

## Report from 2019 COSPAR Capacity Building Workshop on the International Reference Ionosphere

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The COSPAR Capacity-Building Workshop on the International Reference Ionosphere (IRI) was held at Frederick University in Nicosia, Cyprus from September 2 to 13, 2019. The workshop consisted of a week of tutorials, lecture and hands-on demonstrations for the participating students and was combined with an IRI expert meeting during the second week. The focus of the first week tutorials and lectures, was on observation techniques and modelling approaches for the Earth's ionosphere. An important goal of the workshop was to familiarize the students with the access to and usage of ionospheric data sets and models so they will be able to continue their research interests at their home institutions. In response to the official announcement of the workshop in early 2019 we received applicants from 111 students and young researchers to participate in the workshop. These were students from 38 countries including Algeria, Argentina, Bangladesh, Benin, Brazil, Cameroon, Canada, China(10 applications), Congo-ROC, Congo-DRC, Egypt(6), Ethiopia(6), Finland, Germany(2), Hungary, India(11), Iran, Italy, Ivory Coast, Malaysia(4), Morocco(2), Nepal(6), Nigeria(14), Philippines, Poland(2), Russia(2), Rwanda(2), South Africa, South Korea(7), Spain, Sudan(4), Taiwan, Thailand, Turkey(4), Ukraine(3), UK, Vanuatu, and Zambia. The wide range of countries illustrates the wide spread of IRI-related research interests all over the globe. With support from COSPAR and the US Air Force Office of Scientific Research (AFOSR) we were able to partially support the participation of 30 students in the workshop. The students' home universities contributed the rest of the funding required to cover their students' travel costs. Additional support was provided by Frederick University, the Cyprus Space Exploration Organization (CSEO), the Deputy Ministry of Tourism, the Scientific Committee on Solar-Terrestrial Physics (SCOSTEP), the European Space Agency (ESA), the RHEA Group and the Czech Ministry of Education Youth and Sports. The last three supported the meeting by each covering the travel costs for one lecturer. The team of lecturers consisted of



Group photo of the participants of the CCBW-IRI Workshop

Dieter Bilitza (George Mason University, USA), Bodo Reinisch (Digisonde International Inc., USA), Ivan Galkin (University of Massachusetts Lowell, USA), Vladimir Truhlik (Institute of Atmospheric Physics, Prague, Czech Republic), Shigeto Watanabe (Hokkaido University, Sapporo, Japan), Shunrong Zhang (MIT, Millstone Hill, USA), Andrzej Krankowski (University of Warmia and Mazury, Olsztyn, Poland), Alexi Glover (ESA, ESOC, Darmstadt, Germany), Federico Da Dalt (Rhea for ESA, Darmstadt, Germany), and Haris Haralambous (Fredrick University, Nicosia, Cyprus). Lecturers presented a 1-hour tutorial on a specific topic in ionospheric observations and modelling and a 30-minute hands-on demonstration of access to specific ionospheric data and models.

Out of the large number of applications 30 student and young researchers were selected based on an evaluation of their submitted CVs, Letters of Recommendation and Research Plans. It is worth noting that the final selection was nearly gender-balanced with 16 female and 14 male students, in fact this was our first IRI-CCBW with more female than male students. The students and lecturers were housed in two adjacent hotels near the city center and a bus service was arranged for transporting everybody from the hotels to the workshop venue. Unfortunately, there was not an accommodation options for our large group in walking distance of Frederick University. A catered lunch was provided in the university cafeteria.

The 30 selected students, were divided into groups of 4 or 5 and each team received a specific research problem to be studied during the 2-week meeting. Each team had one of the lecturers as their main advisor, but was free to ask help from other lecturers as well. During the second week the students were able to attend and participate in the IRI-2019 Workshop that brought about 60 international ionospheric experts to Nicosia. For many of the students this was an opportunity to present their most recent research results (often the results of their PhD related studies) and get feedback from international experts and make connections with potential future post-doc hosts. At the end of the second week each team presented the results of their 2-week study to the full auditorium. A panel of three judges gave out gold, silver, and bronze awards for the best presentations. A difficult job, because of the high quality of the work and study performed by the 7 teams and the excellent presentations to the full workshop audience. Thanks to a gracious gift by Mandana and Khosrow Sigaroudi we were able to include a small monetary award with these prices.



Gold Medal Team (from right to left): Ayelen Estefania Volk (Argentina), He Huang (China), Diaby Kassamba Abdel Aziz (Ivory Coast), Mefe Moses (Nigeria), Ola Ahmed Abu Elezz (Egypt), Dieter Bilitza (Advisor).  
PROBLEM: IRI-2016 includes three options for the height of the F2 peak, hmF2. Evaluate the performance of these options with different data sources (ionosonde, incoherent scatter radar, COSMIC radio occultation).



Silver Medal Team (right to left): Suin Moon (South Korea), Zhiqi Zheng (China), Ivan Galkin (Advisor), Heba Shalaby (Egypt), Sampad Kumar Panda (India).  
**PROBLEM:** Investigate storm effects on foF2 at a location in the Northern hemisphere and one from a similar latitude region in the Southern hemisphere (ionosonde data, IRI, IRI-Real-Time).



Bronze Medal Team (right to left): Wonseok Lee (South Korea), Hammou Ali Omar (Algeria), Yara Ahmed Badawi (Egypt), Haixia Lyu (China/Spain), NOT SHOWN: Andreas Goss (Germany), A. Krankowski (Advisor).  
**PROBLEM:** Study the extend of the Equatorial Ionization Anomaly (EIA) in Local Time with GPS TEC data.

During the IRI-week 64 talks and 8 posters were presented divided into sessions on ‘Real-Time IRI’, ‘Topside, Plasma Irregularities’, ‘High Latitudes’, ‘Storm Effects’, ‘GNSS and TEC’, ‘F-Peak Mapping’, ‘Equatorial Ionization Anomaly’, ‘E-Region and Bottomside’, ‘Plasmasphere Modelling’, ‘Plasma Temperatures, Ion Composition and Ion Drift’, ‘New Inputs for IRI’, and Posters. Comparisons of IRI predictions with old and new data sources highlighted areas of good performance and times and locations where improvements are needed. Discussing the presentations at this and prior COSPAR meetings the IRI team decided to include the following improvements in the next edition of the IRI model:

- A new model for the D- and E-region based on a compilation of rocket measurements supplemented by incoherent scatter radar data and theoretical considerations (M. Friedrich, Graz, Austria);
- A new model for F2 peak plasma frequency foF2 during quiet and disturbed times based on ionosonde and COSMIC radio occultation data (V. Shubin, IZMIRAN, Russia);

- A correction of the topside electron density model to more accurately describe the variation with solar activity, especially during very low activity levels, using Alouette/ISIS topside sounder data and CHAMP/GRACE/Swarm satellite insitu measurements (D. Bilitza, GMU, USA and Chao Xiong, GFZ, Potsdam, Germany);
- (2) A new model for F2 peak plasma frequency foF2 during quiet and disturbed times based on ionosonde and COSMIC radio occultation data (V. Shubin, IZMIRAN, Russia);
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- Allow users to extrapolate the IRI topside to plasmaspheric heights and also to below 60/80km
- New ion temperature model based on large data base of satellite insitu measurements stretching from OGO-6 in 1969 to C/NOFS in 2018 (V. Truhlik, IAP, Czech Republic)
- Using GNSS TEC data as input for the Real-Time IRI using a formalism similar to the one used for foF2 and hmF2 (I. Galkin, A. Krankowski, A. Fron, D. Bilitza)

Four new members were invited to join the IRI team: Haris Haralambous (Frederick University, Nicosia, Cyprus), Pierdavide Coisson (Université de Paris, Institut de Physique du globe de Paris, CNRS, Paris, France), Michael Pezzopane (Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy) and Bruno Nava (The Abdus Salam International Centre for Theoretical Physics, Trieste, Italy). All four have made important contributions to the IRI project and will continue their support and participation of this important international project in the future.

This meeting would have not been possible without the untiring support and determination of the local organizer Haris Haralambous and co-organizer Christina Oikonomou. They spend many hours and days already before the meeting resolving logistics issues and Visa problem and were a constant source of help for all participants during the meeting. In addition, they were able to prepare the Opening of “The Sun and Us” a Space Weather Exhibit at Frederick University supported by the European Space Agency (ESA) on Tuesday evening of the second workshop week. All workshop participants were invited to attend the opening and the preceding lecture by Stamatios Krimigis (JHU/APL) “Odyssey in Space 1977-2019: The Epic journey of Voyager 1 and 2 from Earth to the Galaxy”, who received an Honorary Doctorate of Frederick University during the occasion.



Stamatios Krimigis with Diaby Kassamba Abdel Aziz (Ivory Coast) and Mefe Moses (Nigeria) during the Opening of the Space Weather Exhibit “The Sun and Us”.

With financial support from the Deputy Ministry of Tourism Haris also organized a very exciting and informative excursion to the ancient Greek city-kingdom of Kourion and a workshop dinner in Limassol giving participants a taste of the delicious Cyprian cuisine. We are very thankful to the Cyprus Space Exploration Organisation (CSEO) and its President George Danos for providing volunteers to help with registration and general meeting support. Thank you, George, for taking us on a walk through Nicosia (including the UN-controlled green zone) and a very moving retelling of the recent history of this divided city. A walk that ended with Cyprian food and drinks under the Moon-lit sky.