

International Reference Ionosphere 2017 Workshop

Improved Real-time Ionospheric Predictions with IRI and FORMOSAT-3/COSMIC and Other GNSS Data

A COSPAR Capacity - Building Workshop

National Central University, Taoyuan City, Taiwan, November 6-17

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The COSPAR Capacity Building Workshop on “IRI-2017 - Improved Real-time Ionospheric Predictions with IRI and FORMOSAT-3/COSMIC and Other GNSS Data” was held at the National Central University (NCU) in Taoyuan City, Taiwan from November 6 to 17, 2017. The workshop consisted of tutorials, online demos and project work for the students during the first week followed by the expert meeting in the second week.



## TRAINING WEEK

During the training week the students received lectures on modelling and monitoring the ionosphere: Ionosphere – An Introduction (B. Reinisch, USA), IRI – Introduction and Open Problems (D. Bilitza, USA), Ionosonde Measurements (B. Reinisch, USA), Real-Time IRI (I. Galkin, USA), Overview of FORMOSAT-3/COSMIC and FORMOSAT-7/COSMIC-2 (J.Y. Liu, Taiwan), COSMIC/GNSS Ionospheric Studies (C. Lin, Taiwan), GNSS Data and Ionospheric Studies (A. Krankowski, Poland), Plasmasphere Modelling (S. Watanabe, Japan),

Scintillations (C. Rino, USA), Ion Densities and Plasma Temperatures (V. Truhlik, Czech Republic), FPMU Data for Ionospheric Studies (J. Minow, USA), Incoherent Scatter Radar (S.-R. Zhang, USA), Coupling between Ionosphere and Thermosphere at Low Latitudes (S. Watanabe, Japan). After listening to these lectures in the morning the students received online tutorials on data and model access in the afternoon. Students for this course were competitively selected from a large number of applications. The selected 38 students represented 16 countries mostly from the East-Asian sector. The students were divided into 9 groups of 4 or 5 students each and each group worked on a specific ionospheric modelling problem related to the workshop topic. Each team had one of the lecturers as adviser. During a special session of the second week IRI meeting each team presented their results to the full auditorium. At the conclusion of the IRI-2017 Workshop each student received a COSPAR Certificate confirming his participation in the training and workshop. The best student teams were presented with Gold, Silver, and Bronze awards.



List of Teams and Assigned Problems and Adviser:

TEAM 1: Virendra Yadav (India), Xin Wan (Germany/China), Siti Harwani bt Md Yusoff (Malaysia), Merlin Mendoza (Philippines)

Problem G: Study the extend of the Equatorial Ionization Anomaly (EIA) in Local Time using TEC data. For what time period are separate cusps observed on both sides of the magnetic equator and when a single maximum at the magnetic equator. Compare with IRI predictions.

Adviser: S. Watanabe

\*\*\*\*\* GOLD MEDAL \*\*\*\*\*

TEAM 2: Ram Singh (India), Lei Liu (China), Ben Reid (Canada), Idahwati binti Sarudin (Malaysia)

Problem F: How can IRI be updated with TEC data. What information can we obtain from the TEC data for the IRI electron density profile and which IRI parameters can be updated. Review earlier studies on this topic and suggest ways to overcome some of their shortcomings.

Adviser: J.-Y. Liu and D. Bilitza

TEAM 3: J R K Kumar Dabbakuti (India), Changjun Yang (China), Juliana Jaen (Argentina), Wan Nur Izzaty binti Ismail (Malaysia)

Problem C: Compare the annual and semi-annual variation of foF2 in the two hemispheres. What are the differences? What could be possible causes? What does IRI predict? Use two comparable Digisonde stations one from each hemisphere (DIDBase at giro.uml.edu).

Adviser: D. Bilitza and C. Liu

TEAM 4: Dibyendu Sur (India), Ming-Hsueh Shen (Taiwan), Siti Syukriah binti Khamdan (Malaysia), Steven Brown (USA),

Problem B: Investigate the effects of the solar eclipse of August 20, 2017 on the ionospheric Total Electron Content.

Adviser: A. Krankowski

TEAM 5: Sheetal Karia (India), JeongHeon Kim (Korea), Tien-I Lin (Taiwan), Abimbola Afolayan (Malaysia/Nigeria)

Problem I: Study the Nighttime Winter Anomaly (NWA) effect described by Jakowski et al. (2015) and investigate if IRI reproduces this effect (Jakowski, N., M. M. Hoque, M. Krieger, and V. Patidar, 2015, The persistence of the NWA effect during the low solar activity period 2007–2009, J. Geophys. Res. Space Physics, 120, doi:10.1002/2015JA021600).

Adviser: D. Bilitza and J.-Y. Liu

TEAM 6: Sneha Yadav (India), Kacper Kotulak (Poland), Afrizal Bahar (Indonesia), Chalachew Mengist (Korea/Ethiopia), Min-Shuon Huang (Taiwan)

Problem D: IRI-2016 includes three options for the height of the F2 peak, hmF2. Evaluate the different options with Incoherent Scatter (IS) measurements and determine which option performs best for high and low solar activity. Use IS data from the Madrigal data base

Adviser: S.-R. Zhang

\*\*\*\*\* BRONZE MEDAL \*\*\*\*\*

TEAM 7: Ajesh Asokan Pillai (India), Yen-Kai Chen (Taiwan), Adam Fron (Poland), Dessi Marlia (China/Indonesia)

Problem H: Study the extent of the Equatorial Ionization Anomaly (EIA) in Local Time using F-peak COSMIC data. For what time period are separate cusps observed on both sides of the magnetic equator and when a single maximum at the magnetic equator. Compare with IRI predictions.

Adviser: V. Truhlik

TEAM 8: Geetashree Kakoti (India), Chen-Jui Li (Taiwan), Junseok Hong (Korea), Jumpon Udomchaibanjerd (Thailand)



Problem E: Use IRI Scintillation Library to investigate scintillation diagnostics. Select or develop measures of scintillation characteristics and demonstrate frequency dependencies. Use simulation program to generate scintillation surrogate and compare results to the two data sets provided.

Adviser: C. Rino

TEAM 9: Mohamed Osman (Sudan/USA), Min-Yang Chou (Taiwan), Zhe Yang (China), Punyawati Jamjareegulgarn (Thailand), Benjamin Lim (Singapore)

Problem A: Investigate the ionospheric effects of the solar eclipse of August 20, 2017 using ionosonde data. How well does IRI Real-Time (IRTAM) represent these changes.

Adviser: I. Galkin

\*\*\*\*\* SILVER MEDAL \*\*\*\*\*



Gold Award Team



Silver Award Team

## IRI WORKSHOP WEEK

The second week IRI Workshop brought together 89 researchers from 23 countries to discuss the status and improvement of the International Reference Ionosphere (IRI) model with special emphasis on improved real-time ionospheric predictions with IRI and FORMOSAT-3/COSMIC and other GNSS data. The workshop was opened by the Deputy Director General of the National Space Organization (NSPO), Shiann-Jung Yu, and by Prof C.H. Liu who put the workshop in the context of the past and present space weather activities at NCU.



The 68 presentations were distributed into sessions covering 'Real-time IRI', 'GNSS and Radio Occultation', 'Scintillation', 'F-peak and above', 'Irregularities and Anomalies', 'Storm

Modelling’, ‘Ion Composition, Temperatures, and Ion Drift’, ‘New Inputs for IRI’, ‘Student Presentations’, ‘Final Discussions’, and a Poster Session. As a result of the presentations and discussions at the workshop significant improvements were proposed for the next version of the IRI model including models for the occurrence probability of scintillations based on COSMIC data (S.-P. Chen, Taiwan) and on GPS data (D. Sur, India), statistics of mid-latitude spread-F occurrence based on Irkutsk ionosonde data (K. Ratovsky, Russia), a model for plasmaspheric densities based on Akebono data from 1989-2015 (S. Watanabe, Japan), improvements of the plasma-temperature models and the topside ion composition model in IRI with new and old satellite data sets (V. Truhlik, Czech Republic), a better representation of the equatorial ion drift with ground magnetometer measurements in the African sector (J.B. Habarulema, South Africa). In addition, the new version of IRI will include the hmF2 storm model of D. Altadill (Spain), the new FIRI model for the lower ionosphere of M. Friedrich (Austria), and work has begun on a sporadic-E modelling effort based on COSMIC radio occultation data (C. Arras, Germany). Several presentations during the meeting dealt with the assimilation of digisonde and/or GNSS data into the background IRI to represent real-time conditions (I. Galkin, USA; J.-Y. Liu, Taiwan; C.-Y. Lin, Taiwan; M.-Y. Chou, Taiwan; M. Pietrella, Italy). New or improved ionospheric indices were the topic of a number of papers indicating very promising performance enhancements (S. Brown, USA; F. Arıkan, Turkey; M. Pezzopane, Italy). IRI-2016 has introduced two new options for the representation of the F-peak height hmF2 based on digisonde and radio occultation data, respectively. Comparisons with Alouette and ISIS topside sounder data (D. Bilitza, USA) and with Swarm satellite in situ data (C. Xiong, Germany) highlighted the areas of disagreement and need for improvements.



**Workshop attendees enjoying excursion to the National Space Organization (NSPO)**

The best student presentations were rewarded with Gold, Silver and Bronze Awards. Jann-Yeng (Tiger) Liu was congratulate on the excellent organization of the workshop by him and his team and he was elected to become a new member of the IRI Working Group.

Papers from the workshop will form the core of a special issue of *Advances in Space Research* on “Improved Real-Time Ionospheric Predictions with IRI and Formosat-3/COSMIC and other GNSS Data”.

The workshop was supported by COSPAR, by the Taiwanese Ministry of Science and Technology, by NCU through its Center for Space and Remote Sensing Research (CSRSR) and its Graduate Institute of Space Science (GISS), and by VarSITI. The next IRI workshop is planned to be held at the Frederick University in Cyprus in September 2019.