Commission G

2015-2017 Triennial Report

Chair: I. Stanislawska, Poland

1 Conferences

Commission G remains a very active commission. It took a very active role in URSI organized conferences and workshops. The special stress has been put to two past flag URSI meetings: 2015 URSI Atlantic Radio Science Conference and URSI and 2016 URSI Asia-Pacific Radio Science Conference.

The First URSI Atlantic Meeting on Radio Science, 18-25 May 2015, Gran Canaria, Spain. Commission G organized 8 sessions with 5 invited papers, 102 oral presentations, YS - 13 papers.

List of the sessions:

- Modeling Geospace Boundaries and the need for Radio Science Observations
- Ionospheric Morphology
- Data Modeling and Forecasting
- GRAPE (GNSS Research and Application for the Polar Environment)
- Space Weather Studies
- Assimilative modeling and the global ionosonde network
- Highly-Transient Space Plasma Events
- Ionospheric Effects on GNSS Systems at Low- latitude
- Radar and Radio Techniques for Ionospheric Diagnostics

2016 URSI Asia-Pacific Radio Science Conference, 21 - 25 August 2016, Seoul, South Korea.
AP-RASC is a triennial international conference in the field of radio science and related issues. Commission G participated in the Technical Program Committee and serves as session conveners. 56 papers (without posters) have been presented during 11 sessions including joint sessions. Special

presentation “Incoherent Scatter Radars: Present and Future” has been given by Craig J. Heinselman EISCAT Scientific Association, Sweden.
List of the sessions presented below represents the wide spectrum of Comm. G topics:

- General Ionospheric Studies
- ULF/VLF Waves
- GPS/GNSS Monitoring of the Ionosphere,
- Radar Probing for the Ionospheric Variability
- Ionospheric Density Variability in the Polar Region
- Satellite Probing for the Ionospheric Variability
- Observation of Ionospheric Plasma Density Variation
- Effects of Wave-Particle Interactions in Earths
- Radio Wave Propagation
- Effects of Wave-Particle Interactions in Earths Magnetosphere and Upper Atmosphere
- Space Weather Impact and Mitigation Efforts

GASS Montreal preparation

Preparation of General Assembly & Scientific Symposium shows 23 sessions accepted and about 400 abstracts and extended abstracts submitted for G Commission including joint sessions.

Past conference - URSI-RCRS 2015, 16-19 November 2015 New Delhi, India.

2 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.
Budget for 2014 – 2017 has been used for supporting following meetings:
1. YS at AT RASC - 1270 €
2. URSI RCRS 2015 supported by 200 €
3. IRI meeting in Bangkok 2015 - 600 €
4. Beacon Satellite Symposium 2016 - 1,400 €
5. ICTP-URSI School 2017- 650 €
6. GASS Montreal 2017 for YS, students and regular participants reserved – 3500 €

3 Working Groups

Commission G working groups are the primary focus for active collaborative research. During the triennium 2014-2017. URSI Commission G has been active through a number of WGs - reports from these WGs are provided below.

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

G1: Ionosonde Network Advisory Group (INAG)
Chair: I.A. Galkin (USA); Vice-Chairs: J.B. Habarulema (RSA), Baiqi Ning (China); INAG Bulletin Editor: P. Wilkinson (Australia)

Over the years, primary focus of INAG recommendations has shifted from the original objective of establishing a knowledgebase of ionogram interpretation rules and standards for data exchange to the intelligent systems for automatic ionogram scaling and new scenarios for the ionosonde network operations. This transformation reflected strengthening role of the HF ionosonde as a fully autonomous instrument for accurate and prompt specification of the ionospheric weather.

Multi-nation, coordinated operation of ionosonde networks plays critically important part in this practical ionospheric weather applications. Correspondingly, in 2015-2017 INAG continued its efforts to sustain and expand community-funded Global Ionosphere Radio Observatory (GIRO) that manages data from 100+ ionosondes (Figure 1), of which ~60 are streaming their real-time data to the Lowell GIRO Data Center for processing and assimilation in IRTAM (IRI-based Real-Time Assimilative Model). Every 15 minutes, IRTAM produces global maps of the density and height of the F2 layer peak, and two profile shape parameters, B0 and B1. Latest version of the International Reference Ionosphere accepts IRTAM maps to synthesize 3D plasma density distributions of the sub-peak ionosphere.

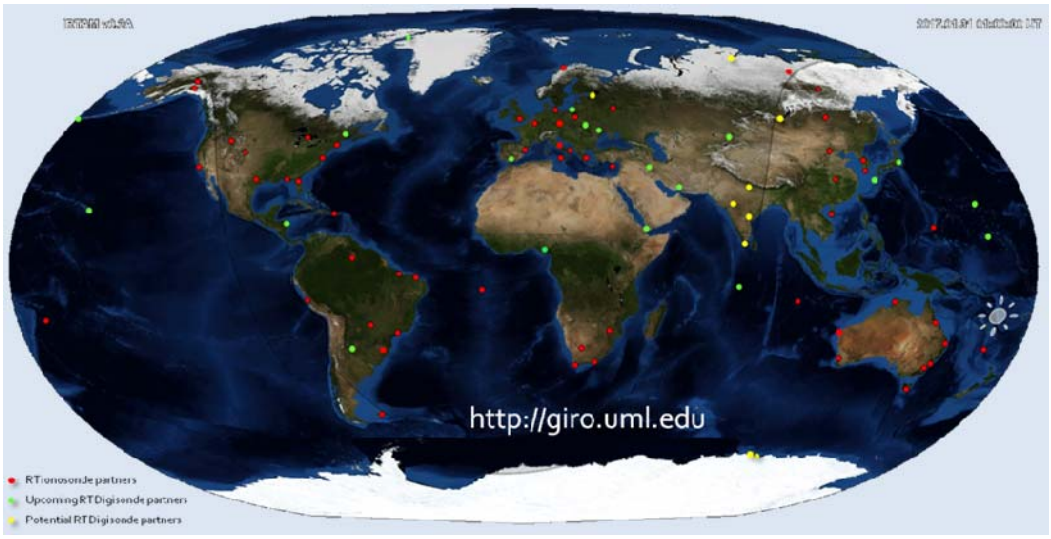

Figure 1. Global Ionosphere Radio Observatory with its current ~60 real-time data streaming ionosondes and plans for expansion.

INAG welcomes new GIRO participants and acknowledges long-time participants throughout the world. In 2016, The Australian Bureau of Meteorology joined GIRO, providing autoscaled data from a network of ten 5D ionosondes in Oceania. Continuing USAF NEXION project will add another 15 DPS4D instruments over the next 5-6 years. Negotiations with Russian Federation Helio/Geophysics Monitoring Center are underway to add network of ten Parus-A ionosondes to GIRO. Other new ionosonde observatories joined GIRO during the report Triennium, including installations in Brazil, USA, and Poland. INAG continues to be the communication point for contributing observatories; its membership remains fairly constant of about 380 with ~150 core participants in the activities. New

INAG newsletter is circulated to subscribers since 2014; INAG meetings occur regularly at URSI General Assemblies and National Commission Radio Conferences.

The 2015-2017 triennium is marked by increased interest to emerging technologies for detection and evaluation of traveling ionospheric disturbances (TID) that leverage recently developed analysis techniques for data from coordinated oblique-incidence sounding between DPS4D ionosondes. A pilot Network for TID Evaluation (Net-TIDE) started operations in 2016, https://sites.google.com/site/spsionosphere/. A TID warning service is established at http://tid.space.noa.gr/ that publishes alerts of TID events of defferent levels of severity.

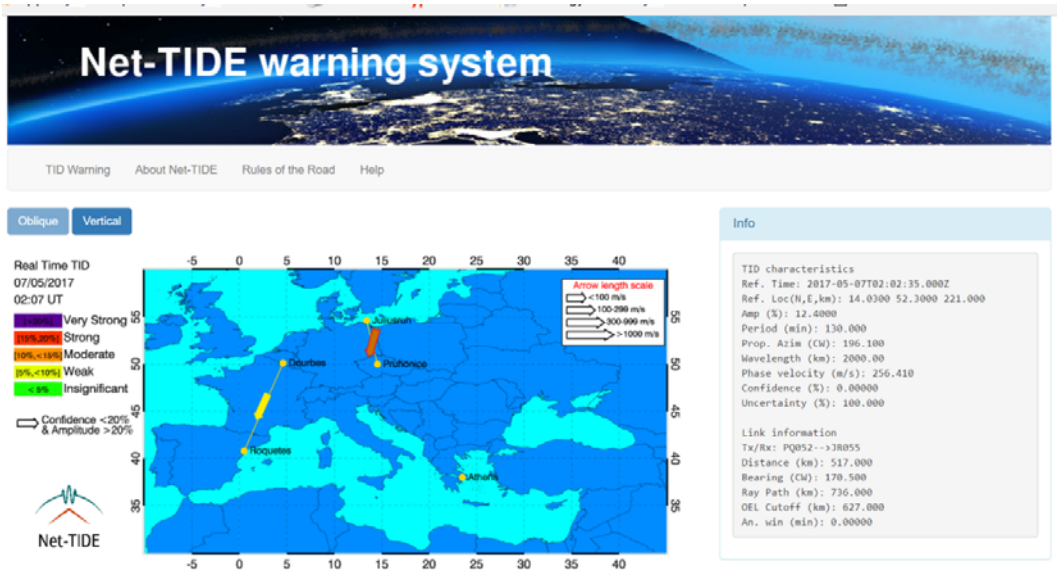

Figure 2: TID Warning system report for May 7, 2017 02:07 UT indicating presence of a large-scale moderate-strength TID travelling SSW at 250 m/s phase velocity.

The Net-TIDE project announced its plans for expansion once new DPS4D observatories join the network and MIMO technologies are implemented for the multi-node sounding between contributing ionosondes.

The INAG Bulletin is still available online and after a hiatus, further articles are now once again being posted. The current address is: http://webauth.syd.ips.gov.au//IPSHosted/INAG/ and Kehe Wang, Manager of World Data Centre, Space Weather Services (SWS), Bureau of Meteorology, Australia is looking after the site.

Ivan A. Galkin and Phil Wilkinson

G2: Studies of the ionosphere using beacon satellites
Chair: P. Doherty (USA); Vice Chairs: B. Nava (Italy), A. Krankowski (Poland)

The Beacon Satellite Group (BSG) is interdisciplinary, servicing science, research, applications, and engineering interests. The prime objective is to study the ionosphere using beacon satellite signals.

This working group continued to be active in its traditional fields, namely compilation, exchange and dissemination of information, communication and exchange of experience of various organizations of relevance (augmentation systems for GPS based satellite navigation, international and national advisory bodies, the United Nations Office for Outer Space Affairs (UNOOSA), the Institute of Navigation, the NASA International Space Weather Initiative (ISWI) and others), providing advice and collaboration

on request. These activities were carried out by correspondence and through attendance at conference and other meetings.

The most notable activities of the BSG are the Beacon Satellite Symposia. After a fore runner organized at the Max-Planck Institut fur Aeronomie at Lindau, 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. To date, there have been 19 symposia held in different countries including Russia, USA, Italy, India, Finland, China, Argentina, the United Kingdom, Hungary and Spain. All of these events were organized by the Chairs of the BSG together with a local chair and organizing committee consisting of URSI Commission G members. The most recent symposium was held in 2016 in Trieste, Italy. This event titled BSS2016 was hosted by the International Centre for Theoretical Physics with Professor Sandro Radicella and Dr. Bruno Nava as the local organizing chairs.

This 19th International Beacon Satellite Symposium (BSS2016) was extraordinarily successful. It attracted nearly 200 participants from 48 countries. The presentations were of high quality and the organization and venue were impeccable. One of the most notable differences from prior symposia was the unprecedented number of participants from developing countries. This is attributed to the generous support of our sponsors and the attraction of the ICTP as a driving force behind global efforts to advance scientific expertise in the developing world (http://www.ictp.it/about-ictp.aspx).

The BSS2016 featured 120 oral presentations and more than 60 poster presentations. The presenters included experienced scientists, young scientists and students from many backgrounds. Countries represented at the symposium included Algeria, Argentina, Austria, Azerbaijan, Belgium, Brazil, Canada, Peoples Republic of China, Cameroon, Croatia, Cuba, Egypt, Ethiopia, Finland, France, Germany, Ghana, Hungary, India, Indonesia, Islamic Republic of Iran, Italy, Cote d'Ivoire, Japan, Kenya, Malaysia, Nepal, Nigeria, Norway, Pakistan, Peru, Philippines, Poland, Palestine, Republic of Korea, Russian Federation, Rwanda, South Africa, Spain, Sri Lanka, Taiwan, Thailand, Turkey, Uganda, United Kingdom, Ukraine, United Republic of Tanzania and the United States of America

The opening ceremony began with a general welcome to the ICTP by Dr. Fernando Quevedo, Director of ICTP. This was followed by welcoming notes from Professor Sandro Radicella (ICTP), Patricia Doherty (Boston College) and Bruno Nava (ICTP), Chairs of BSS2016. Dr. Kent Miller of the Air Force Office of Scientific Research and Ms. Sharafat Gadimova of the United Nations Office for the Peaceful Outer Space Affairs (UNOOSA) also expressed their welcome and interest in this meeting as sponsors of BSS2016. Dr. Paul Cannon, President of URSI presented the keynote talk on The BSS, Radio Science and URSI.

The opening ceremony culminated with a dedication of BSS2016 to the memory of Dr. P.V.S. Rama Rao who passed away in 2014. Dr. Rama Rao was a long term member of URSI and co-chair of many Beacon Satellite Symposia. He was remembered in a heartfelt presentation of his work by his former students, Drs. Gopi Seemala and Venkatesh Kavatarapu. A plaque dedicating BSS2016 to Dr. Rama Rao was presented to his son, Mr. Anand Paluri, who attended the opening ceremony with his family. Mr. Paluri gratefully accepted the dedication expressing his father's devotion to the Beacon community and satellite studies.

The technical sessions included innovative presentations on Total Electron Content (TEC), ionospheric irregularities and scintillation, monitoring natural hazards from space, polar effects on GNSS, data assimilation modeling, ionosphere-thermosphere modeling and validation, ionospheric effects on satellite based navigation systems, radio occultation techniques and measurements, and space weather. An impressive poster session was also held with nearly 60 posters presented on all of the relevant sessions. All of the presentations and the ensuing discussions initiated many international collaborations and interests. Numerous remarks were made on the quality and excellence of the

presentations during this symposium. In addition, with the inclusion of many participants from developing countries in Africa, participants had the opportunity to learn of research efforts in countries not represented in earlier Beacon Symposia.
Social events included a welcome reception, a poster session reception and an excursion to the UNESCO World Heritage site at Aquileia in Friuli-Venezia Giulia. The final social event was a banquet held at Ristorante Le Terrazze at Hotel Riviera where the food was superb and the views of the Adriatic Sea were breathtaking. All of these events provided further opportunities to renew old acquaintances, establish new collaborations and plan for the future of the Beacon Satellite Symposia.

During the final ceremony, Ms. Doherty also conducted a group business meeting where many valuable comments and recommendations were made by the membership for the continued success of the Beacon Satellite Studies group and the Beacon symposia. Ms. Doherty publicly thanked former chairs, Dr. Reinhart Leitinger and Mr. Jack Klobuchar, for their dedication and many years of service to the Beacon Satellite Studies group and symposia. She also presented the new co-chairs who will join her in the leadership of the Beacon Satellite Studies group and Beacon Satellite Symposia. The new co-chairs include Bruno Nava of ICTP and Andrzej Krankowski of the University of Warmia and Mazury in Olsztyn, Poland. The membership then unanimously endorsed this leadership team of Patricia Doherty, Bruno Nava and Andrzej Krankowski.

The meeting ended with the announcement that next Beacon Symposium will be hosted by Dr. Andrzej Krankowski at the University of Warmia and Mazury in Olsztyn, Poland in 2019.
Commission F, G and H: URSI-ICTP School on Radio Physics

Another activity organized by Commissions F, G and H was the URSI-ICTP School on Radio Physics. This activity was jointly organized by URSI Commissions F, G and H and the The Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy. It was held from 27 - 31 March 2017 at the ICTP in Trieste. The School was co-sponsored by URSI Commissions F, G and H, the ICTP, Boston College of the United States of America and the United Nations Office of Outer Space Affairs.

With increased societal dependence on space and ground based radio systems for communications, navigation and remote sensing it is increasingly important to train the next generation of scientists in the theory and applications of radio wave propagation. This school provided radio physics training to more than 40 young scientists and graduate students from around the world, but with a particular focus on developing countries. The school also acted as an introduction to URSI with and the mission and interests of Commissions F, G and H of URSI. These commissions respectively address the topics of wave propagation and remote sensing, ionospheric radio and propagation, and waves in plasmas.
Lectures included:

- introductions to URSI and the mission and interests of Commissions F, G and H
- radar sensing of precipitation
- microwave emission and backscattering from bare and vegetated soils
- active and passive microwave remote sensing of terrestrial snow
- implementation of inversion algorithms for the retrieval of geophysical parameters from microwave data
- introductions to GNSS
- remote sensing with GNSS
- introduction to radar
- introduction to incoherent scatter radar
- space weather and its effects on radio systems;
- introduction to space plasmas
- plasma waves, theory of wave propagation through ionized media

- introduction to the ionosphere and ionosphere modeling

The school provided the added benefit of networking opportunities for graduate students and scientists together with the introducing the attendees to URSI, an organization that stimulates and coordinates studies in the fields of radio, telecommunication, and electronic sciences through scientific and technical symposia and publications.
Lecturers included:

- Patricia Doherty, Boston College, USA
- Iwona Stanislawska Polish Academy of Sciences, Poland
- Sandro M. Radicella, ICTP, Italy
- Bruno Nava, ICTP, Italy
- Simonetta Paloscia, IFAC-CNR, Italy
- Luca Baldini, ISAC-CNR, Italy
- Paolo Pampaloni, IFAC-CNR, Italy
- Emanuele Santi, IFAC-CNR, Italy
- Susan Skone, University of Calgary, Canada
- Anthea Coster, MIT Haystack Laboratory, USA
- Christine Amory, LLP, France
- Craig Kletzing, University of Iowa, USA
- Katy Alazo, ICTP, Italy

By all accounts, the school was a success in introducing young scientists and graduate students from around the world to the International Union of Radio Scientists and the scientific interests of Commissions F, G and H.

Patricia Doherty

G3: Incoherent scatter Working Group
Chair: I. McCrea (UK); Vice Chair: E. Spanswick (Canada)

During the period 2015-2017, I have acted as Chair of the URSI Incoherent Scatter Working Group, with Emma Spanswick (University of Calgary, Canada) as co-chair. In this time, the URSI ISWG has continued to carry out its main task of coordinating the combined "World Day" operations of all the global incoherent scatter radar facilities around the world. This was done using the following mechanism:

- A call for applications was sent out in the spring of each year, for experiments to be run the following year.
- Discussion of these applications took place during a workshop session convened each year at the US CEDAR meeting
- Aa a result of these discussions, allocations of time were awarded to each proposal, or proposals with similar aims were amalgamated as appropriate
- Discussions then took place between the proposers and the teams operating each facility, in order to achieve the optimum observing mode for each of the applications concerned.

The tables below show the World Day allocations awarded for 2015, 2016 and 2017. The process of arranging World Day intervals for 2018 is underway at the time of writing.

2015 World Days

Name	Proposer	Start Date	Duration (days)	Alert Period (if any)
Stratospheric Warming and Gravity waves	L.Goncharenko (MIT)	10/02/2015	5	15/01/2015 - 15/02/2015
Observations during the Total Solar Eclipse	I.Haggstrom (EISCAT)	20/03/2015	2	
Storm studies, supporting the Meridian Circle programme	S.Zhang (MIT)	17/03/2015	4	13/03/2015 - 27/03/2015
Synoptic Observations	URSI ISWG	15/07/2015	2	
Northern Deep Polar Winter	H.Carlson (Alaska) Y.Dabakk (Oslo) A.Wood (Nottingham Trent)	09/12/2015	4	

2016 World Days

Name	Proposer	Start Date	Duration (days)	Alert Period (if any)
Ionospheric Flow Channels	T.Nishimura (UCLA)	05/01/2016	7	
Gravity Wave Studies	A.Kavanagh (BAS)	08/02/2016	5	
Storm studies, supporting the Meridian Circle programme	S.Zhang (MIT)	14/03/2016	5	05/03/2016 - 19/03/2016
Ionospheric irregularities	H.Dahlgren (KTH) G.Perry (Calgary)	28/11/2016	5	

2017 World Days

Name	Proposer	Start Date	Duration (days)	Alert Period (if any)
Ionospheric Flow Channels	T.Nishimura (UCLA)	01/01/2017	3	
Gravity Wave Studies and Inter-	T.Ogawa (NIPR)	15/01/2017	10	15/01/2017 -

hemispheric coupling				03/02/2017
Ionospheric Flow Channels	T.Nishimura (UCLA)	24/01/2017	3	
Storm studies, supporting the Meridian Circle programme	S.Zhang (MIT)		5	13/09/2017 - 27/09/2017
Convection and polar cap patches	L.Baddeley (UNIS)	16/12/2017	4	

Notes

Several of the above operations used the principle of "alert periods". Usually such experiments are intended to study a particular geophysical phenomenon,whose occurrence is unlikely on any particular day, but becomes more likely over a longer period. Under this arrangement, a window is defined, which can be anything from a week to a month in extent. A shorter period, during this interval is set aside for the World Day run, which begins on a day within the alert window when the correct conditions occur, or are anticipated. The proposer is responsible for deciding on the start date and coordinating with the facilities.

On some occasions, multiple proposals were combined, if it was judged that their scientific aims were very similar, or could be covered by a single set of observations. The World Day run starting December 9th 2015 was such a case, in which three proposals were received proposing the study of phenomena that could be best observed under winter high latitude conditions. These were combined into a single experiment, with the consent of the proposers. Although it has two listed proposers from different institutions, the World Day beginning November 28 2016 originated from a single proposal on which two research groups had collaborated.

The World Day observations between March 17 and March 21 2015 were of particular note. As well as containing a total solar eclipse, visible from Svalbard on March 20, this interval also coincided with the "Saint Patrick's Day Storm", which began on March 17th and was the largest geomagnetic storm up to that point of solar cycle 24. The results obtained during this interval formed the basis of a special workshop session at the 2016 CEDAR meeting.

Ian McCrea

GEH: Seismo Electromagnetics (Lithosphere-Atmosphere- Ionosphere Coupling)
Co-Chair for Commission G: S. Pulinets (Russia)

During accounting period the members of the Inter-commissions GEH Working group "Seismo-Electromagnetics (Lithosphere-Atmosphere-Ionosphere Coupling) actively participated in many international events (conferences, symposia, workshops) including two events organized by USRI:
2015 1st URSI Atlantic Radio Science Conference (URSI AT-RASC)
18-th International Beacon Satellite Symposium 2016, where chairman of GEH Commission was a co-organizer of the special session "Monitoring Natural Hazards".
The members of the Working group won the contest and implemented the ESA project ESA ITT AO/1-7548/13/NL/MV "IoNosphere Sounding for Pre-seismic anomalies Identification Research" (INSPIRE), 2015-2016

The Working group activity was concentrated on the three main subjects:

1. Further development of the physical mechanisms of pre-earthquakes ionospheric anomalies generation
2. Statistical confirmation of the pre-earthquake ionospheric anomalies existence
3. Development of the technologies of automatic identification of the pre-earthquake ionospheric anomalies

Results of these activities could be found in the following publications:

Pulinets S.A., Ouzounov, D.P., Karelin A.V., Davidenko D.V., Physical Bases of the Generation of Short-Term Earthquake Precursors: A Complex Model of Ionization-Induced Geophysical Processes in the Lithosphere–Atmosphere–Ionosphere–Magnetosphere System, Geomagnetism and Aeronomy, 55, No.4, 540-558, 2015

Liu J.Y., Y.I. Chen, C.C. Huang, Michel Parrot, X.H. Shen, S.A. Pulinets, Q.S. Yang, Y.Y. Ho, A spatial analysis on seismo-ionospheric anomalies observed by DEMETER during the 2008 M8.0 Wenchuan earthquake, Journal of Asian Earth Sciences, 114(p.2), 414-419, doi:10.1016/j.jseaes.2015.06.012, 2015

Pulinets S.A., The Physical Bases for the Short-Term Earthquake Precursors Generation, Proceedings of the V-th International conference "Atmosphere, Ionosphere, Safety", June 20-24, 2016, Kaliningrad, Kant Federal University Publ., ISBN 978-5-9971-0412-2, 24-29, 2016

Parrot M., V. Tramutoli, Tiger J.Y. Liu, S. Pulinets, D. Ouzounov, N. Genzano, M. Lisi, K. Hattori, A. Namgaladze, Atmospheric and ionospheric coupling phenomena related to large earthquakes, Nat. Hazards Earth Syst. Sci. Discuss., doi:10.5194/nhess-2016-172, 2016

Pulinets S.A., Atmosphere-Ionosphere Coupling: The role of boundary layer in generation of ionospheric precursors of earthquakes, Proceedings of the International Beacon Satellite Symposium BSS-2016, 26 June 1July 2016, Trieste, Italy, 1-3, 2016

Pulinets S., Ouzounov D., Davydenko D., Petrukhin A., Multiparameter monitoring of short-term earthquake precursors and its physical basis. Implementation in the Kamchatka region, E3S Web of Conferences 11, 00019 (2016), DOI: 10.1051/e3sconf/20161100019

Armstrong F. Sompotan, Nanang T. Puspito, Endra Joelianto and Katsumi Hattori, 2015. Analysis of Ionospheric Precursor of Earthquake using GIM-TEC, Kriging and Neural Network. *Asian Journal of Earth Sciences, 8: 32-44.*

Shinji Hirooka, Takashi Ichikawa, Katsumi Hattori, Peng Han, Chie Yoshino, Jann-Yeng Liu, Spatial and Temporal Distribution of the Pre-Seismic Ionospheric Anomaly Prior to the 2011 Off the Pacific Coast of Tohoku Earthquake (Mw9.0), IEEJ Transactions on Fundamentals and Materials, Vol. 136 (2016) No. 5, p. 265-271

Ryu, K., Oyama, K.-I., Bankov, L., Chen, C.-H., Devi, M., Liu, H., Liu, J.-Y., Precursory enhancement of EIA in the morning sector: Contribution from mid-latitude large earthquakes in the north-east Asian region, Advances in Space Research, Volume 57, Issue 1, 1 January 2016, Pages 268-280

Shinji Hirooka, Katsumi Hattori, Validation of Ionospheric Tomography using Residual Minimization Training Neural Network, IEEJ Transactions on Fundamentals and Materials, Vol.135 No.2 pp.117-123 DOI: 10.1541/ieejfms.135.117

Michel Parrot and Mei Li, DEMETER Results Related to Seismic Activity, Radio Science Bulletin, No 355 (December 2015), p. 18-25

Jann-Yenq Liu and Chi-Kuang Chao, An observing system simulation experiment for FORMOSAT-5/AIP detecting seismo-ionospheric precursors, Terr. Atmos. Ocean. Sci., Vol. 28, No. 2, XXX-XXX, April 2017, doi: 10.3319/TAO.2016.07.18.01(EOF5)

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)

Activities of the URSI/COSPAR International Reference Ionosphere (IRI) Working Group during this time period have concentrated on the release of the 2016 version of the model and on the development of the Real-Time IRI. IRI-2016 includes a number of improvements, most importantly two new options for the representation of the F2 peak hmF2. It was decided to include two models because they are based on different data sources and are ripe for assessment and validation by the IRI user community. The recommended/default option is the model developed by Altadill and colleagues (Ebro observatory, Spain) based on ionosonde measurements from the Global Ionosphere Radio Observatory (GIRO). In addition the user can opt to choose either the old IRI-2012 hmF2 model or the model developed by Shubin (IZMIRAN, Russia) based primarily on COSMIC radio occultation data. The two new options provide direct representations of hmF2 whereas the older IRI hmF2 had the shortcoming of relying on a global representation of the propagation factor M(3000)F2 and the correlation between this parameter on hmF2. All the changes from IRI-2012 to the new IRI-2016 were reviewed and described by Bilitza et al. in a 2016 Space Weather paper (doi:10.1002/2016SW001593).
The IRI team organized an IRI Workshop on the topic 'Improved Accuracy at Equatorial Latitudes and Progress Towards Real-Time IRI' at the King Mongkut's Institute of Technology Ladkrabang in Bangkok, Thailand, November 2-13, 2015 within COSPAR's Capacity Building Workshop program. The workshop was attended by about 120 participants including 35 students with a strong participation from southeast Asian countries. The students were competitively selected form the 114 applications received and participated in the training in ionospheric monitoring and modelling during the first workshop week and also the second week which was organized as an IRI community and experts meeting with latest results on comparisons, improvements and applications of this international standard; IRI was elected to be the official ISO standard for the ionosphere in April 2014.

IRI results and updates were presented at several science meetings during this time period including the URSI AT-RASC meeting 2015, the American Geophysical Union (AGU) Fall meetings in 2014, 2015, and 2016, the European Geosciences Union (EGU) meetings in 2015 and 2016, the International Beacon Satellite Symposium in 2016, and the Ionospheric Effects Symposium (IES) in 2015 and 2017. Many of the presentation focused on the development and successes with the Real-Time IRI based on an assimilation of GIRO ionosonde data into the IRI model. A special session on empirical models was organized during the 2016 CEDAR meeting that included an IRI tutorial.

IRI is widely used as documented by the large number of accesses to the online IRI services for calculating IRI parameter, now at the level of 5 million access per month. About 10% of the papers published in Radio Science each year make use of the IRI model (1914: 10.7%, 2015: 9.6%, 2016: 13.2%). At the 2017 IES meeting almost every second or third paper was using IRI in some way or form mostly as the background ionosphere for wave propagation related studies and applications.

A special issue of Advances in Space Research (Volume 55, Issue 8, 2015) was published with a core set of papers from the 2013 IRI Workshop in Olsztyn, Poland that had as its topic 'IRI and GNSS'.

Bodo Reinisch, who is a longtime IRI member and chaired the Working Group from 2002 to 2010, received the International Kristian Birkeland medal for Space Weather and Space Climate from the Norwegian Academy of Science.

International Reference Ionosphere 2015 (IRI 2015) Workshop
2-13 November, 2015, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand

1. **Training Week: 2-6 November, 2015**

The IRI Workshop was preceded by a 1-week training school on ionospheric monitoring and modelling for young research from the region. Ten lecturers and thirty-three trainees participated in the 5-day Training session that took place in the computer lab #109 of the Engineering Instructional Building, Faculty of Engineering, KMITL. The trainees were competitively selected from 114 applicants and represented 11 mostly Southeast-Asian countries including Thailand, Malaysia, Singapore, Philippines, Indonesia, Vietnam, India, South-Korea, Taiwan, China, and USA. On each Training day, lectures were given in the morning, while the afternoons were devoted to the practical part and the time for Team Projects. On Monday morning, November 2nd, we welcomed Assoc. Prof. Komsan Maleesee, the Dean of Faculty of Engineering, who presided over the Opening session and welcomed the participants. In addition, Prof. Mariano Mendez welcomed the participants and introduced the COSPAR activities and opportunities for fellowships. Prof. Dieter Bilitza gave a welcome message as well on behalf of the COSPAR/URSI International Reference Ionosphere (IRI) project.

The lecture topics during the training week were: Ionosphere-An introduction, IRI-Introduction and open problems, Comparison of IRI with ionosonde data from the Asian sector, IRIweb and related online services, Ionsonde measurements, Real-Time IRI, Ionosondes in the Asian Sector, Ionosonde data online: GIRO and SPIDR, GNSS data and ionospheric studies, Irregularities at equatorial latitudes, TEC comparisons with IRI in the Asian sector, Access to GNSS data, Coupling between ionosphere and thermosphere at low latitudes, Ion densities and plasma temperatures, Solar irradiance and Upper atmospheric chemistry, Incoherent scatter radar, and Ionospheric storms.

On the first training day the trainees were divided into 8 teams and the 8 science problems were distributed to the teams via lottery. A lecturer was assigned to each problem to work as adviser with the specific team. Below is a listing of the lecturers, students and topics/problems assigned to each team.

2. **Presentation Week: 9-13 November, 2015**

During this week, a conference format with oral presentations and poster presentations was organized. We had received 116 abstract submissions from 25 countries. The accepted presentations were distributed in sessions entitled ‘Improved Accuracy of IRI at Equatorial Latitudes I, II, III’, ‘Progress Towards Real-Time IRI’, ‘F-peak Modelling and Comparisons’, ‘Description of Plasma Temperatures and Ion Composition in IRI’, ‘TEC and Topside Modeling and Comparisons’, ‘Description of the Ionosphere Below the F-peak’, Poster session, ‘New Inputs and Applications’. The opening session on Monday morning, November 9th, was presided by Assoc. Prof. Supan Tungjitkusonman, Vice Provost in Academic and Research Affairs, and Assoc. Prof. Komsan Maleesee, the Dean of Faculty of Engineering. In addition, Prof. Dieter Bilitza, COSPAR/URSI IRI Committee Executive Secretary, and Assoc. Prof. Pornchai Supnithi, the General Chair of the IRI 2105 Workshop and Asst. Prof. Prasert Kenpankho, representative of the Technical Program Committee, made Welcome Remarks. Representatives of the sponsor organizations received an Appreciation Certificate and a small gift.

The venue for the next IRI 2017 Workshop was discussed and proposals were presented for Havana, Cuba and Irkutzk, Russia. Drs. Pornchai Supnithi and Prasert Kenpankho were elected as new members for the IRI Working Group.

Finally, the awards for the best student teams were presented: **Gold award**: Team 5, **Silver award**: Team 1, **Bronze award**: Team 4.

The workshop was financially supported by COSPAR in the framework of its Capacity Building Workshop Program. Additional financial support was provided by the International Union of Radio Science (URSI), the US Airforce Office of Scientific Research, the US Office of Naval Research, the Thai Geo-Informatics and Space Technology Development Agency, the Asian Office of Aerospace R&D, NovAtel, KMITL, Thaicom, and TCEB.

Dieter Bilitza

Other Working Groups

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

4 In Memoriam

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

- Andrzej Wernik (Poland)
- Rama Rao (India)
- Xueqin Huang (USA)
- Staffan Ström (Sweden)
- Yury V. Chugunov (Russia)

5 Chair's Comments

My considerable thanks to the President Paul Cannon and vice chair Patricia Doherty for their advice and help with Commission activities