



Commission Triennial Report
Commission G

1. Chair's Comments

Commission G is a very active commission as reflected by their extensive participation in the URSI triennium meetings and working groups. The focus of the commission is on studies of the ionosphere in order to provide the broad understanding necessary to support space and ground-based radio systems. From the earliest studies of ionospheric morphology to transforming advancements in diagnostic techniques, ionospheric modeling, theory and radio system applications; Commission G scientists have been at the forefront of discovery of the complex ionospheric environment and its effects on radio waves.

Much of the success of Commission G over the last 4 years has been due to the generous support from the Commission Vice Chair, ECRs, working group chairs and session conveners. I sincerely thank Dr. Giordiana De Franceschi, Commission G Vice Chair, for providing continuous support and advice during the past four years. She has been particularly active with preparation and participation in all of the URSI triennium meetings. Dr. Seebany Datta-Barua and Dr. Sean Elvidge, the first Early Commission G Representatives, have provided new perspectives and insight for the commission and have supported our activities since their election as officers to commission G. The immediate past Chair, Dr. Iwona Stanislawska, offered knowledgeable counsel and endless patience during the transition of officers four years ago. Finally, we thank the working group chairs for keeping things going in various activities and to the session conveners for all of the URSI meetings.

2. In Memoriam

The following friends and colleagues from the URSI Commission G community passed away since our last commission report in 2017:

- William Burke, 1935-2020, Physicist known for significant contributions to the understanding of the space environment and the hazards impacting the operations of Air Force space systems, Air Force Research Laboratory and Boston College, USA.
- Don Farley, 1933-2018, Pioneer of incoherent-scatter radar theory, world leader in ionospheric research, and inspiring teacher and mentor, 1996 URSI Sir Edward Appleton Award, Cornell University, USA.
- Bengt Hultqvist, 1927-2018, Founder of the Swedish Institute of Space Physics, Chair of Commission G 1978-1980, Sweden.
- Edward S. Kazimirovsky, 1937-2018, An avid ionospheric researcher and former Dean of Radio Electronics at a university in Irkutsk, Russian Academy of Sciences, Russia.
- Leo McNamara, 1940–2021, Author of 'Radio Amateurs Guide to the Ionosphere' and 'Ionosphere: Communications, Surveillance and Direction Finding,' Australian Ionospheric Prediction Service (1970-1986), Andrews Corporation (1986-1993), Air Force Research Laboratory (1993-2020), Australia and the USA,
- Aleksandr P. Potekhin, 1951 – 2019, Head of Radio physics Research at the Institute of Solar-Terrestrial Physics SB, Russian Academy of Science, Russia.
- Karl Rawer, 1913-2018, Pioneer in the exploration of the ionosphere from the ground and from space, and in the understanding of radiowave propagation in the ionospheric medium. Commission G Chair (1970-1972), 1st Karl Rawer Gold Medal awarded in his honor in 2017, Germany.



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- Alan Rodger, 1951-2020, Editor of the Journal of Geophysics Research (Space Physics) and former interim Director of the British Antarctic Survey (BAS), United Kingdom.
- Charlie Rush, 1942-2020, Eminent scientist in ionospheric physics, modeling and radio propagation, NTIA, US Department of Commerce, USA.
- Yuri Ruzhin, passed away in 2021, Deputy Director, Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, Russian Academy of Sciences (ISMIRAN), Chairman of Commission G of the National URSI Commission of Russia, Russia.
- Bill Wright, 1929-2018, A pioneer in Ionospheric sounding using advanced techniques, NOAA, USA.

We honor all of our departed colleagues for their scientific excellence; their commitment to ionospheric and radio propagation research, and to Commission G.

3. URSI Triennial Meetings

AT-RASC 2018: The second URSI Atlantic Meeting on Radio Science (AT-RASC) was held on 28 May to 1 June 2018 in Gran Canaria, Spain. Commission G hosted 9 sessions with 105 oral and 13 poster presentations. Commission G supported two other sessions led by other commissions. A total of 25 Young Scientist papers were submitted to Commission G. Thirteen of them received a Young Scientist award.

The list of sessions included:

- G01: Ionospheric Impact on Remote Sensing: Challenges and Opportunities
- G02: Progress in Ionospheric Modeling and Data Assimilation
- G03: Advances and Challenges in the use of GNSS in Ionospheric Monitoring
- G04: Advances in Space-born GNSS Receiver Techniques for Monitoring the Topside Ionosphere
- G05: Ionospheric Response to the Solar Eclipse of 2017
- G06: New Advances in Scintillation Monitoring
- G07: Sensor Networks for Ionospheric Weather Nowcast
- G08: Global Electric Circuit and the Ionosphere
- G09: Meteors, Collisional EMPs, and other Highly-Transient Space Plasma Events
- HG1: Radio Science for Space Weather Science and Operations
- JACEFG1: Applications for Pattern Recognition Methodologies

AP-RASC 2019: AP-RASC 2019 was the fourth URSI Asia-Pacific Radio Science Conference (AP-RASC). This meeting was held on 9-15 March 2019 in New Delhi, India. Commission G hosted 5 dedicated sessions and 2 joint sessions. A total of 75 oral presentations and 44 posters were presented.

The list of sessions included:

- G01: GNSS/IRNSS Based Remote Sensing of the Ionosphere
- G02: Ionospheric Irregularities: New Insights and Challenges
- G03: Ionospheric Effects of Space Weather
- G04: Innovations in Ionospheric Modeling and Data Assimilation
- G05: Open Session
- EGH1: Lithosphere, Atmosphere, Ionosphere and Magnetosphere Electromagnetic Coupling
- HG1: Lightning Effects on the Ionosphere

URSI GASS 2021: The 24th URSI General Assembly and Scientific Symposium will be held on 28 August to 4 September 2021 in Rome, Italy. The 23rd meeting that was planned to be held in 2020 was cancelled due to the COVID-19 pandemic. For the upcoming GASS, Commission G was extremely proactive with



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the organization of 16 dedicated sessions, 5 joint sessions and a workshop on Space Weather. This resulted in 208 oral presentations together with 98 FIP presentations. FIP (Flash Interactive Presentations) are replacing the historical poster presentation format. The FIP format will be comprised of a short set of slides viewable via a laptop. A total of 10 Young Scientists Awards from Commission G will be presented at the upcoming URSI GASS meeting. The awardees are listed in the URSI website: https://www.ursi.org/young_scientists.php.

This list of GASS sessions include:

G01: Data Assimilation for Space Weather
G02: Advances on High Accuracy GNSS solution
G03: International Reference Ionosphere: Improvement, Validation and Usage
G04: Science with Modern Ionosondes and Associated Instrumentation and Models
G05: Advances in Irregularities and Scintillation Studies
G06: Innovations in Geospace Science Using Incoherent Scatter Radar Techniques
G07: Design and Application of HF and OTH Radar Systems
G08: Ionospheric Space Weather
G09: Radio Occultation and Reflectometry: ionosphere compensation, monitoring and modelling
G10: Radio Studies of Mid and Low Latitude Aeronomy
G11: International Beacon Satellite Studies
G12: Long-term Ionosphere Forecasting: State of the Art and Recent Advances
G13: Open Session
G14: Predictability of the Earth's Ionosphere and Space Weather Dynamics
G15: PRESTO: The New SCOSTEP Space Weather and Space Climate Program
G16: Space Weather impacts on GNSS
GH1: Meteors, Collisional EMPs & other Highly-transient Space Plasma Events
GH2: Plasma Instabilities in the Ionosphere
GH3: Lessons learned from Ground-based Active Ionospheric Experiments
GHE1: Seismo Electromagnetics (Lithosphere-Atmosphere-Ionosphere Coupling)
GHJ1: The Polar Environment and Geospace
WS3: Radio Science in Space Weather

4. Working Group Reports

G1: Ionosonde Network Advisory Group (INAG)

Chair: I.A. Galkin (USA); Vice-Chairs: J.B. Habarulema (RSA), Baiqi Ning (China); INAG Bulletin Editor: K. Wang (Australia). Membership registrations: 479.

On January 11, 2021, the Ionosonde Network Advisory Group (INAG) has reached new landmark: 90 year anniversary of the monitoring of the ionosphere by means of High-Frequency (HF) radio sounding. Regular observations of the ionospheric dynamics began with the first-ever 24-hour timeline of the ionosonde measurements on January 11, 1931 at Slough observatory in the UK. Recognizing the accomplishments over the past 90 years, INAG notes strengthening role of the HF ionosonde as a fully autonomous instrument for accurate and prompt specification of the ionospheric weather.

The ionosonde remains one of the most sensitive remote-sensing instruments to detect and characterize plasma disturbances. Since its inception in the 1920, radio engineering made sub-km, sub-degree, and sub-Hz precision in ionosonde equipment possible to detect even the slightest manifestations of plasma irregularities. Rapid measurement cadences of less than 10 sec allowed tracking of plasma in time and place. A multitude of ionogram and skymap features associated with irregularities of various scales are now provided with interpretation manuals and described in academic publications. Multi-nation, coordinated operation of ionosonde network plays critically important part

in the practical ionospheric weather. Correspondingly, in 2018-2021 INAG continued its efforts to sustain and expand community-funded Global Ionosphere Radio Observatory (GIRO) that manages data from 100+ ionosondes (Figure 1).

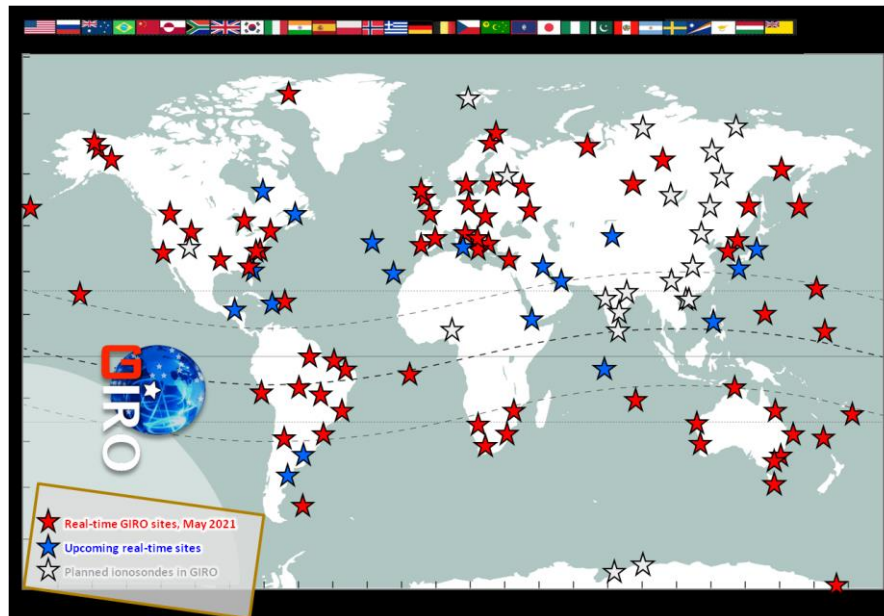


Figure 1. Global Ionosphere Radio Observatory with its current ~60 real-time data streaming ionosondes and plans for expansion.

New ionosonde observatories joined GIRO during the report Triennium, including

- 10 existing Parus-A ionosondes of the Russian Federation Helio/Geophysics Monitoring Center of Roshydromet; and
- 7 new Digisonde DPS4D installations in Sopron (Hungary), Kent Is., MD, Eareckson, AK, Poker Flat, AK (USA), Wake Is., Thule (Greenland), and El Arenosillo, Spain.

INAG welcomes new GIRO participants and acknowledges long-time participants throughout the world. Continuing USAF NEXION project will add another 12 DPS4D instruments over the next 5-6 years.

Near real-time capability of ionospheric specification that GIRO provides, has given rise to operational warning systems. In 2020, TechTIDE project [<http://tech-tide.eu/>] started regular online operations (Figure 2) to integrate European and South African ionosondes into a synchronized network of Digisonde-to-Digisonde (D2D) sounding radio-links for detection of the large- and medium-scale Traveling Ionospheric Disturbances (TID).

Other real-time ionosonde resources include:

- NOAA Mirrion real-time charting portal at www.ngdc.noaa.gov/stp/IONO/rt-iono/realtime/
- New GAMBIT Situation Room at Lowell GIRO Data Center, giro.uml.edu, that includes several ionospheric weather resources
- Animated foF2 maps at Australian Space Weather Service, www.sws.bom.gov.au/HF_Systems/6/5
- New Ham radio enthusiasts webpage for MUF(3000) and foF2 mapping, prop.kc2g.com

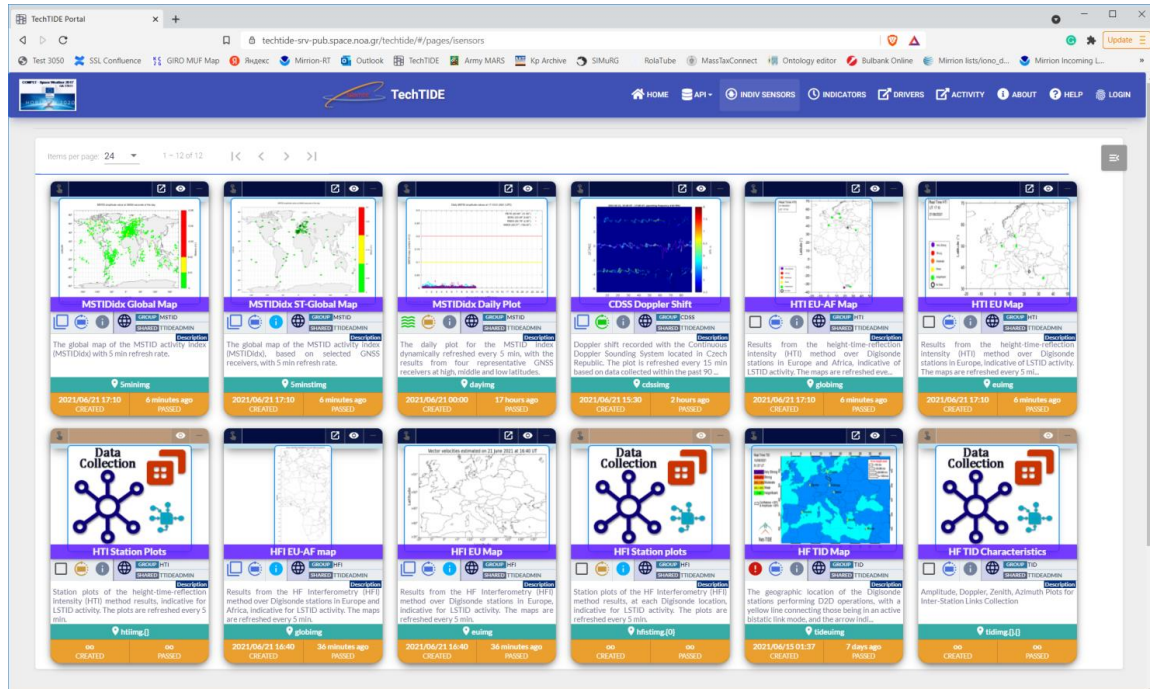


Figure 2. TechTIDE web portal showing current status of TID alert service that involves GIRO ionosondes in Europe and South Africa.

<https://techtide-srv.pub.space.noa.gr/techtide/#/pages/isensors>

XV International GIRO Forum 2019, jointly organized by the University of Massachusetts Lowell and Lowell Digisonde International, LLC to celebrate 50 years of Digisonde, was held on 21-23 May, 2019 in conjunction with the Real-Time IRI Task Force meeting. Academic and engineering topics of the IGD2019 included global real-time ionosphere nowcast using GIRO sensors, combined vertical and oblique ionogramming with DPS4D, TID Detection and Warning System with Digisonde D2D and VTT modes of operation, new web portal and data access to Lowell GIRO Data Center, including DIDBase, TID Warning System, and GAMBIT coefficients for “real-time IRI “.

Engineering efforts continued to develop new ionosonde models:

- Ionorde 4 by Norderevle GmbH, Germany;
- Rainbow (Paдypa) ionosonde, a successor of NIIDAR "Avgur-D", by Technos-RM, Moscow, Russia;
- Frequency-hopping coded-continuous wave ionosondes, Norway-USA-Korea;
- Pseudo-random sequencing for low probability of intercept (LPI) sounding, by SwRI, San Antonio, TX, USA;
- Orthogonal codes for MIMO and simultaneous vertical and oblique sounding, China
- Low-cost software-defined-radio (SDR) ionosondes, by Penn State University, USA.

Miniaturized and low-power solutions are pursued for the next-generation HF instrumentation, including CubeSat HF topside ionosonde ECHOES (NASA Goddard Space Flight Center) and a monostatic chirp-sounder with < 10 W power (ISTP, Irkutsk, Russia).

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Academic interest to the ionosonde-inspired research continues with new concepts of data fusion with other sensor instrumentation. Using available expertise in URSI Commission G, coordinated global maps of NmF2 (GIRO) and VTEC (GNSS) provide two new analysis tools for the storm studies: (1) joint “ionospheric anomaly” representations that plot weather-minus-climate values (Figure 3), and (2) F2 layer slab thickness maps (Figure 4) derived as the ratio of VTEC/NmF2. Comparative studies of GNSS and GIRO data bring new understanding of the operational impact of TIDs on radio systems as seen by different sensing instrumentation, as well as formulate recommendation for the future efforts to jointly detect, evaluate, and backtrack TIDs. Overall, current tendency for the ionosonde network is to proceed from its current well-established capability of nowcasting ionospheric anomalies to their forecast and further to the operational systems for warnings and alerts.

INAG continues to be the communication point for contributing observatories; its membership grew steadily over the three years to reach 500, with ~150 core participants in the group activities. INAG newsletter is continuously circulated to all subscribers.

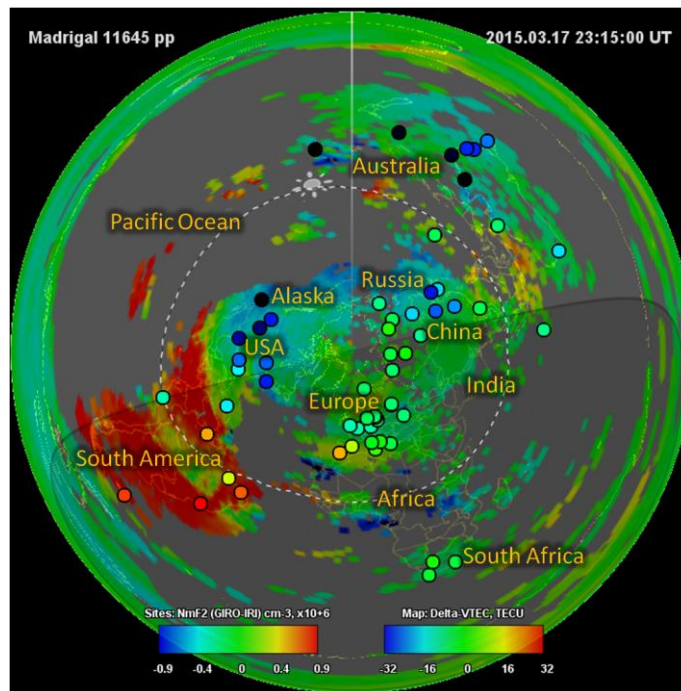


Figure 3. Global VTEC and NmF2 *anomaly* maps plotting *weather-minus-climate* deviations to represent how different is ionosphere from its expected quiet-time behavior. Blue shades correspond to less than usual, and red shades to more than usual. Color dots are GIRO observatories, and color surface is GNSS VTEC from Madrigal database.

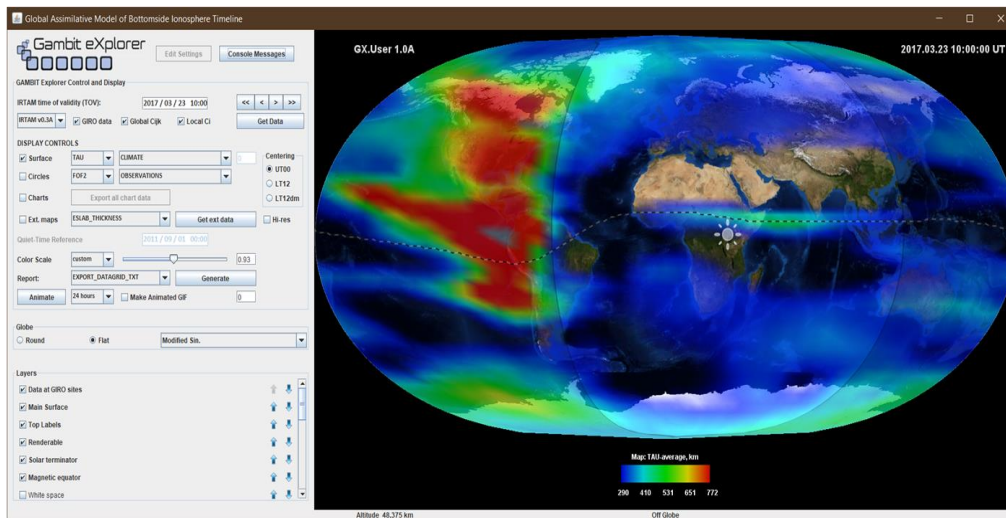


Figure 4. Real-time global maps of the F2 region slab thickness are now available from GAMBIT Explorer in cooperation of GIRO and GNSS observatories; <http://giro.uml.edu/GAMBIT>

G2: Studies of the Ionosphere Using Beacon Satellites

Chair: P. Doherty (USA); Vice-Chairs: B. Nava (Italy), A. Krankowski (Poland)

The Beacon Satellite Group 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 including all of the URSI Triennium Meetings.

The most notable activities of this study group 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 Beacon Satellite Study Group together with a local chair and organizing committee consisting of URSI Commission G members. These meetings provide unique opportunities for ionospheric scientists from all over the world to meet and collaborate on the ionospheric effects on radio propagation and space weather.

The most recent Beacon Satellite Symposium (BSS) was held at the University of Warmia and Mazury in Olsztyn, Poland on 19-23 August, 2019. The symposia are the primary event held triennially by the Beacon Satellite Group of the International Union of Radio Scientists (URSI) Commission G. This BSS symposium was a great success with many sessions dedicated to space weather characteristics and effects; monitoring the ionosphere and space weather with ground and space-based receivers, radio occultation techniques and measurements, advances in ionospheric modeling and much more.

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The opening session included welcome remarks by local Olsztyn officials, Dr. Andrzej Krankowski (Chair of the LOC) and Patricia Doherty (URSI, Commission G Chair and Chair of the Beacon Satellite Studies Group). Session descriptions, abstracts and the program can be viewed at the symposium website: bss2019.uwm.edu.pl. A special section with papers presented in this symposium have been produced in the Radio Science Journal.

This event included over 140 scientists from 32 countries. Thanks to the generosity of our sponsors, including SCOSTEP, NSF, URSI, ICG, Boston College and the University of Warmia and Mazury, approximately 50 participants from developing countries received some level of scholarship to defray the cost of their participation in the prestigious event.

Discussion on the next Beacon Satellite Symposium are now taking place. It will be held in 2022.



Group Photo – Beacon Satellite Symposium 2019, Olsztyn, Poland

G3: Incoherent Scatter

Chair: E. Spanswick (Canada); Vice Chair: A. J. Kavanagh (UK) [2018 -2020]
Chair: A. J. Kavanagh (UK); Vice Chair: TBD[2021-]



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During the period 2018-2020, Emma Spanswick (University of Calgary, Canada) acted as the Chair of the URSI Incoherent Scatter Working Group, with Andrew Kavanagh (British Antarctic Survey, UK) as vice-chair. Andrew took over as chair in 2021 but a vice chair is yet to be confirmed.

- During this time the URSI ISWG has carried out its principal task of coordinating the combined World Day operations of all the global incoherent scatter radar facilities around the world. For the 2018/2019 period this was done using the following mechanism:
- A call for applications was sent out in the spring of each year (usually May), for experiments to be run the following year. Applications can now be made using a standard form (https://www.eiscat.rl.ac.uk/WorldDays/ISR_WorldDay_proposal_template.docx) and ISWG has now written some guidance for applicants (https://www.eiscat.rl.ac.uk/WorldDays/WorldDay_Guidelines.pdf)
- A session was convened at the US CEDAR meeting to discuss these applications. This session was open to all attendees at CEDAR, but representatives of each of the ISR facilities were encouraged to attend as were the proposal authors.
- During this discussion, allocations of time were agreed for each proposal, or proposals with similar aims were amalgamated. The aim is to limit the time of operation to about 30 days in total.
- Discussions then took place between the proposers and the ISR operators to ensure the desired, optimum observing modes were use, and to make sure that the operators knew what the requirements were.

It should be noted that proposers are strongly encouraged to present their work at the CEDAR meeting.

For 2020 (and 2021) a different process was employed, due to the pandemic. There was still a call in the spring, but the discussion of the proposal took place on-line with an open call to the community (via mailing lists) for anyone interested to take part. This was done in the first instance via email, with an agreement for a full meeting via video-link if it was deemed necessary.

The tables below show the World Day allocations for 2019, 2020 and 2021. The process for arranging World Day intervals for 2022 is underway at the time of writing.

2021

Name	Proposer	Start Date	Duration (days)	Alert period
ISR observations during a campaign of Interhemispheric Coupling Study by Observations and Modelling (ICSOM)	K. Sato(U. Tokyo)	04/01/2021	10	15/01/2021 to 15/02/2021
Coordinated Observations of Geospace Storms (CONGS-21)	S. Zhang (MIT)	22/3/2021	5	~ 21/3/2021 or 12/9/2021
10 June 2021 Arctic Annular Eclipse (Eclipse)	R. Varney (SRI)	9/6/2021	3	
Global Coverage of High Latitude E-region Winds and Ion Drifts (Winds)	S. Kaeppler (Clemson)	21/6/2021	5	*

*note 1: this experiment has been postponed to 2022.



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2020

Name	Proposer	Start Date	Duration (days)	Alert period
Global conjunctive GNSS scintillation and ISR measurements (GCGS-ISR)	D. Loucks (Westpoint)	22/9/2020 10/12/2020	3 3	
Dynamics, electrodynamics, temperature and electron density in the lower and upper thermosphere and ionosphere during sudden stratospheric warming (SSW)	L. Goncharenko (MIT)	4/2/2020	10	15/1/2020 to 15/2/2020*
ISR observations during a campaign of Interhemispheric Coupling Study by Observations and Modelling (ICSOM)	K. Sato (U. Tokyo)	Merged with SSW due to similar requirements		
High-Latitude Influence on Equatorial Space Weather during Solar Minimum (Bubbles)	A. Burrell (US NRL)	24/2/2020	4	
2020 Coordinated Observations of Geospace Storms (CONGSS-20)	S. Zhang (MIT)		5	~21/3/2020 *

* note 1: CONGSS had priority if conditions warranted it. Only 1 block of March/September would run for GCGS-ISR

2019

Name	Proposer	Start Date	Duration (days)	Alert period
ISR observations during a campaign of Interhemispheric Coupling Study by Observations and Modelling (ICSOM)	K. Sato (U. Tokyo)	2/1/2019	10	15/1/2019 – 31/1/2019
High-Latitude Influence on Equatorial Space Weather during Solar Minimum (Bubbles)	A. Burrell (US NRL)	2/2/2019	5	
2020 Coordinated Observations of Geospace Storms (CONGSS-19)	S. Zhang (MIT)	23/3/2019	3	~21/3/2019 or ~21/9/2019
Mid- and High-latitude Ionospheric Responses to Geomagnetic Storms Induced by Various Interplanetary Transients (IRGSIT)	S. Zou (Michigan)	Merged with CONGSS due to similar requirements		
Polar patch detection for HF radio wave propagation and scattering studies (PDPSS)	R. Gillies (Calgary)	Merged with Bubbles due to similar requirements		



Some experiments are based on alerts: the start of a sudden stratospheric warming event, or an incoming coronal mass ejection, etc. These World Days will have a specific period within which the alert should happen, though sometimes, such as for ICSOM in 2021, runs can begin early of the operators are prepared. Due to problems with operations during the pandemic for some ISR, some 2021 experiments will be held over until 2022.

GEH: Seismo Electromagnetics (Lithosphere-Atmosphere-Ionosphere Coupling)

Co-chairs: S. Pulinetz (Russia), M.Y. Hobara (Japan), H. Rothkaehl (Poland)

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 URSI:

- 2018 II URSI Atlantic Radio Science Conference (URSI AT-RASC)
- 19th International Beacon Satellite Symposium 2019

Two monographs were published where the Seismo-Electromagnetic thematic was presented:

Ouzounov D., S. Pulinetz, K.Hattori, P.Taylor (Ed's) Pre-Earthquake Processes: A Multi-disciplinary Approach to Earthquake Prediction Studies, American Geophysical Union. Published 2018 by John Wiley & Sons, Inc., 385 pp
<https://agupubs.onlinelibrary.wiley.com/doi/book/10.1002/9781119156949>

Pulinetz S. and D. Ouzounov The Possibility of Earthquake Forecasting: Learning from nature, Institute of Physics Books, IOP Publishing, 2018, 168pp <https://iopscience.iop.org/book/978-0-7503-1248-6>

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:

Pulinetz S.A., Davidenko D.V., The Nocturnal Positive Ionospheric Anomaly of Electron Density as a Short-Term Earthquake Precursor and the Possible Physical Mechanism of its Formation, *Geomagnetism and Aeronomy*, 58, 559-570, 2018 doi.org/10.1134/S0016793218040126

Pulinetz S. A., A. D. Legen'ka, V. V. Hegai, V. P. Kim, and L. P. Korsunova, Ionosphere Disturbances Preceding Earthquakes According to the Data of Ground based Station of the Vertical Ionospheric Sounding Wakkanai, *Geomagnetism and Aeronomy*, 2018, Vol. 58, No. 5, pp. 686–692, doi.org/10.1134/S0016793218050110

Sergey Pulinetz, Dimitar Ouzounov, Alexander Karelin, and Dmitry Davidenko, Lithosphere Atmosphere–Ionosphere–Magnetosphere Coupling – A Concept for Pre-Earthquake Signals Generation, In: Pre-Earthquake Processes: A Multidisciplinary Approach to Earthquake Prediction Studies, Editors(s): Dimitar Ouzounov, Sergey Pulinetz, Katsumi Hattori, Patrick Taylor, Publisher: AGU/Wiley, 2018, p. 77-98, doi.org/10.1002/9781119156949.ch6



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Tramutoli V., Marchese F., Falconieri A., Filizzola C., Genzano N., Hattori K., Lisi M., Liu J.-Y., Ouzounov D., Parrot M., Pergola N., Pulnests S., Tropospheric and Ionospheric Anomalies Induced by Volcanic and Saharan Dust Events as Part of Geosphere Interaction Phenomena, *Geosciences*, 9 (4), 177, 2019, DOI: 10.3390/geosciences9040177

Jann-Yenq (Tiger) Liu, Katsumi Hattori, Yuh-Ing Chen, Application of Total Electron Content Derived from the Global Navigation Satellite System for Detecting Earthquake Precursors, In: *Pre-Earthquake Processes: A Multidisciplinary Approach to Earthquake Prediction Studies*, Editors(s): Dimitar Ouzounov, Sergey Pulnests, Katsumi Hattori, Patrick Taylor, Publisher: AGU/Wiley, 2018, 305-317, <https://doi.org/10.1002/9781119156949.ch17>

Michel Parrot Mei Li, Statistical Analysis of the Ionospheric Density Recorded by the DEMETER Satellite During Seismic Activity, In: *Pre-Earthquake Processes: A Multidisciplinary Approach to Earthquake Prediction Studies*, Editors(s): Dimitar Ouzounov, Sergey Pulnests, Katsumi Hattori, Patrick Taylor, Publisher: AGU/Wiley, 2018, 319-328, <https://doi.org/10.1002/9781119156949.ch18>

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Pulnests S.A., V.V. Hegai, A.D. Legenka, and L.P. Korsunova, Effects in the Ionosphere After the Chilean Earthquake on 27.02.2010, According to Data of Ground-based Ionosondes, *Geomagnetism and Aeronomy*, 59 (5), 671-680, 2019, DOI: 10.1134/S0016793219050104

Titova M.A., Zakharov V.I., Pulnests S.A., Determination of Ionospheric Disturbances over Seismic Sources During Large Earthquakes of 2010 by Radiophysical Methods under Conditions of Quiet Geomagnetic Field, In *2019 issue Russian Open Conference on Radio Wave Propagation (RWP)*, IEEE publ., p. 160-162, DOI: 10.1109/RWP.2019.8810168

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Rapoport Y., Grimalsky V., Krankowski A., Pulnests S., Fedorenko A., Petrishchevskii S., Algorithm for modeling electromagnetic channel of seismo-ionospheric coupling (SIC) and the variations in the electron concentration, *Acta Geophysica*, 68(1), 253-278, 2020 <https://doi.org/10.1007/s11600-019-00385-0>

Aleksandra Nina, Sergey Pulnests, Pier Francesco Biagi, Giovanni Nico Srđan T. Mitrović, Milan Radovanović, Luka Č Popović, Variation in natural short-period ionospheric noise, and acoustic and gravity waves revealed by the amplitude analysis of a VLF radio signal on the occasion of the Kraljevo earthquake ($M_w=5.4$), *Science of the Total Environment*, 710, 2020, 136406 <https://doi.org/10.1016/j.scitotenv.2019.136406>

Pulnests, S. and Khachikyan, G.: Solar induced earthquakes – review and new results, EGU General Assembly 2020, Online, 4-8 May 2020, EGU2020-10821, <https://doi.org/10.5194/egusphere-egu2020-10821>, 2020

Nina A., Pulnests S., Biagi P.F., Nico G., Mitrović S.T., Radovanović M., Popović L.Č., Reduction of lower ionosphere plasma fluctuation – new earthquake precursor? *Publ. Astron. Obs. Belgrade* No. 99, 303 – 306, 2020



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GJFEH: Interdisciplinary Space Weather

Co-chairs: I. Stanislawska (Poland), R. Fallows (Netherlands)

The advanced state of space physics as well as the progress of techniques and technology meant that the development of space weather gained new acceleration. Many phenomena having a significant impact on life on our increasingly-advanced technical civilization have proved to be predictable, forecast and mitigated. This indicated the need to undertake new research directions and intensify others, which, with access to improved, innovative tools and methods, have just become an additional impulse for development. So, recent years have seen an extremely offensive rise in space weather activity. This activity was also marked by the dynamic participation of URSI interdisciplinary Space Weather Working Group members in new bodies.

During the accounting period the members of the Inter-commissions GJFEH actively participated in Space Weather related organizations and associations, many international events (conferences, symposia, workshops) and organizations, also by publishing the results and conclusions:

- International Space Environment Service ISES
- COSPAR International Space Weather Action Teams (ISWAT)
- Horizon H2020, European Space Surveillance Tracking SST
- ESA Space Situation Awareness SSA
- WMO Inter-Programme Team on Space Weather Information, Systems and Services (IPT-SWeISS)
- International Space Weather Initiative
- Low-Frequency Array (LOFAR)
- PECASUS - Pan-European Consortium for Aviation Space weather User Services for ICAO

Programs and research conducted in many URSI Committees constitute our significant contribution to scientific and especially in operational works. The working group activities have concentrated on following three main subjects:

- new radio science tools for space weather
- radio science challenges for space weather services
- radio science in planetary exploration

Full face-to-face meetings have been very limited, especially in the recent pandemic period, where most meetings were held online. Nevertheless, an online Radio Heliophysics Catch-up meeting was held on 10-13 May in place of a more-formal physical meeting originally planned for December 2020. This attracted more than 100 registrations, with 21 submitted abstracts covering multiple aspects of radio research across the solar and heliosphere space weather domains.

The results of the work will be presented in aggregate at the Space Weather Workshop (WS3) that is planned for the URSI GASS 2021 workshop in Rome. This workshop will be devoted to the novel radio science tools for space weather, radio science in planetary exploration and radio science challenges for space weather services.

Three Panels of experts, including 3 invited presentations in total, and related open discussion towards the three topics that are:

NEW RADIO SCIENCE TOOLS FOR SPACE WEATHER

The aim of this panel is to bring together the scientists using new arrays for space weather purposes (e.g. radio astronomers) and space weather scientists, who may be unfamiliar with the capabilities of these new instruments, to discuss how they can best be used to advance space weather science, and to discuss how these instruments and dedicated space weather instrumentation can best support one another in their respective goals.



RADIO SCIENCE CHALLENGES FOR SPACE WEATHER SERVICES

Knowledge of effects imposed by the space weather on current and new generation operational radio systems, the development and implementation of techniques to mitigate the deleterious effects of the space weather on such systems are the primary scientific goals. The main issue to discuss within this panel is the generation of the novel directions for services to approach current and future radio science challenges.

RADIO SCIENCE IN PLANETARY EXPLORATION

Since the start of the space venture fifty years ago, the interest of the effects of the space weather on the space missions and human exploration has strongly raised. Among the many diagnostic capabilities, radio experiments have proven to be very efficient both for remote and in-situ exploration. The aim of this panel is thus to bring together researchers from planetary and interplanetary past and future missions as well as engineers from radio domains to discuss the results of recent missions (like Mars Express) and address the results foreseen by the future, Solar Orbiter, Parker Solar Probe or Juice.

5. Funding and Sponsorship

The URSI Board provides the Commission with a budget at the start of each Triennium. The funds assist travel for the chairs and early commission representatives for their participation in the Triennium meetings together with additional funds to be used for sponsorship of Commission G meetings and members. For the period of 2018 to 2021, Commission G sponsored the following 3 events:

- 1) 2019 Beacon Satellite Symposium, 2500 euros for travel assistance for young scientists.
- 2) 2019 East Africa Global Navigation Satellite Systems and Space Weather Workshop, 1900 euros for travel assistance
- 3) 2020 East Africa Space Weather Workshop, 2000 euros for travel assistance. Meeting was cancelled due to COVID travel restrictions. Tickets purchased were refunded and the funds will be used for the next workshop in 2021

Limited funds will be distributed for speaker support for URSI GASS.

6. Thank you

As the outgoing chair of Commission G, I thank the URSI board and Commission G for this experience. I have learned much and met many exceptional scientists who have become friends.

I wish the greatest success to the incoming Chair, Dr. Giorgiana De Franceschi, who has already demonstrated her remarkable talents and capabilities as Vice Chair. I also wish to thank Dr. Seebany Datta-Barua as she steps down from her role as the first Early Career Representative for Commission G. Dr. Datta-Barua was elected to this role at the URSI GASS 2014 in Beijing. Since then, she has worked to make URSI more attractive to scientists in the early stages of their career. She has also been an active organizer and participant in many sessions, workshops and Triennial meetings.

Elections for a new Vice-Chair and ECR are in progress. The final election and results will be held at the first Commission meeting at URSI GASS 2021.

Sincerely,

Patricia Doherty
Chair, Commission G (2018-2021)