



The International Reference Ionosphere - A Commission G Success Story

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Earth's ionosphere is a layer of molecular and atomic ions (NO^+ , O_2^+ , O^+ , N^+ , He^+ , H^+) that surrounds the earth from about 50 to 1000 km. This plasma layer is responsible for retarding and refracting effects on traversing radio waves and enabled Marconi's groundbreaking radio link from Europe to the United States in 1902. Many of our modern space technologies depend on such propagating radio waves. It is understandable then that the study and modelling of Earth's ionosphere is one of the core responsibilities of URSI, the International Union in charge of Radio Science. Specifically, URSI's Commission G was given the task to lead this endeavor with the goal to provide the broad understanding of the ionosphere necessary to support space and ground-based radio systems. When the Committee on Space Research (COSPAR) decided to follow the success of its COSPAR International Reference Atmosphere (CIRA) with a similar project for the ionosphere, URSI joined forces and an inter-union Working Group was established in 1969 under the leadership of Karl Rawer (Commission G Vice-Chair and then Chair 1966-1972). The new project was called International Reference Ionosphere (IRI) and like CIRA it was intended to combine approved experimental results so as to be a useful reference with no dependence on theoretical assumptions. The two organizations, URSI and COSPAR, were ideal partners bringing different data sets to the table. URSI the decades-long record of ground-based measurements in particular by the world-wide network of at times over 100 ionosondes and COSPAR the much needed global coverage through space-based observations by the Alouette, ISIS, Atmosphere Explorer, and AEROS satellites to name just a few. They also had somewhat different goals and thus broadened the user communities of the model. While URSI's prime interest is in defining the background ionosphere for radiowave propagation studies and applications, COSPAR's prime interest is in a general description of the ionosphere for the evaluation of environmental effects on spacecraft and experiments in space.

This tutorial will tell the story of the model development from the early beginnings to the international standard that it is now. I will discuss the milestones reached with the release of different editions [1-8] during the continuous improvement process supported by IRI-related activities in many parts of the world. These activities are discussed during bi-annual IRI Workshops that have been held since 1983. Dedicated issues of *Advances in Space Research* and of *Earth, Planets, and Space* (36 in all) document the progress made during these meetings. Model usage and performance in multi-model assessment studies will be highlighted. I will discuss the improvements introduced with the latest version of the model and plans for the future, including the progress towards to real-time ionospheric weather predictions.

References

- [1] K. Rawer, S. Ramakrishnan and D. Bilitza, "International Reference Ionosphere 1978," International Union of Radio Science, *Special Report*, Brussels, Belgium, 1978.
- [2] K. Rawer, D. Bilitza, and S. Ramakrishnan, "Goals and status of the International Reference Ionosphere," *Reviews of Geophysics*, **16**, #2, 177 - 181, 1978, doi:10.1029/RG016i002p00177.
- [3] D. Bilitza, "International Reference Ionosphere 1990," 155 pages, National Space Science Data Center, NSSDC/WDC-A-R&S 90-22, Greenbelt, Maryland, November 1990.
- [4] D. Bilitza, and Reinisch, B.W., "International Reference Ionosphere 2007: Improvements and new parameters," *Advances in Space Research*, **42**, #4, 599-609, 2008, doi:10.1016/j.asr.2007.07.048.
- [5] D. Bilitza, L.-A. McKinnell, B. Reinisch, and T. Fuller-Rowell, "The International Reference Ionosphere (IRI) today and in the future," *Journal of Geodesy*, **85**, 909-920, 2011, doi:10.1007/s00190-010-0427-x.
- [6] D. Bilitza, D. Altadill, Y. Zhang, C. Mertens, V. Truhlik, P. Richards, L.-A. McKinnell, and B. Reinisch, "The International Reference Ionosphere 2012 – a model of international collaboration," *Journal of Space Weather and Space Climate*, **4**, A07, 1-12, 2014, doi:10.1051/swsc/2014004.
- [7] D. Bilitza, D. Altadill, V. Truhlik, V. Shubin, I. Galkin, B. Reinisch, and X. Huang, "International Reference Ionosphere 2016: From ionospheric climate to real-time weather predictions," *Space Weather*, **15**, 2017, 418-429, doi:10.1002/2016SW001593.
- [8] D. Bilitza, M. Pezzopane, V. Truhlik, D. Altadill, B. W. Reinisch, and A. Pignalberi, "The International Reference Ionosphere model: A review and description of an ionospheric benchmark", *Reviews of Geophysics*, **60**, 2022, e2022RG000792. doi:10.1029/2022RG000792.