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

Ionospheric Plasma Structuring and Irregularities at High Latitudes

Wojciech J. Miloch*(1), Lisa M. Buschmann(1), Gaute A. Holen(1), Steffen M. Brask(1), Anna Piterskaya(2), Daria S. Kotova(1), Yaqi Jin(1), Rinku Mishra(1), Nicholas Ssessanga(1), and 4DSpace team(1,2)

(1) Department of Physics, University of Oslo, Oslo, Norway, e-mail: w.j.miloch@fys.uio.no; l.m.buschmann@fys.uio.no; gauteah@student.matnat.uio.no; s.m.brask@fys.uio.no; annapit@math.uio.no; daria.kotova@fys.uio.no; yaqi.jin@fys.uio.no; rinku.mishra@fys.uio.no; nicholas.ssessanga@fys.uio.no
(2) Department of Mathematics, University of Oslo, Oslo, Norway, e-mail: annapit@math.uio.no

Dynamics of ionospheric plasma are controlled to a large degree by geomagnetic activity. In the polar regions the ionosphere is directly coupled to the magnetosphere and to space plasma, and it also plays a role in energy transfer into the neutral atmosphere. This dynamic coupling often results in plasma instabilities and turbulence. There are numerous drivers for plasma structuring at high latitudes, including flow shears, auroral particle precipitation, or polar cap patches. The resulting plasma irregularities can alter the propagation of trans-ionospheric radio waves, leading to scintillations in the received signal. Consequently, they can degrade communication or positioning with the Global Navigation Satellite Systems (GNSS), such as GPS or Galileo. Thus, ionospheric plasma structuring and irregularities at high latitudes are important aspects of the space weather system and their understanding is vital for modeling of the state of the ionosphere and building the capability of predicting and mitigating severe space weather effects in the polar regions.

We present case and statistical studies on formation of plasma irregularities in the polar regions, in both hemispheres. We combine the ground-based observations from the Arctic and from Antarctica with 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 is related to the edges of the auroral oval [1]. The results from recent climatological studies of the global occurrence of irregularities and plasma variability based on the satellite data are also presented in the context of the space weather effects observed with the ground-based instruments [2,3]. We also discuss our ongoing initiatives which aim at developing models and forecasting services for the space weather effects in the polar regions, their status, challenges, and prospects.

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).

References

1. L. M. Buschmann, J. W. Bonnell, S. Bounds, L. B. N. Clausen, C. Kletzing, S. Marholm, W. J. Miloch, R. Roglans, and A. Spicher, “The role of particle precipitation on plasma structuring at different altitudes by in-situ measurements,” *Journal of Space Weather Space Climate*, **13**, 13, 2023, doi: 10.1051/swsc/2023012.

2. Y. Jin, C. Xiong, L. B. N. Clausen, A. Spicher, D. Kotova, S. Brask, S., G. Kervalishvili, C. Stolle, and W. J. Miloch, “Ionospheric plasma irregularities based on in situ measurements from the Swarm satellites,” *Journal of Geophysical Research: Space Physics*, **124**, 2020, e2020JA028103, doi: 10.1029/2020JA028103.

3. D. Kotova, Y. Jin, L. Spogli, A. G. Wood, J. Urbar, J. T. Rawlings, I. C. Whittaker, L. Alfonsi, L. B.N. Clausen, P. Høeg, and W. J. Miloch, “Electron density fluctuations from Swarm as a proxy for ground-based scintillation data: A statistical perspective,” *Advances in Space Research*, **72**, 2022, pp. 5399-5415, doi: 10.1016/j.asr.2022.11.042.