sites near HAARP as well as far sites located at Homer and Poker Flat in the absence of electrojet currents. The implication is that HF sites far from the auroral electrojet region can possibly generate ELF radiation. In fact this has now been reported from the mid-latitude Sura Facility near Vasilsursk, Russia.

Additionally extensive new studies at HAARP utilizing the flexibility of the HF phased array antenna have generated interesting new waveforms and beam polarizations to exert more control over the nature of the HF perturbations. New stimulated electromagnetic emissions (SEE) have been identified as well, improving our understanding the HF interactions and enabling extremely accurate determination of local plasma parameters.

The EISCAT HF facility at Tromsø continues to be used extensively between 2008 and 2011 with at least 200 hours per year by groups from China, Finland, Germany, Japan, Norway, Portugal, Sweden, Russia, Ukraine, UK and USA. The facility has been upgraded with new RF generation hardware and control software allowing for more flexible frequency and other parameter changes and better monitoring. In addition a radar receiving mode has been added using one of the three antenna arrays purely for reception. Mesospheric and magnetospheric radar experiments are being performed. The facility remains unique in having multiple co-located incoherent scatter radars as a main diagnostics.

Experiments have been performed in the following areas: Langmuir turbulence using the VHF and UHF incoherent scatter radars. Upper-hybrid phenomena like the excitation of striations (meters to tens of meter scale irregularities) were studied using coherent HF backscatter radars and the electron heating and artificial ion upwelling with incoherent scatter radar. Particularly the dependence of the various phenomena on geometry of the heating and radar beams with respect to the geomagnetic field continues to be investigated. Surprising effects were found from X-mode heating. ELF/VLF generation experiments were performed for the Demeter and other satellites. Mesospheric physics including PMSE and PMWE echoes are being studied using artificial heating of the mesospheric electrons and three different wavelength radars as diagnostics. Some experiments, particularly optical ones continued to be hampered by the effects of solar minimum, but this situation is now improving.

A number of new studies were carried out at the Sura HF Facility near Vasilsursk, Russia during the 2008-11 period. A method for controlled excitation of a magnetospheric maser through the production of artificial density ducts by high - power HF radio emission from the Earth's surface has been proposed and implemented in an in-situ experiment. Artificial density ducts allow one to affect the maser resonator system and the excitation and propagation of low-frequency electromagnetic waves in a disturbed magnetic flux tube. The characteristics of electromagnetic and plasma disturbances at outer-ionosphere altitudes were measured in situ by the DEMETER satellite as it passed through the magnetic flux tube connected to the region of intense generation of HF-induced artificial ionospheric turbulence.

In 2011 artificial ULF signals were generated by SURA facility in night time conditions without current modulation. The signals were detected at each modulation frequency from 2 to 20 Hz. Such ULF signals have been generated in separate cases when the SURA operation frequency was below and above the F-layer critical frequency.

A new method of electron density determination at E-region heights is under development at the "Sura" facility. The method is based on creating artificial periodic irregularities (API) with two spatial scales (by using two powerful radio-waves at different frequencies) and sounding the API by probe radio waves. The electron density is determined using a relation of relaxation times of the API with different scales.

During pump wave frequency sweeping near fourth and fifth harmonics of the electron cyclotron frequency f_{ce}, it was established that the different spectral features of the stimulated electromagnetic emission (SEE) are quenched near the multiple gyro resonance at the same frequency coinciding with the pump frequency at which the total SEE intensity is minimal, and, according to the model, to the double resonance (multiple gyro and double resonance) frequency. This allows one to determine magnetic field strength, plasma density and double resonance height in the ionosphere with high accuracy.

During F-region O-mode pumping facility it was found that, depending on the state of the ionosphere, either amplification or quenching of the 630 nm airglow occurred. This enabled studies to separately investigate the role of electron acceleration and ohmic electron heating effects.

The comparison of the measured SEE inverse decay times with calculated plasma wave damping rates allowed to determine characteristics of plasma waves mostly contributing to the SEE generation, such as wave numbers and the angles between the wave vectors and geomagnetic field, and the altitude region of the SEE source. It was shown that plasma (upper hybrid) waves with "moderate" wavenumbers ~ 0.10 – 0.15 inverse gyro radii propagating at angles ~ 60-70° to the magnetic field, most probably provide the primary contribution to the intensity of plasma waves responsible for SEE generation, at least for the pump wave near 4^{th} gyroharmonics.

A new HF facility is under construction at the Arecibo Observatory in Puerto Rico. The transmitter building has been completed, the transmitters have been moved into it, and the antenna modeling work has been completed. This facility is designed to to transmit a high-power, high-frequency wave into the Earth's ionosphere with high reliability and safety, using surplus equipment when possible. The Arecibo 305-m dish provides the required necessary large effective aperture. A feed using dipoles and a subreflector is being constructed to illuminate the dish efficiently. The high-power transmitters and transmission lines have been obtained surplus.

Several key engineering issues had to be solved in order to design and construct this HF facility. The first problem was to find an antenna geometry to feed the 305-m dish with an efficient illumination pattern. A useful solution must allow other feeds, especially the two 430-MHz feeds used for the incoherent scatter radar, to operate simultaneously. A practical constraint is that the feed system must not load the suspended platform. Any solution must be modeled accurately to assure proper operation with a minimum of construction and test time. The design needed to use available surplus transmitters and incorporate them into the system in an economical way.

The unique design uses a Cassegrain subreflector and six pairs of crossed dipoles (three operating in each of two frequency bands). The sub-reflector will be a light square mesh constructed from 1/16-inch stainless steel cables (with larger support cables). The sub-reflector will be supported from the three main towers, not the platform. The dipoles will be located approximately one half wave length above the 305-meter dish (and will use it as a reflecting surface) and radiate upwards to the subreflector. The subreflector will direct the RF to the main dish. The facility will operate at 5.1 and 8.175 MHz.

The facility is expected to be ready for testing and initial use by the end of 2011. Use of the facility will require a proposal to be submitted following the usual guidelines at the NAIC web site.

4.7 URSI/COSPAR on International Reference Ionosphere (IRI)

Chair: Dr Lee-Anne McKinnell (South Africa), Vice Chair for COSPAR: Dr Shigeto Watanabe (Japan), Vice Chair for URSI: Dr Vladimir Truhlik (Czech Republic), Secretary: Dr Dieter Bilitza (USA)

During the reporting period (2008 – 2011) annual meetings were held by the URSI/COSPAR joint working group on the International Reference Ionosphere (IRI). The working group is extremely active with regular contributions from members that assist towards the improvement of the model and general understanding of ionospheric behaviour and the applications for such a global model.

A 2-day session on the Updating of Ionospheric Models with Ground and Space Data was held by the IRI working group during the 2008 Scientific Assembly of the Committee on Space Research (COSPAR) in Montreal, Canada. The session was divided into oral and poster sessions with the oral sub-sessions being focused on 'Updating Ionospheric Models', 'TEC Data and Models', F-peak Mapping', Topside Modelling', 'Storm Modelling', 'New Inputs for IRI', and 'Solar Cycle Effects'.

The IRI 2009 workshop was held in Kagoshima, Japan from 2 - 6 November 2009. The special emphasis of the 2009 Workshop was on (1) regional modelling of the ionosphere and (2) ionosphere/atmosphere/geosphere coupling studies for improvement of IRI. Other topics of interest for the workshop included comparisons of IRI with other models and with satellite/ground observations, proposed changes to the IRI models for improved performance and accuracy, and applications of the model in the many areas of interest. The workshop received financial support from the following sponsors: COSPAR, URSI, Kagoshima Prefecture, Kagoshima City, Hokkaido University, Japan Aerospace Exploration Agency (JAXA), Kagoshima University, National Institute of Information and Communications Technology (NICT), US Air Force Office of Scientific Research, Society for Promotion of Space Science, Hombo Shoten Company, Ltd.

The workshop was a great success with 113 participants from 20 countries including many students and several first time IRI contributors from Japan, China, Taiwan, Thailand, Malaysia, and Phillipines. The 117 presentations were grouped into one poster session and three oral sessions covering the topics “Structure and Dynamics of the Ionosphere”, “Solar and Geomagnetic Variability of the Ionosphere”, and “Ionosphere-Thermosphere Coupling”. A Final Discussion session reviewed the presented results and came up with proposals for future improvements of IRI.

A two-day session on the ‘Representation of the Auroral and Polar Ionosphere in the International Reference Ionosphere (IRI)’ was held during the 38th Scientific Assembly of the Committee on Space Research (COSPAR) in Bremen, Germany. A total of 42 presentations were given which were grouped into 5 topical areas: IRI at High Latitudes, GNSS Observations and IRI, Representation of the Topside Ionosphere in IRI, Improving the Description of Solar Forcing in IRI, and New Inputs to IRI. A hallmark of IRI sessions is the wide variety of data sources used to check and improve the model. The Bremen meeting was no exception and included presentation that were based on satellite measurements from TIMED, TOPEX, Jason, GPS, COSMIC, CHAMP, Alouette, ISIS, ACTIVE, APEX, CORONOS-I, AE-E, AE-E, and OGO-5, and on ground based measurements from the global network of ionosondes, and on incoherent scatter radar observations from EISCAT, Kharkov, and Arecibo. The majority of presentations were focused on the performance of the IRI model at high latitudes and possible improvements. A new committee for the IRI working group was elected during the COSPAR session.

The 2010 version of the International Reference Ionosphere will include a number of significant improvements including new models for the electron and ion densities in the lower ionosphere, auroral boundaries varying with magnetic activity, solar cycle variations of electron temperature, and the impact of precipitating electrons on the auroral E-region densities. Progress towards this goal was discussed during the COSPAR-2008 IRI session, the 2009 IRI Workshop in Kagoshima, Japan, and the COSPAR-2010 IRI session in Bremen. A special task force activity was started in 2009 that focuses on producing a Real-Time IRI model through data assimilation and model updating. A first task meeting was held at the US Air Force Academy in Colorado Springs in April 2009. The IRI model is the widely used standard for ionospheric densities and temperatures and is now also recognized by the International Standardization Organization in its Technical Specification TS 16457. Comparison with IRI is often one of the first tasks of a satellite or rocket science team and helps to identify critical times and regions for follow-on studies and for data evaluation efforts. IRI is the benchmark against which other models are compared in community model evaluations like the recent Electrodynamics Thermosphere Ionosphere (ETI) challenge of the CEDAR community.

Papers from the 2007 IRI Workshop have been published in two issues of Advances in Space Research:

Bilitza D., Jan Laštovička, B. Reinisch, (eds.), Ionosphere - Modelling, Forecasting, and Telecommunications I, Advances in Space Research, Volume 43, Number 11, Pages 1595-1846, 2 June 2009.

Reinisch, B., Bilitza D., Jan Laštovička, (eds.), Ionosphere - Modelling, Forecasting, and Telecommunications II, Advances in Space Research, Volume 44, Number 6, Pages 641-774, 2 June 2009.

The papers from the Kagoshima Workshop will be published in a special issue of “Earth, Planet, Space” (EPS), and selected papers from the Bremen session will be published in Advances in Space Research.

The IRI working group will hold their 2011 annual workshop in Hermanus, South Africa during the period 10 – 14 October 2011. The workshop will be hosted by the South African National Space Agency (SANSA).

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

4.8 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: K. Schlegel (Germany)
- EGH: Seismo Electromagnetics (Lithosphere-Atmosphere-Ionosphere Coupling)
  Co-Chair for Commission G: S. Pulinets (Russia)
- FG: Atmospheric Remote Sensing using Satellite Navigation Systems
  Co-Chairs for Commission G: Dr. Cathryn Mitchell (G)
- 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:

- MST12 - 12th Workshop on Technical and Scientific Aspects of MST Radars, London, Ontario, Canada, 17-23 May 2009
- EMC 2009, VIII International Symposium and Exhibition on Electromagnetic Compatibility and Electromagnetic Ecology, St Petersburg, Russia, 16-19 June 2009
- Nordic Shortwave Conference HF 10, Longwave Symposium LW 10, Fårö, August 17-19, 2010
- VERSIM workshop 2010, Prague, Czech Republic, 13-17 September 2010
- 2011 Ionospheric Effects Symposium (IES2011), Alexandria, Virginia, USA, 17-19 May, 2011
- 3rd International Colloquium on Scientific and Fundamental Aspects of the Galileo Programme, Copenhagen, 31 Aug-2 Sept 2011
- ICEAA - APWC, Torino, Italy, 12-17 September 2011.

3.2 Mode B sponsorship

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

- 3rd VERSIM URSI-IAGA workshop, Tihany, Hungary, 15-20 September 2008
- ISAR-NCU 2008 meeting, Chung-li, Taiwan, 6-18 October 2008
- IHY-Africa/SCINDA 2009 workshop, Livingstone, Zambia, 7-12 June 2009
- IRI2009 Workshop, Kagoshima, Japan, 2-7 November 2009.
- Sixth European Space Weather Week, Brugge, Belgium, 16-20 November, 2009
- 8th International Nonlinear Waves workshop, La Jolla, CA, USA 1-5 March 2010
- SCOSTEP - STP12, Berlin, Germany, 12-16 July 2010
- COSPAR Scientific Assembly, Bremen, 18-25 July 2010
- Space weather, Nairobi, Kenya, 19-23 July 2010
- ICEAA'10 - International Conference on Electromagnetics in Advanced Applications, Sydney, Australia, 20-24 September 2010
- Asia-Pacific Radio Science Conference (AP-RASC'10), Toyama, Japan, September 22-26, 2010
- Seventh European Space Weather Week7 (ESWW7), Brugge(Belgium), 15-19 November 2010
- IAGA/ICMA/CAWSES - II workshop on Vertical coupling in the Atmosphere-Ionosphere System, Prague, Czech Republic, 14- 18 February 2011.
- IconSpace2011, Malaysia, 12 to 13 July 2011.