URSI GASS 2021, Rome, Italy, 28 August - 4 September 2021

Ground based and in-situ studies of the polar ionosphere

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In the polar regions, the Earth's ionosphere is directly coupled to the magnetosphere and to space plasma. This dynamic coupling often results in plasma instabilities and turbulence, and it gives rise to irregularities in the ionospheric plasma density. They can influence the propagation of radio signals, and hence degrade communication or positioning services using the Global Navigation Satellite Systems (GNSS), such as GPS, Galileo or GLONASS. As such, ionospheric plasma irregularities at high latitudes are an important aspect of the space weather system. Their understanding is important for modeling of the state of the ionosphere and building the capability of predicting and mitigating severe space weather effects in the polar regions.

Combining ground-based observations with the in-situ and remote studies by sounding rockets and satellites gives a comprehensive understanding of processes in the polar ionosphere. Commonly used ground-based instruments include all-sky-imagers, magnetometers, TEC and scintillation receivers, and radars. International efforts in enhancing the ground-based network in both Arctic and Antarctica, together with the in-situ experiments by rockets give better insight into physical processes behind forming of plasma irregularities in the polar ionosphere [1]. In this talk I will demonstrate these synergistic effects with the first selected results from the *Grand Challenge Initiative – Cusp* rockets campaigns, and with an example from coordinated efforts in Antarctica for the studies of dynamics of plasma irregularities and related GNSS scintillations.

Satellites can provide a global coverage of phenomena in the ionosphere, albeit often at larger spatial scales than studies with the ground-based instruments. Satellite data can be invaluable in statistical studies of the ionosphere in the polar regions. For example, the Swarm mission provides a variability of the ionospheric plasma at various scales by both in-situ plasma and topside TEC measurements. I will discuss results from recent climatological studies of the polar cap patches and ionospheric irregularities in the polar regions based on the Swarm IPIR dataset [2,3]. Furthermore, a new approach for mapping plasma irregularities by using multiple satellites and topside TEC observations will also be demonstrated. Ground-based and satellite observations can be combined to develop physics-based and semi-empirical models for plasma irregularities. In the final part of the talk I will present ongoing initiatives which aim to develop such models for the polar regions, their status, challenges, and prospects.

References

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