EGU22-8293
https://doi.org/10.5194/egusphere-egu22-8293
EGU General Assembly 2022

Statistical characteristics of ionospheric irregularities in the cusp ionosphere based on multi-instrument techniques

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Plasma density irregularities disturbing signals from Global Navigation Satellite Systems (GNSS) are known to be regular features of the high-latitude ionosphere, especially around the cusp and auroral regions. Despite their relevance for society, irregularity formation and evolution are still relatively poorly understood, and observations revealing the spatio-temporal characteristics of ionospheric structuring at different scales are needed to assess the exact mechanism(s) responsible for them.

In this study, we focus on data from the European Incoherent Scatter Scientific Association (EISCAT) Svalbard Radars (ESR) operating in fast scanning mode. We use ESR experiments in which the antenna was swept in elevation, and create consecutive two-dimensional images showing how electron density, ion velocity, electron temperature, and ion temperatures change with latitude and time at different altitudes.

We present selected events in which the ESR scans are combined with all-sky images and in-situ data from the Swarm satellites to provide multi-scale observations of cusp phenomena comprising polar cap patches, flow channels, particle precipitation, and ion heating. We compare the observations with the presence of GNSS scintillations, allowing to monitor the onset and development of irregularities causing scintillations, and to inspect their connection with the phenomena above-mentioned. We then extend the analysis by performing a statistical study using all ESR fast scans identified between January 2001 and December 2015. We investigate the statistical characteristics of the measured parameters at different altitudes and under different geomagnetic conditions. Overall, this study will provide further insights onto the spatio-temporal evolution of ionospheric cusp dynamics, and on the possible physical sources causing ionospheric irregularities with Space weather impacts.