4th URSI AT-RASC, Gran Canaria, 19-24 May 2024

Forecasting Ionospheric Irregularities in the Arctic Regions

Yaqi Jin(1), Wojciech J. Miloch*(1), Rinku Mishra(1), Daria Kotova(1), Knut Stanley Jacobsen(2), Krzysztof Zawada(3), Federico Da Dalt(4), and Alexi Glover(5)

(1) Department of Physics, University of Oslo, Oslo, Norway; e-mail: yaqi.jin@fys.uio.no; w.j.miloch@fys.uio.no; rinku.mishra@fys.uio.no; daria.kotova@fys.uio.no
(2) Norwegian Mapping Authority, Hønefoss, Norway; e-mail: Knut.Stanley.Jacobsen@kartverket.no
(3) GMV Innovating Solutions, Warsaw, Poland; e-mail: kzawada@gmv.com
(4) Rhea System GmbH, Darmstadt, Germany; e-mail: Federico.Da.Dalt@ext.esa.int
(5) European Space Agency, Darmstadt, Germany; e-mail: Alexi.Glover@esa.int

The high-latitude ionosphere is often highly turbulent and consists of significant electron density irregularities, which can be detrimental to the Global Navigation Satellite System (GNSS) services that rely on trans-ionospheric radio waves. For a more reliable use of GNSS applications, it is important to enable the forecasting of ionospheric irregularities and scintillations. To meet this specific challenge, we develop an empirical model for the Arctic ionosphere based on more than one solar cycle of data (2010–2021) of the rate of change of the total electron content index (ROTI) maps [1]. The model is simple and robust as it is only dependent on a few helio-geophysical indices that represent the main drivers/sources of ionospheric irregularities. Though it is simple, the model is able to reproduce all the statistical features of high-latitude ionospheric irregularities. The statistical data-model comparisons show satisfactory results with good correlations.

We further implement the model into a real-time space weather forecasting service. In order to meet the scenario when certain helio-geophysical indices may be unavailable at times, we develop another three versions of ROTI model using different sets of helio-geophysical indices. The real-time space weather service works in three different scenarios: i) For the nowcast, we make use of the real-time solar wind data and Kp index. ii) For the short-time (< 1 hour) forecast, we use the real-time solar wind data and forecasted Kp index. iii) For the long-time (~3 hour) forecast, we use forecasted Kp index as input. Finally, we validate the nowcasted and forecasted ROTI maps using ground-based data from permanent GNSS networks. While the forecasted ROTI maps can reveal the general distribution of ROTI activity, there are also some limitations in the model that can be improved in the future.

Acknowledgements
This research is part of the 4DSpace Strategic Research Initiative at the University of Oslo. The development of the pre-operational application is funded by the European Space Agency (ESA), under the Space Situational Awareness programme (now ESA Space Safety programme) within the Space Weather activity P3-SWE-XL Ionospheric Scintillation Products for Arctic (under ESA contract number 4000139062/22/D/KS). YJ, DK, WM acknowledge funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (ERC Consolidator Grant agreement No. 866357, POLAR-4DSpace)

References

1. Jin, Y., Miloch, W. J., Kotova, D., Jacobsen, K. S., Stevanović, Đ., Clausen, L. B. N., et al. (2023). Modeling TEC irregularities in the Arctic ionosphere using empirical orthogonal function method. Space Weather, 21, e2023SW003531. https://doi.org/10.1029/2023SW003531