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Preface on the Special Issue “*International Reference Ionosphere: Improvement and Evaluation of a Global Standard*”

Dieter Bilitza[1], Joseph Olwendo[2], Alessio Pignalberi[*,3], Michael Pezzopane[3]

(1) George Mason University, Fairfax, Virginia, USA
(2) Pwani University, Department of Physics, Kilifi, Kenya
(3) Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy

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The Earth’s ionosphere is a layer of ions and electrons embedded in the neutral atmosphere and extending from about 50 km to 1000 km of altitude. This layer of plasma is a fundamental component of the near-Earth space environment and plays a crucial role in the propagation of radio waves and satellite signals. Its retarding and refractive effects directly influence a wide range of scientific and technological applications, including satellite navigation, telecommunications, remote sensing, over-the-horizon radar, and space-based observations. As our society becomes increasingly dependent on space-based infrastructure and services, the need for an accurate and reliable representation of ionospheric conditions becomes ever more important.

Recognizing this need, the *Committee on Space Research* (COSPAR) and the *International Union of Radio Science* (URSI) established the *International Reference Ionosphere* (IRI) as the empirical standard model of the ionosphere. Based on a broad body of ground-based and space-based observations, IRI has become the internationally accepted reference for ionospheric specification, being widely used in science, engineering, and education (Bilitza et al., 2022). Its continuous development over the decades has relied on the integration of new datasets, the testing of improved modelling approaches, and the systematic validation of outputs against observations collected under different geophysical conditions and over diverse regions of the globe.

This Special Issue provides an updated overview of current efforts to assess and further improve the IRI model. The contributions collected in this issue address key aspects of IRI development, including the proposal of new formulations for specific ionospheric parameters and regions, the evaluation of model performance using new ground-based and space-based datasets, the assimilation of real-time or retrospective observations, and examples of applications that highlight the practical relevance of IRI for both research and operations.

The twelve contributions included in this Special Issue are organized into three main thematic sections: *TEC observations and comparisons and evaluation of IRI*; *New inputs for IRI*; and *Representation of irregularities*. Together, these papers provide a broad and timely picture of the diversity of present-day IRI-related research and of the directions along which further model development is expected to proceed.

The first section, *TEC observations and comparisons and evaluation of IRI*, focuses on model assessment against observations and on methodologies that improve the derivation of reliable ionospheric quantities from measurements. Mondal et al. (2025) compare total electron content (TEC) predictions from IRI-2016 and IRI-2020 over Indian near-equatorial and equatorial ionization anomaly regions, providing a detailed evaluation of the NeQuick and COR2 topside options during low solar activity conditions. Adero et al. (2026) investigate low-latitude topside ion composition using complementary COSMIC-2 and ICON observations and compared the measured O^+ and H^+ fractions with IRI-2020 predictions, showing that the model reproduces the large-scale climatological structure while still exhibiting systematic discrepancies in the transition region and around dawn and dusk. Kenpankho et al. (2026) focus on GNSS receiver-bias modelling for near-real-time TEC monitoring over low-latitude Thailand, demonstrating the importance of local bias correction for improved TEC estimation. Keokhumcheng et al. (2026) examine TEC fluctuations and their implications for GPS signal delay over Thailand during the ascending phase of Solar Cycle 25, emphasizing the practical relevance of ionospheric variability for satellite navigation systems.

The second section, *New Inputs for IRI*, presents contributions that offer new observational benchmarks, reconstruction methods, and modelling tools of direct relevance to future IRI developments. Moses et al. (2026) provide a comparison of sporadic-E (Es) characteristics derived from coincident COSMIC-2 radio occultation and digisonde observations, contributing important information for future Es occurrence and intensity modelling. Yenen et al. (2026) apply the IONOLAB-Fusion computerized ionospheric tomography framework over Africa and Türkiye, demonstrating that advanced four-dimensional reconstructions can improve regional electron density specification even in areas with sparse data coverage. Gulyaeva and Shubin (2026) explore the use of different two-dimensional climatological models within the IRI-Plas framework, showing the potential of alternative *fo*F2 and *hm*F2 formulations to improve the representation of electron density profiles and TEC. Erdem Kocak and Arikan (2026) present IONOLAB-RAY, a flexible three-dimensional ray-tracing tool able to synthesize both virtual and real-height ionograms, thus linking empirical ionospheric modelling to radio-wave propagation studies and ionogram interpretation. Wang et al. (2026) introduce a global foF2 prediction model based on COSMIC-1 and COSMIC-2 radio occultation data and an interpretable XGBoost approach. The model reproduces key ionospheric structures and, when validated against independent GRACE and GIRO observations, outperforms IRI-2020 and other reference models. By combining predictive skill with SHAP-based interpretability, this study offers an interesting new data-driven contribution to future improvements in *fo*F2 modelling.

The third section, *Representation of irregularities*, is about ionospheric variability under disturbed or highly structured conditions. Pansong and Kenpankho (2026) compare the ionospheric effects of two matched intense equinoctial geomagnetic storms during Solar Cycles 24 and 25, documenting marked differences in TEC, *fo*F2, and *hm*F2 responses across low latitudes. Lukianova (2026) addresses the high-latitude F-region ionosphere with a regional numerical model and corresponding comparisons with Swarm satellite observations, showing how large-scale structures such as the tongue of ionization and the polar hole can be reproduced by physics-based modelling, thereby complementing the smoother morphology of empirical climatologies. Hegy and Abdelrahman (2026) evaluate neural-network forecasting of geomagnetic indices during Solar Cycle 25, a topic of relevance for operational space-weather prediction and, more broadly, for the specification of disturbed ionospheric conditions.

Taken together, the papers in this Special Issue show how the IRI development continues to rely on the close interaction between empirical modelling, new observational datasets, advanced reconstruction techniques, and studies of disturbed ionospheric behaviour. The Special Issue brings together contributions that range from the validation of IRI outputs to the introduction of new tools and inputs that may support future model improvements.

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***CORRESPONDING AUTHOR: Alessio PIGNALBERI**,
Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy
e-mail: alessio.pignalberi@ingv.it