URSI AP-RASC, Sydney, Australia, 17-22 August 2025

Ionospheric Plasma Irregularities in the Polar Regions

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The Earth's ionosphere is often subject to instabilities and turbulence which can lead to irregularities in the ionospheric plasma density. In the polar regions, at high geomagnetic latitudes, they result from dynamic processes related to coupling between the ionosphere and magnetosphere, and energetic particle precipitation leading to aurora. Ionospheric plasma irregularities are important space weather effects, which can strongly impact the propagation of radio waves through the upper atmosphere, and consequently degrade the quality of trans-ionospheric signals and communication with satellites. This can decrease the accuracy of positioning with the Global Navigation Satellite Systems (GNSS), such as GPS, Galileo, and GLONASS. In the worst-case scenario, such services might become temporarily unavailable. A comprehensive understanding of ionospheric irregularities is vital for both research and operations that rely on satellite signals, and for the development of space weather forecasting services.

We present recent studies of ionospheric irregularities in the polar regions carried out using the satellite- and ground-based measurements. We combine the ground-based observations from our observatories in the Arctic and in Antarctica with the in-situ and remote studies by sounding rockets and satellites. We consider the role of auroral particle precipitation and demonstrate that the strongest plasma structuring can be associated with the edges of the auroral oval [1], and that both refractive and diffractive effects are present in narrow auroral arcs [2]. The case studies help to understand physical processes leading to irregularities, while climatology allow for developing models for ionospheric irregularities [3,4]. We also discuss our recently completed models and corresponding products for forecasting irregularities in the polar regions as well as ongoing collaborative initiatives to advance our understanding on ionospheric plasma irregularities.

Acknowledgments
This work has been supported by the European Union's Horizon 2020 research and innovation programme (ERC Consolidator Grant agreement No. 866357, POLAR-4DSpace).

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