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Validation of the topside ionosphere description made by the International Reference Ionosphere model through in-situ satellites, GNSS radio occultation, and incoherent scatter radars observations

Alessio Pignalberi*(1), Michael Pezzopane(1), Dieter Bilitza(2,3), Bruno Nava(4), and David R. Themens(5,6)
(1) Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy;
e-mails: alessio.pignalberi@ingv.it; michael.pezzopane@ingv.it
(2) Department of Physics and Astronomy, George Mason University, Fairfax, VA, USA;
e-mail: dbilitza@gmu.edu
(3) Heliospheric Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD, USA
(4) The Abdus Salam International Centre for Theoretical Physics, Trieste, Italy; e-mail: bnava@ictp.it
(5) School of Engineering, University of Birmingham, Birmingham, UK; e-mail: d.r.themens@bham.ac.uk
(6) Department of Physics, University of New Brunswick, Fredericton, Canada

The International Reference Ionosphere (IRI) is an empirical model describing the primary ionospheric parameters based on the long data record from ground-based ionospheric observatories and space-based satellite missions. IRI describes the monthly averages conditions of the ionosphere on a global basis and for different diurnal, seasonal, solar and magnetic activity conditions. It is recognized as the official standard for the Earth's ionosphere by the International Standardization Organization, the International Union of Radio Science, the Committee on Space Research, and the European Cooperation for Space Standardization.

This work focuses on the topside region electron density modelling by the last version of IRI, i.e., IRI-2020 [1]. The topside ionosphere is the region extending from the F2-layer peak, the electron density absolute maximum of the ionosphere, to the overlying plasmasphere. In the topside ionosphere the electron density decreases monotonically with height as the ion population smoothly transitions from heavy O^+ to lighter H^+ and He^+ ions, and the plasma temperature increases. Moreover, also the electron density vertical variation rate, i.e., the plasma scale height, is dependent on height [2]. IRI describes this complex behavior through four topside options based on different sub-models [1,3-5]. All the options have in common the F2-layer peak as an anchor point, while they differ in their topside electron density profile and/or plasma scale height formulations. In this work, we perform a validation of the accuracy and precision of the four IRI topside options based on different data sources: in-situ electron density observations by low-Earth-orbit satellites (Swarm, CHAMP, DMSP, ICON); topside electron density profiles by COSMIC/FORMOSAT-3 through GNSS radio occultation measurements; topside electron density profiles by ground-based incoherent scatter radars at Jicamarca, Arecibo, and Millstone Hill facilities. Datasets used in this study cover different diurnal, seasonal, and solar activity conditions, on a global basis and for the height range from the F2-layer peak altitude to about 1,000 km. The extension of the dataset allows evaluating the ability of the four IRI topside options in reproducing the spatial and time variations of the topside ionosphere for different solar activity conditions. The weaknesses and strengths of each IRI topside option are highlighted and discussed, and indications about how to improve the modelling of the challenging topside ionosphere region within the IRI are provided for future reference.

References

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