Report from 2023 COSPAR Capacity Building Workshop on the International Reference Ionosphere

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The 2023 COSPAR Capacity-Building Workshop (CCBW) on the International Reference Ionosphere (IRI) was held at the Korea Astronomy and Space Science Institute (KASI) in Daejeon, South Korea on May 8 – 19, 2023, expertly organized by Dr. Young-Sil Kwak (KASI) and Prof. Yong Ha Kim (Chungnam National University) and their team. During the first week tutorials, lectures and hands-on demonstrations taught the students the basics and recent advances in 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. The meeting was combined with an IRI expert meeting during the second week giving the students an opportunity to attend an international science meeting, for some the first time, and an opportunity to present a talk or poster at the meeting about their own research. It was also a great opportunity to talk about potential post-doc positions. The workshop was opened with welcome speeches by KASI President Dr. Young-Deuk Park and by the President of the Korea Space Science Society (KSSS) Prof. Yu Yi.

In response to the official announcement of the workshop in early 2023 we received applications from 60 students and young researchers to participate in the workshop. These were students from 29 countries illustrating the wide spread of IRI-related research interests all over the globe. With support from COSPAR, the Korea Astronomy and Space Science Institute (KASI), Chungnam National University, the Small Scale Magnetospheric and Ionospheric Plasma Experiments (SNIPE) project, and the Korea Space Science Society (KSSS), we were able to partially support the participation of 34 students in the workshop. The students' home universities contributed the rest of the funding required to cover the full travel costs. Additional support for the workshop was provided by NASA (travel support for two US lecturers), the Local Organizing committee of the COSPAR 2024 General Assembly, and the Daejeon Tourism Organization.

The team of lecturers consisted of Dieter Bilitza (George Mason University, 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), Yong Ha Kim (Chungnam National University, Korea), Jaejin Lee (KASI, Korea), Moonseok Yoon (Korea Aerospace Research Institute, Korea), Geonhwa Jee (Korea Polar Research Institute, Korea), Jaeheung Park (KASI, Korea), and Charles Lin (National Cheng Kung University, Taiwan). Lecturers gave 45-minute or 30-minute tutorials on a specific topic in ionospheric observations and modelling followed in some cases by a 30-minute hands-on demonstration of access to specific ionospheric data and models. The topics were: 'Physics of Ionosphere', 'International Reference Ionosphere Introduction, Current Status, and Future Plans', 'Global Ionosphere Radio Observatory (GIRO)', 'ISR and ionospheric studies', 'GNSS data and ionospheric studies', 'Ionospheric Studies with GNSS data', 'Better Understanding of Ionospheric Effects on GNSS Applications', 'Representation of Plasma temperatures in IRI', 'Representation of ion composition in IRI', 'Access to satellite data', 'Radio Occultation and access to COSMIC data', 'Scintillation, spread-F, and plasma bubbles', 'The SNIPE Mission for

Observing Small Scale Ionospheric and Magnetosphric Plasma Phenomena', 'Principles of data assimilation in ionospheric application', and 'The Polar Ionosphere'.

34 students and young researchers were selected based on an evaluation of their submitted CVs, Letters of Recommendation and Research Plans. The final selection included students from China (7), Egypt (1), Ethiopia/Brazil (1), France/USA (1), India (5), Kenya (1), Malaysia (2), Myanmar/Thailand (1), Pakistan/South Korea (2), Poland (1), South Korea (5), Sri Lanka (1), Taiwan (3), Thailand (1), UK (1), and Vietnam/South Korea (1). With 13 female and 21 male students the gender balance was not as good as at the last two IRI-CCBWs. Unfortunately, two selected female students from Africa were unable to attend due to health and passport problems. The 34 selected students, were divided into 7 groups 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. Each project was related to a number of recommended data sets and modelling sites. Lecturers familiar with the different data sets and models were on hand to help with any questions. The prime modelling site was the IRI homepage at irimodel.org with access to online computations of IRI parameters as well as to downloading the model code. 34 students working with the model code also gave important feedback regarding code improvements that were partly implemented during the meeting. The first week ended with a dry run of each team presenting their results so far and getting feedback from the lecturers

Lectures in the morning and team work in the afternoon

Student visit to the Korea Aerospace Research Institute (KARI)

Student visit to the Korea Astronomy and Space Science Institute (KASI) labs

The students continued their work during the second week while they were also able to attend and participate in the IRI-2019 Workshop that brought about 60 international ionospheric experts to KASI. 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 for the IRI experts it was a great opportunity to find candidates for post-doc or early career positions at their institutions. 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. All lecturers were amazed how quickly the students were able to access and download large volumes of data and present the result of their investigation in graphical form. I think it documents the positive impact the CCBW activity has on the science environment in developing countries.

During the IRI-week 53 talks and 6 posters were presented in the following sessions: 'IRI and Data Assimilation', 'Data Sources for IRI', 'Representation of Irregularities', 'Topside', 'TEC and Plasmasphere', 'Applications and Usage', Programs and Services', 'Comparison and Model Assessment', 'IRI Comparisons and Improvements', 'Measurement Techniques', 'Low Latitude Ionosphere', 'Ionospheric Effects and Special Events', '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. It was also an opportunity to officially release the latest version of the IRI model, which includes the following improvements and additions: (1) A new model for the D- and E-region based on a compilation of rocket measurements supplemented by incoherent scatter radar data and theoretical modelling (Friedrich et al., 2018); (2) A correction of the topside electron density model to more accurately describe the variation with solar activity using Alouette/ISIS topside sounder data and CHAMP/GRACE/Swarm satellite in situ measurements (Bilitza & Xiong, 2021); (3) A new extension of IRI to plasmaspheric altitudes using the Ozhogin et al. (2012) or the Gallagher et al. (2000) model (Bilitza, 2022); (4) A new ion temperature model based on a large data base of satellite in situ measurements stretching from OGO-6 in 1969 to C/NOFS in 2018 (Truhlik et al., 2021); (5) Replacing the Scherliess & Fejer (1999) for the ion drift with the newer and better Fejer et al., 2008) model that is based on 5 years of ROCSAT-1 data.

This meeting would have not been possible without the untiring support and determination of the local organizer Young-Sil Kwak and her team. The meeting was originally planned for the spring of 2021 but had to be twice postponed because of the COVID crisis. Throughout this time the steadfast support by Yong Ha Kim (Chungnam National University) and Jaejin Lee (SNIPE PI, KASI) was essential for keeping the idea of an IRI Workshop at KASI alive. Thankful for their support and for their workshop organization the IRI team invited Dr. Young-Sil Kwak (KASI) and Prof. Yong Ha Kim (Chungnam National University) to become members of the COSPAR/URSI IRI Working Group, which they gladly accepted. Dr. Young-Sil Kwak is already a co-convener of the IRI session during the 2024 COSPAR Scientific Assembly which will be held in Busan, South Korea and Prof. Yong Ha Kim is a member of the organizing committee for the session.

Gold Medal Team (from right to left): Young-Sil Kwak (LOC), Yuyang Huang (China)
Malini Aggarwal (India), Nina Servan-Schreiber (France/USA), Abdalla Shaker (Egypt), Dieter Bilitza
(Advisor). Not shown Minwook Kang (South Korea). PROBLEM: IRI now includes three options for the
extension into the plasmasphere. Study the differences between these three options and compare with
TEC data.

Left side: Silver Medal Team (right to left): Nur Awatiff (Malaysia), Andrzej Krankowski (Advisor), Bin
Zhang (China), Danish Naeem (Pakistan/South Korea), Lin Min Myint (Myanmar/Thailand). Not shown
Jenan Rajavarathan (Sri Lanka). PROBLEM: Study the extend of the Equatorial Ionization Anomaly
(EIA) in Local Time with COSMIC I and II data and GNSS-TEC data. Compare with IRI predictions.
Right side. Bronze Medal Team (right to left): Shunrong Zhang (Advisor), Natelie Reeves (UK), Angkita
Hazarika (India), Tingwei Han (China), Mei-Yu Chen (Taiwan), Yujin Cho (South Korea). PROBLEM:
IRI-2020 includes a new representation of the ion temperature. Study the differences and improvements
compared to the older version and how well do both versions perform in representing characteristic
diurnal, seasonal and solar activity variations observed by incoherent scatter radars (ISRs).

Excursion to the Baekje Cultural Land

The Local Organizing Committee (LOC) organized a very informative visit to the nearby Korea Aerospace Research Institute (KARI), one of the prime aerospace institutes in South Korea in charge of testing, assembling, and launching satellites and much more. A tour of KASI gave the students insights into KASI's space weather activities and services. We all enjoyed a wonderful workshop reception at the Daejeon Science Expo Tower with a beautiful sunset and delicious Korean food. During the second week the students were treated to a visit of the Baekje Cultural Land learning a lot about Korean history and how people were living during earlier times. The excursion was followed by an unforgettable evening and dinner at the Daejeon Expo Aquarium with exotic fishes and dancing mermaids.