Commission G on Ionospheric Radio and Propagation

by Christian Hanuise

1. Introduction

During the triennium 2002-2005, URSI Commission G has been active through its Working Groups (WGs) and sponsored symposia and workshops. The Commission has a website hosted by URSI and an electronic mailing list for communicating with people who have expressed an interest in Commission G activities. The address is http://www.ips.gov.au/mailman/listinfo/ursi-commission-g. The mailing list membership is self-managing and the Commission Chair moderates the group. Currently, there are 709 addresses in the mailing list.

2. Working Groups Reports

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

2.1 G1: Ionosonde Network Advisory Group

Chair: T. Bullett (USA), Vice-Chair: C Davies (UK), INAG Editor: P. Wilkinson (Australia)

Activity within INAG has been low during the last three years, according to the relatively few numbers of articles in the INAG bulletin and messages in the INAG email list. This quiet period is likely to end soon, as many ionosouding technical developments are about to become public.

The mailing list membership has risen to 247 members. All failed addresses have been purged from this list so although the membership is quiet, at least the list is active and growing at a slow rate.

The first INAG Bulletin appeared in September 1969 and has proven a useful source of information on ionosondes and ionosonde data and short notes on ionospheric measurements and data analysis. For some years now the Bulletin has only appeared on the Web. It was decided at the last Assembly there would be a separate volume per year and consequently there were three Bulletins issued this triennium (numbers 64, 65 & 66). Collectively, this amounted to eight articles. Chris, Phil and I would like to thank the authors of these articles for taking the time to support the Bulletin.

One further project was commenced during this triennium but has not yet been completed. During the last triennium UAG-23A, the URSI ionogram scaling conventions, was converted to a PDF document and made available through the INAG Bulletin web pages. Currently, John Titheridge's report on POLAN, UAG-93, is being converted to PDF and will be placed on the INAG Website when the conversion is completed.

Over the last three years there have been many technical developments in the ionosonde community. However, most of these are still under development by their respective institutions, and are not yet ready for announcement or in need of INAG guidance. One such example is the imminent use of ionosonde derived electron density profiles by data assimilation ionosphere models. These models use multiple data types and have optimal estimation algorithms such as the Kalman filter. These applications require quantified uncertainty or error estimates in the observations. Once the techniques

for making these error bars are developed and validated by the various ionosonde camps, some new data exchange format is required.

Ionosonde owners and operators still practice commendable levels of data sharing, although international fiscal and intellectual property pressures endanger this foundation, without which the ionosonde would be relegated to historical obscurity.

Vital data sharing efforts are fundamental to the various real time ionosonde data networking efforts. In addition to the venerable Digital Ionospheric Sounding System network run by the US Air Force, networks of ionosondes are being established or expanded in Europe (DIAS), Australia (IPS), South Africa, and other regions. Data exchange is evolving from a scheme where individual sensors report hourly scaled ionogram characteristics to a local world data center into a model where sensors report high time resolution ionogram data over the Internet in real time to regional data or warning centers, with data exchange occurring between the regional data centers. Relational database and web services information technologies are being applied to ionosonde networks with great effectiveness. INAG's role in this development is one of supporting standards of data interchange and advocating open and generous exchange of these data.

INAG believes it still has a useful role to play and wishes to continue as an URSI Working Group in the forthcoming triennium.

2.2 G2: Studies of the ionosphere using beacon satellites

Chair: R. Leitinger (Austria), Vice-Chairs: J.A. Klobuchar (USA; until October, 2004); P. Doherty (USA, since October, 2004) 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 Action 271, Augmentation Systems for GPS based satellite navigation, international and national advisory bodies, GPS data retrieval and archiving organisations, and others), providing advise 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 years rhythm the next is planned for 2007. The venue for which we have two invitations will be selected according to funding and travel / local expenses possibilities.

The Beacon Satellite Symposium 2004 again ranks among the most successful ones. The venue was at the Abdus Salam International Center for Theoretical Physics (ICTP), Trieste, Italy from 18 through 22 October, 2004.

Scientific Committee
Prof. Reinhart Leitinger, University of Graz, Austria (Reinhart.Leitinger@uni-graz.at)
Prof. P.V.S. Rama Rao, Andhra University, Visakhapatnam, India (palurirao@yahoo.com)
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The statistics on the Beacon Symposium are as follows:
Number of participants: 89
Number of countries represented: 22
Number of sessions: 17 (15 oral sessions and 2 poster sessions)
Number of papers presented: 102 (counting posters)
Number of sponsors with substantial monetary support: 2

During the opening ceremony the participants were welcomed by Prof. Sandro Radicella on behalf of the host organization. The director of the Abdus Salam ICTP, Dr. Katepalli R. Sreenivasan, joined later in the week with formal welcomes and thanks for bringing a unique scientific group to ICTP. Dr. Ken Davies presented a tribute to two recently deceased members of our community, Dr. K.C. Yeh and Dr. Elizabeth Essex. Drs. Yeh and Essex were long-term members of our scientific community and their contributions have been many and important ones.

At the end of the opening ceremony Dr. Leitinger announced the recent retirement of his friend and co-chair, Mr. Jack Klobuchar and thanked him for his long-term contributions. He announced that Patricia Doherty has acted in Jack's absence and will assume the role of Western Region co-chair. This change in WG2 leadership was accepted unanimously by the Working Group.

BSS 2005 also included meetings of The International Ionospheric Tomography Community (IITC). This BSS studies sub-group was born at BSS'01 under the direction of Dr. Ed Fremouw. At IITC's 2004 meeting, tomography research results, ideas and plans for participation in the IPY 2007-2008 were discussed. The IITC Web site may be found at http://www.nwra-az.com/iitc/main.html. In addition, a new sub-group was formed to study matters of advanced GNSS-based navigation systems under the leadership of Ms. Patricia Doherty. A third interest group was formed to determine the feasibility of archiving historical ionospheric data sets. This group has collected a variety of irreplaceable data sets that should be archived for future studies.

The Beacon Satellite Group is pleased and very grateful that due to substantial financial support from ICTP it was possible to support students and participants from developing countries. The financial support from the US Federal Aviation Agency allowed us to have a very good representation from South America, India and other countries. Since ICTP provided the meeting facilities and the printed material distributed to the participants, it was possible to exempt from the registration fee all "young scientists" and all participants who got financial assistance. Coupled with inexpensive accommodation and reasonable travel costs this enabled a comparatively large number of "young scientists" to attend. The Beacon Satellite Group misses a "real" young scientist programme of URSI and urges Commission G to formulate relevant opinions.
There have already been two offers to host the next meeting in three years. More information on those plans will be announced as they mature.

From the beginning there have been two main areas of interest in Beacon Satellite Studies which can be summarised under the key words: "Electron Content" and "Scintillation". With the developments in Ionosphere Tomography and with the Global Satellite Navigation Systems (GNNS, presently the US system GPS and its Russian equivalent, GLONASS) and GPS receivers onboard Low Earth Orbit Satellites (LEOs) the "Electron Content" part gained new momentum and new perspectives. However, there is also renewed interest in scintillation studies, especially for satellite based navigation systems.

There is now considerable interest in assessment studies for various applications of satellite-to-ground and satellite-to-satellite propagation of L band signals. Very large numbers of GPS receivers are operated by different organisations, many of who lack experience with the ionosphere and plasmasphere propagation effects. The members of the BSG produce only a small fraction of data compared with the very large amount of potentially usable GPS data collected elsewhere. However, the members of the BSG have expertise in the ionosphere and plasmasphere and need to assess so-called "ionosphere products" produced by others, to provide advice, suggestions and even warnings. It is an important task for the BSG to organise assessment studies, to act as a distribution centre for relevant requests and to archive answers of more general interest.

GNSS-LEO occultation is a very important source of ionospheric data but needs further relevant assessment studies. GNSS occultation receivers will be installed simultaneously on several LEO satellites in the near future. The primary purpose is neutral atmosphere research and system development (e.g., climate research, possible data sources for weather prediction systems). These ambitious applications (e.g., to gain stratospheric temperature or tropospheric water vapour profiles) need to include very careful consideration of the residual plasma influences that necessarily remain after removal of the first order influences.

VHF/UHF beacons onboard Low Earth Orbit satellites still exist and a successor system is in sight to replace the NIMS system with three active but very weak operational beacons. Ground reception of the VHF/UHF beacon signals provides the data for high-resolution ionosphere tomography.

A considerable amount of high quality ionosphere and plasmasphere data is derived from ground and space observation of GNSS signals. However, these "Novel Data Sources" and the relevant data retrieval and preparation procedures still need careful testing and comparison with data from established instrumentation.

We continue to have a need for high resolution and high accuracy absolute values of vertical and slant electron content, especially in the context of near real-time ionospheric corrections for advanced satellite navigation systems. Other applications (e.g., the use of GNSS signals in surveying) need information on smaller scale wavelike disturbances (mostly, but not exclusively, from Travelling Ionospheric Disturbances).

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.

2.3 G3: Incoherent scatter

Chair: W. Swartz (USA). Vice-Chair: J.P. Thayer (USA)

Establishing "World Day" (WD) schedules to coordinate experiments at all the incoherent scatter radars and associated instrumentation is one of the activities of the URSI Incoherent Scatter Working Group (ISWG). The ISWG publishes these schedules as part of the International Geophysical Calendar. The link to the current schedule (as well as those for previous years) may be found at: http://people.ece.cornell.edu/wes/URSI_ISWG.

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 or yet planned for 2005.

World Day facts:

- World Days provide for coordinated operations of two or more of the incoherent scatter radars (ISRs) for common scientific objectives. (Experiments that require only 1 should be set up separately and directly with those in charge of that ISR.)
- 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.
- The number of World Days per year has been increased to 58 this year which includes several normal runs of a few days plus one long run of 30 days.

World Day requests should:

- Outline the science objectives.
- Describe the measurements required to meet the science objectives (including a list of the parameters to be measured, the altitude, azimuth, and elevation ranges over which the measurements are to be made, and time resolutions, with the dates or seasons, number of days or hours, phase of the moon, etc.).
- List which ISRs and which instruments are to be included.

- Include the radar operating modes for each ISR.
- Name a point person for coordinating the details of the experiments.

2005 World Day observations

LTCS (Lower Thermosphere Coupling Study): Tidal Variability

After 17 years of collecting ISR data in the lower thermosphere under the LTCS (Lower Thermosphere Coupling Study) program, the basic structure of tides is relatively well understood with the most striking single property of atmospheric tides being the very large variability of tidal amplitudes. Possible sources for this variability include non-migrating tides, planetary waves, and geomagnetic influences. Now efforts must focus on the sources of this tidal variability and are conditioned on obtaining wind and temperature data from altitudes between 100 and ~130-140 km.
The program requires synoptic lower thermospheric observations during two intervals of 4-5 days each per year. The 30-day run (the "World Month") planned for 2005 will particularly address longer period waves, e.g., the 5 to 16-day waves. (See special note on this long run below.) We plan to coordinate the analysis of this data with SABER temperature data, TIDI mesospheric winds, and MF/meteor radar winds.

LTCS Contact: Larisa P. Goncharenko

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

Magnetic storms and substorms are fundamental disturbances in the magnetosphere and can significantly increase, or decrease ionospheric electron densities (termed positive or negative storms, respectively). Electric fields originating in the magnetosphere can penetrate to the low-latitude ionosphere resulting in vertical motions that restructure the *F*-region density profiles due to the height dependence of the recombination rate. Substorm electric fields can change *F*-peak densities by 20-30% within one hour and correspondingly large changes also occur in TEC at low latitudes.

There are a number of outstanding problems with the effects of storms and substorms on the middle- and low-latitude ionosphere that remain unsolved.

- How much do magnetic storms affect the low-latitude ionosphere?
- How significant are the changes in TEC and *F*-region densities that result from penetrating magnetospheric substorm electric fields?
- How are changes in the low-latitude ionosphere coupled with the variations in the magnetosphere and solar wind?
- What processes are responsible for the ionospheric electron density disturbances?
- How do the disturbances in the electron density profiles and TEC vary with longitude and latitude?
- What are the atmospheric and dynamic processes at low latitudes during magnetic storms?

Radar chain measurements of the ionospheric plasma parameters (velocity, density, and temperature) are needed to solve, or partially solve, these problems. A magnetic storm generally lasts for 2-3 days. Periodic substorms often occur over a time interval of 10-30 hours during storms. Substorms evolve over 2-3 hours while penetration electric fields occur with times scales on the order of 30 minutes. The radar chain experiments should therefore last 5-7 days to include some quiet times before and after the storm, and have a reasonably high time resolution of 5-15 minutes.

Millstone Hill data from the M-I Coupling World Day of 2004 April 4 show factors of 2 to 3 increases in *F*-region electron densities. Unfortunately the SSC began just at the end of the regular World Day period and the other observatories missed the event, except for the Jicamarca Digisonde which did observe similar increases.

MI-Coupling Contact: Chaosong Huang

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

Recent multi-technique observations have shown that the equatorial ionosphere and inner plasmasphere are coupled from low to auroral latitudes by electric fields and plumes of storm enhanced electron densities which feed tongues of ionization into the polar caps. This global mechanism carries low-latitude dayside plasma into the nightside auroral ionosphere. These events cause significant space weather effects during major magnetic storms, but also occur during less-disturbed conditions.

Wide latitude coverage is needed to study such events and should include

- Measurements of plasma perturbations due to inner magnetospheric electric fields (Sonderstrom, EISCAT, Millstone Hill, SuperDARN)
- Topside observations (Arecibo and Jicamarca)
- Mid-latitude profiles (Kharkov and Irkutsk)
- Global GPS TEC imagery
- Particle precipitation and electric fields (DMSP)
- Plasmaspheric imagery (IMAGE)

Experiments should be conducted during the Spring and Fall Equinoxes for 2 full days with the moon down.

GPS-Radar Contact: John Foster

Meteoric Ions (Global observations of ionization created by the Perseids and Leonids)

During the 2002 Leonids, the EISCAT UHF radar detected enhanced ionization between 90 and 180 km with densities up to 3.3 x 10^11 m-3. No systematic study of such enhancements has yet been performed. Three-day runs for the Perseids (starting on August 10 at 0900 UT) and for the Leonids (starting on November 17 at 1600 UT) are suggested.

Meteoric Ions Contact: Ingemar Haggstrom

Synoptic

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 databases that have relatively little data.

Synoptic Contact: Wes Swartz

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

- improved understanding of the physical processes active in the background ionosphere and thermosphere in which plasma instabilities grow:
- the identification of those mechanisms that trigger or quench the plasma irregularities responsible for signal degradation; and
- determining how the plasma irregularities affect the propagation of electro-magnetic waves.

The C/NOFS satellite is to be launched into a low inclination (13°), elliptical (~ 400 x 700 km) orbit. It will be 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 will have a 45-day repeating precession. Complementary ground-based measurements including the Jicamarca and Altair radars are also critical to the success of the mission. Calibration comparisons will be scheduled for local noon in Northern Spring/Summer 2005 and validation comparisons will be during local nighttime in Fall 2005 and Winter 2006. 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.

C/NOFS Contacts: Odile de La Bedaujardiere, David Hysell, Wes Swartz

CPEA (Coupling Processes in the Equatorial Atmosphere)

This is an initiative for studying the coupling of dynamical coupling processes in the equatorial atmosphere from the troposphere up through the thermosphere and ionosphere centered around the Indonesian Equatorial Atmospheric Radar (EAR). Opportunities for collaborations initially focused on the successful March-April 2004 campaign period.

CPEA Contacts: Shoichiro Fukao, Project Leader, Sunanda Basu, Janet Kozyra

MST (Studies of the Mesosphere, Stratosphere, and Troposphere)

Coordinated *D*- and *E*-region campaigns where the ISR's and supporting instruments focus on their lower altitude capabilities. JRO uses a high resolution MST mode, while Arecibo uses a dual mode of *D*- and *E*-region drifts (with accompanying lidar & imaging measurements). The main interest is in obtaining gravity wave momentum fluxes. Minimum requirements would be winds with a time resolution of one or two minutes and a height resolution 450 meters or better. It may be possible to collect the lower atmospheric winds at Jicamarca with little or no adverse impact to the upper atmospheric/ionospheric measurements and may tie nicely in with the LTCS World Day periods.

MST Contacts: Gerald Lehmacher, Erhan Kudeki, Jorge L. Chau

World Month (Searching for Long Period Effects)

Studies of long period waves and tides require measurements over many sequential days. This 30-day run should provide an unprecedented data set for such studies. Experimental modes should emphasize the lower thermosphere as for the LTCS campaigns. It is anticipated that not all of the ISRs will be able to run for the full 30-day period, in which case only a "best effort" is asked for. For example, Sixto Gonzales of the Arecibo Observatory suggested that they could only run for about 10 of the 30 days, and these 10 may need to be in two groups of 5 days each. Labor or power saving modes may be adapted at some sites. For example, John Foster of Millstone Hill suggested that they would probably limit their runs to just the daytime hours. Further specific details are yet to be worked out.

WM Contacts: Larisa P. Goncharenko, and Wes Swartz

2.4 G4: Ionospheric Research to support radio systems

Chair: P. Wilkinson (Australia), Vice-Chair: M. Angling (United Kingdom)

URSI Commission G Working Group 4: Ionospheric Research to Support Radio Systems was formed at the Maastricht General Assembly with Dr Phil Wilkinson as the Chair and Dr Matthew Angling as Vice-Chair. The group has wide objectives, and seeks to maintain an overview of all ionospheric research related to radio systems. Those supporting the group felt that wider communications through a working group and an associated mailing list could enhance both our interests in these areas as well as advance the research in general. With this in mind, a website was set up at: http://www.ips.gov.au/IPSHosted/wg4/index.html.

The areas of general interest for the group are reflected in the website topic areas: meetings, useful links and contacts. The meetings section is intended to advertise meetings that are of general interest to members of the group, the useful links section is intended to bring together links to websites that are of general interest to the group. Although search engines can find sites rapidly, there are still advantages having specialist listings available.

A moderated mail list was established and currently has 144 members. In addition to a general information role, the group felt it was appropriate to sponsor at least two projects that were felt of general importance. The areas selected were data assimilation and propagation predictions for digital radio. Under the data assimilation section, a challenge was proposed. The challenge was to model the MUF for a European HF circuit by assimilating data available from the IGS databank into various models. The second project was intended to focus on propagation predictions for digital radio. The website was intended to form a discussion forum alongside the mail list.

Both the website and mail list were established in September 2004. However, activity since then has been slow. However, some initial comparisons of data assimilation models have been conducted by QinetiQ, Fusion Numerics and the University of Bath. Results have been reported in the proceedings of the Beacon Satellite Symposium (2004) and the Ionospheric Effects Symposium (2005). Further informal discussions were held at IES and it is hoped that additional comparative testing will be undertaken.

Although the group has not been as active as hoped, it fills an important gap in the Commission G spectrum and we recommend it continue for a further triennium.

2.5 GF: Middle atmosphere

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

The Proceedings of the 9th International Workshop on Technical and Scientific Aspects of MST Radar were published by SCOSTEP and MeteoFrance in October 2000, and in the special issue of the journal Annales Geophysicae, vol. 19, No. 8, 2001.

In November 2000, a 2-weeks course was held at the International Centre for Theoretical Physics in Trieste (ICTP) on "Physics of Mesosphere-Stratosphere-Troposphere Interactions with Special Emphasis on MST Radar Techniques", which was also devoted to activities of URSI WG GF1, and J. Röttger et al. were lecturers.

In July 2001 the Tenth International EISCAT Workshop was held in Tokyo, Japan, and in August 2003 the Eleventh International EISCAT Workshop was held in California, USA. Several papers were directed to coupling and research of the middle atmosphere with radio methods, which is the subject of URSI Working Group GF1.

During three weeks in November and December 2002 the Third International School on Atmospheric Radar, ISAR-3, was held at the International Center of Theoretical Physics in Trieste. J. Röttger, together with D.N. Rao of India and S. Radicella of ICTP were directing this school, which allowed young scientists to become acquainted with the radar and radio techniques used for middle and lower atmosphere research. Some financial support had been allocated by URSI.

J. Röttger was chairing the International Steering Committee of the Tenth Workshop on Technical and Scientific Aspects of MST Radar, MST-10, which was held in May 2003 in Piura, Peru. Sponsorship and financial support from URSI was granted. Preparations and performance of this workshop were part of the URSI WG GF1 work. A significant part of this workshop dealt with lectures, reports and outlines of new techniques, methods and science for radio/radar studies of the middle and lower atmosphere. The Proceedings of the 10th International Workshop on Technical and Scientific Aspects

of MST Radar were published by the Universidad de Piura and the Radio Observatorio de Jicamarca, Instituto Geofisico del Peru in December 2003, and a special issue of the Journal Annales Geophysicae was published in 2004.

The EISCAT Scientific Association had established a committee on defining the needs and future directions for the coming decades for scientific research of the Earth's ionosphere, magnetosphere and atmosphere. J Röttger is member in this committee and a member in the EISCAT Council.

In early 2004 a new project was launched during a colloquium, held end January 2005 in Tirupati, India: The International Network on Tropical Atmosphere Radar – INTAR - will help to coordinate radar observations in low latitude regions and foster cooperation and exchange programs between facilities and observatories in the tropical and extra-tropical region. The activities of WG GF1 are related to this new project. J. Röttger is Chairman of the International Steering Committee of INTAR.

In summary, the Working Group GF1 "Middle Atmosphere" again has had a successful triennium and the continuation of this URSI Working Group GF1 is requested, since we are in the process of preparing the 11th International Workshop on Technical Aspects of MST Radar, MST-11, to be held in Australia and are establishing a permanent International School on Atmospheric Radar, where sponsorship by URSI and other organizations will be most helpful.

2.6 GH1: Active experiments in plasmas

Co-Chair for Commission G: Sa. Basu (USA), Co-Chair for Commission H: T. Leyser (Sweden) / Bo Thide (Sweden)

The Working Group on Active Experiments in Plasmas reports enthusiastic support to its Call for Papers for this XXVIIIth URSI General Assembly. A session entitled, "Ionospheric Modification by High Power Radio Waves: Coupling of Plasma Processes" has been organized that features 10 oral presentations from leading international experts in this field of Radio Science and a further 4 papers, that could not be accommodated in the oral session, have been scheduled in the poster session.

During the period under review (August 2002 to October 2005) the Working Group reports active international cooperation in this field resulting in several breakthroughs in the area of interaction between the ionospheric plasma and high power high frequency radio waves. Research has been performed at the EISCAT, Sura and HAARP ionospheric modification facilities located in Norway, Russia, and Alaska, USA respectively. The EISCAT HF facility has distinguished itself by fostering collaborative research with scientific groups from U.K., Finland, Sweden, Germany, Japan, and Russia.

During the period under review the artificial optical emissions induced by HF pumping at harmonics of electron gyro-frequency have been intensively studied at all three facilities mentioned above. At EISCAT, it was demonstrated that the upper hybrid waves are important in accelerating the electrons, which are the source of artificial optical emissions in the F-layer. By performing optical measurements at multiple wavelengths the pump accelerated electron energy spectrum has been established for the first time. It was discovered that the pump wave with appropriate modulation could increase the strength of Polar Mesospheric Summer Echoes (PMSE) as observed by the UHF radar at 224 MHz. It holds the promise of a diagnostic for the dusty mesosphere. The modification experiments in Sura, Russia have been supported by an array of ground diagnostics that included the backscatter receivers including UTR-2 in the Ukraine. At Sura, the radio wave induced red OH Meinel band emission has been discovered and attributed to focusing by weak sporadic ionization near 80-85 km. Further, the broadening of the spectrum of the artificial ionospheric turbulence has been detected when the pump frequency was close to the fourth harmonic of the electron gyro-frequency. Alfven wave generation has been attempted at both EISCAT and Sura by the use of modulated pump wave and by directing the pump wave along the geomagnetic field.

The High Frequency Active Research Program (HAARP), a major high power HF wave facility in Gakona, Alaska is nearing completion. The facility is currently operated with the maximum effective radiated power of 0.96 GW and it will attain 3.6 GW level when completed. The HAARP facility will be supported by an array of ground-based diagnostics that will include incoherent scatter radar, ELF/VLF receivers, optical imagers and VHF radar. At both the EISCAT and HAARP facilities, it has been established that when the pump beam is pointed south of the zenith the optical emission tends to appear on or close to the magnetic zenith. This magnetic zenith effect has recently been confirmed by observations at the Sura facility. At HAARP it has been observed that the optical emission is dramatically enhanced when the pump frequency is close to the second harmonic of the electron gyro-frequency. The SuperDARN radar in Alaska and the Advanced Modular Incoherent Scatter Radar (AMISR) observations show that at this time the upper-hybrid resonance and Langmuir turbulence can coexist and this may account for the intense optical emission.

A new high power HF facility, Space Plasma Exploration by Active Radar (SPEAR), is being deployed on Spitzbergen in the Svalbard archipelago. The principal capabilities of SPEAR will include the generation of artificial irregularities, operation as an all-sky HF radar, and remote sounding of the magnetosphere. SPEAR being located near the cusp region at the boundary of the open- and closed field line boundary will provide a unique opportunity for exciting polar cap plasma physics experiments. Overall, this area of research is poised for important breakthroughs and discoveries in the coming years.

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

2.7 GHC: Wave and turbulence analysis

Co-Chair for Commission G: D. Hysell (USA), Co-Chair for Commission H: T. Dudok de Wit (France), Co-Chair for Commission C: G Kubin (Austria)

The HGC working group was created more than a decade ago with the aim to foster interactions between different communities that were applying the same techniques (nonlinear wave and turbulence analysis techniques) in different contexts. This group played an important role in disseminating knowledge about novel concepts. Its main activity consisted in organising multidisciplinary workshops + a session at each general assembly.

Two major actions were taken during the 2001-2005 period:

1. In September 2001, members of the working group organised a one-week summer school on Analysis techniques for space plasma data in La Londe (French Riviera). This summer school was attended by 70, mostly European students. The number of applications we received was more than twice that number, which confirms the large demand fur such topics. The school mainly consisted of lectures given by specialists and some computer sessions. Some of the topics were : spectral analysis, multiscale analysis, multipoint data, statistical analysis of urbulence, nonlinear transfer functions, . . .
This school was hosted by the french national research agency CNRS but was also supported by URSI commission H.
The documents of the school can still be accessed at the address http://lpce.cnrs-orleans.fr/~ddwit/lalonde/

2. In May 2004, members of the working group organized a two-week workshop on Data analysis techniques for multipoint magnetospheric missions in Beijing. This was the third of a series of capacity building workshops that are hosted by COSPAR; their objective is to provide intensive training to a selected team of young and bright students from developing countries.
Attendance was limited to 25 students, who mostly came from China, India and Eastern Russia. Lectures were delivered by scientists from the international community. The programme included lectures in the morning and hands-on computer sessions in the afternoon. Most topics were related to multipoint missions, and in particular to the ongoing Chinese Double Star mission.

The organisation of such a workshop was a new and very rewarding experience. We are confident that most of the students will greatly benefit from the contacts that were established during that intensive two-week training. We also believe that this formula could easily be adapted to other regions, such as India or Eastern Europe, with adapted topics such as Space Weather.
The cost per student of such a workshop is quite high (about 2600 $ / student) since there is no registration or accomodation fee, and financial travel support is provided to all. This high level of support, however, has turned out to be essential to guarantee access to all.
This school was hosted by COSPAR but was also generously supported by the URSI board. The documents of the school can still be accessed at the address http://www.faculty.iu-bremen.de/jvogt/cospar/cbw3

As for the future evolution of this HGC working group, we believe that its relevance it not so clear anymore, even though the topics it addresses remain pertinent. Indeed, the interest for turbulence analysis (and associated microphysics) has decreased. Several of topics that were initially addressed by this WG only, have now become part of the programme of other sessions. Therefore, we suggest to bring this WG to an end, with the hope that other pluridisciplinary actions will emerge.

2.8 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),

International collaborations continued within the International Reference Ionosphere (IRI) project. Current work focuses on improvements of the topside electron density profiles, using data from the ISIS and Intercosmos 19 topside sounders, and on the development of a model describing the monthly variability of ionospheric characteristics. These are the main topics of the IRI Task Force Activities held annually at the Abdus Salam International Center for Theoretical Physics (ICTP) in Trieste, Italy. The proceedings of these meetings are published as ICTP Reports (e.g., IC/IR/2002/23, IC/IR/2003/7, IC/IR/2004/1). Selected papers from the 2001 IRI Workshop in Sao Jose dos Campos, Brazil, were published in a dedicated issue of Advances in Space Research (Volume 31, Number 3, 2003) entitled "Description of the Low Latitude and Equatorial Ionosphere in the International Reference Ionosphere". The 37 papers provide a good overview of ongoing modeling and measurement efforts in the low latitude ionosphere with special emphasis on the South-American sector.

During the 2002 World Space Congress and COSPAR General Assembly in Houston, Texas, the IRI team conducted a 2-day session on the "Path Toward Improved Ionosphere Specification and Forecast Models". Most of the 40 presentations are published in Advances in Space Research, Volume 33, Number 6, 2004. New models were presented for the topside ion composition (Triskova et al., using AE-C and IC-24 data), for the topside electron density profile (Bilitza, using ISIS data), for the plasmaspheric electron density distribution (Huang et al., using IMAGE/RPI data), for temperature profiles (Kutiev et al., using AKEBONO data), and for the D-region densities (Friedrich et al., using EISCAT data).

The 2003 IRI Workshop was held at Rhodes University in Grahamstown, South Africa, with support from COSPAR, URSI Commissions G and H, the US National Science Foundation, ICTP, and several local organizations including Rhodes University, the Hermann Ohlthaver Institute for Aeronomy (HOIA), the South African National Research Foundation (NRF), and the Grintek Ewation Company. About 40 scientists participated in the week-long meeting and discussed future improvements and enhancement of IRI with special emphasis on "Quantifying Ionospheric Variability". Participants also discussed concerns regarding the data quality of groundbased ionosonde data archived in the World Data Centers. Noting the importance of such data for studying long-term trends, Prof. Reinisch as chair of IRI sent a letter to the World Data Center in Boulder, CO.

In October 2003, the IRI group organized a day-long session during the German National URSI Meeting in Kleinheubach/Miltenberg in honor of Prof. Karl Rawer's 90th birthday. K. Rawer was the first Chairman of the IRI Working Group and has continued to strongly support and promote the IRI effort.

Papers presented during this session were published in Advances in Radio Science – Kleinheubacher Berichte.

A very successful two day session on "Modeling of Ionospheric Temperatures and Ion Composition" was organized by the IRI Working Group during the 2004 COSPAR General Assembly in Paris, France (July 18-24). Papers are now being reviewed for inclusion a special issue of Advances in Space Research.

Improvements of the IRI model at equatorial latitudes in the African sector were studied in the framework of an NSF- and Fulbright-supported visits of Dr. Olivier Obrou (University of Cocody, Abidjan, Ivory Coast) and Prof. Jacob Adeniyi (Universiytyt of Ilorin, Ilorin, Nigeria) at NASA's Goddard Space Flight Center working with Dr. Dieter Bilitza. The results will benefit the representation of ionospheric variability and of F-peak parameters in IRI for the African region.

The IRI Workshop 2005 will be part of the centennial celebration of the Ebro Observatory in Roquestes, Spain. The meeting chaired by Dr. David Altadill will be held from June 27 to July 1 and will focus on "New satellite and ground data for IRI, and comparison with regional models" (homepage at http://www.obsebre.es/w3/wsiri/).

2.9 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)
- FG: Atmospheric Remote Sensing using Satellite Navigation Systems
  Co-Chair for Commission G: C. Mitchell (United Kingdom)
- HGEJ: Supercomputing in Space Radio Science
  Co-Chair for Commission G: A. Barakat (USA)
- URSI/IAGA VLF/ELF remote Sensing of the Ionosphere and Magnetosphere (VERSIM)
  Co-Chair for Commission G: M. Parrot (France)
  The Working Group report appears in the commission H report

3. Sponsored meetings

3.1 Mode A sponsorship

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

- Getting the Most out of the Radio Spectrum, London, United Kingdom, 12-25 October 2002
- STAMMS – Spatio-Temporal Analysis and Multipoint Measurements in Space, Orléans, France, 12-16 May 2003
- Atmospheric Remote Sensing Using Satellite Navigation Systems (URSI Joint Working Group FG), Matera, Italy, 13-15 October 2003
- WARS04 (Workshop on Applications of Radio Science) conference, Hobbart, Australia, 18-20 February 2004
- COSPAR Capacity Building Workshop: Analysis of Data from Multisatellite Magnetospheric Missions, Beijing, China, 3-14 May 2004
- African Regional Workshop, Nairobi, Kenya, 16-20 August 2004
- Radar 2004, Toulouse, France, 19-21 October 2004
- Internatioanl School / Symposium for Space Simulations, Kyoto, Japan, 26-31 March 2005
- 2005 Ionospheric Effects Symposium – IES 2005, Alexandria, Virginia, 10-12 May 2005-06-16

3.2 Mode B sponsorship

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

- **COSPAR 2002 / IRI Session**
  Full report: The Radio Science Bulletin, December 2002, p. 61

The 34th COSPAR congress was held in Houston, USA. The IRI session, held on 17-18 October, reviewed ongoing ionospheric modelling activities, with a special emphasis on efforts that involve the IRI model.

- **ISAR-3**
  Full report: The Radio Science Bulletin, June 2003, p. 50

The 3rd International School on Atmospheric Radar was held in Trieste, Italy, 25 November – 13 December 2002. 28 participants from 17, mostly developing countries, attended the school.

- **MST-10**
  Full report: The Radio Science Bulletin, September 2003, p. 57

The 10th International Workshop on Technical and Scientific Aspects of MST Radar was held 13-20 May 2003 at the campus of Universidad de Piura in Peru. A total of 109 oral papers (24 thereof invited) and 66 poster papers were presented.

- **IRI 2003 Workshop**
  Full report: The Radio Science Bulletin, June 2005

The International Reference Ionosphere (IRI) Working Group held their annual workshop in 2003 at Rhodes University in Grahamstown, South Africa from 6 to 10 October. A total of 30 delegates representing 13 different countries attended the 5-day meeting presenting a total of 38 papers. The theme of IRI 2003 was "Ionospheric Variability" and 12 papers were presented covering this topic.

- **Vertical Coupling in the Atmsosphere / Ionosphere System**
  Full report: The Radio Science Bulletin, September 2004, p. 115

The 2nd IAGA/ICMA workshop on Vertical Coupling in the Atmosphere / Ionosphere System was held in Bath, UK, on July 12-15, 2004. It was attended by 65 scientists from 19 countries. The participants presented 60 papers, from which 9 were solicited

- **COSPAR 2004 / IRI Session**
  Full report: The Radio Science Bulletin, December 2004, p. 110

The session, held during the COSPAR congress held 18-25 July 2004 in Paris, was organized by the IRI Working Group with the goal of improving the description of the electron and ion temperature and the ion composition in the IRI model.

- **NATO Advanced Study Institute on Sprites, Elves and Intense Lightning Discharges**

The meeting was held at Corte University, France on 21-30 July 2004. No report is available at the time of writing.

- **AP/RASC 2004**

The Asia-Pacific Radio Science Conference was held 20-23 August 2004 in Beijing, China. No report is available at the time of writing.

- **IRI 2005 Workshop**

The IRI 2005 workshop was held 27 June – 1 July at the Ebro Observatory in Roquetes, Spain. No report is available yet.

Commission H on Waves in Plasmas

by Umran S. Inan

report not yet available

Commission J on Radio Astronomy

by Makoto Inoue

report not yet available