Observing plasma structures at multiple scale sizes in the high latitude ionosphere using a suite of ground-based instrumentation

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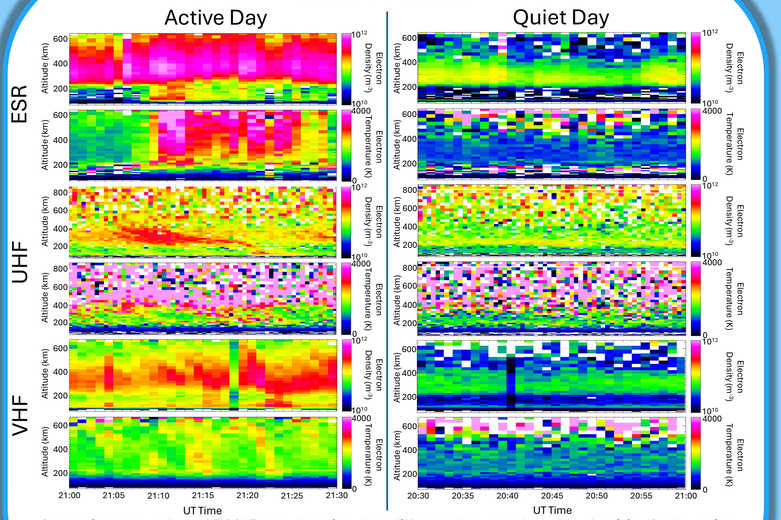
Abstract

For more detail on this experiment, please visit the abstract by following the QR code.

Experimental Background

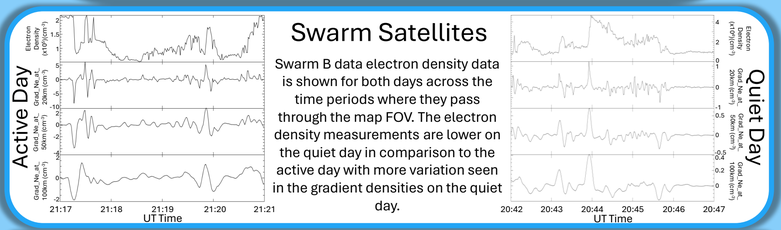
In winter 2024, a European Incoherent Scatter (EISCAT) Special Programme experiment named Scales of Ionospheric Plasma Structuring (SIPS) was conducted. The aims of the experiment were to investigate the relationship between irregularities of varying scale sizes; the formation and generation of small-scale irregularities that occur due to instability mechanisms; and determine under which conditions scintillation can occur. This experiment used a suite of ground-based instrumentation and the Swarm satellites to observe structuring in the high-latitude ionosphere across several scale sizes. Two observations are presented; one where the geomagnetic conditions were active and one where they were quiet. Over the field of view displayed in the central map, several instruments simultaneously made measurements which are presented. A more detailed description can be found in the abstract.

EISCAT Radars



Comparing the two days of EISCAT data, there is a clear difference between the levels of activity. On the active day, evidence of polar cap patches are observed with auroral precipitation below 200km. Interesting features are also seen in the UHF electron density data which is in a similar position to KAIRA, and there is also high electron densities observed in the VHF. There is very little activity observed on the quiet day, making this an acceptable baseline dataset for comparison.

Swarm Satellites

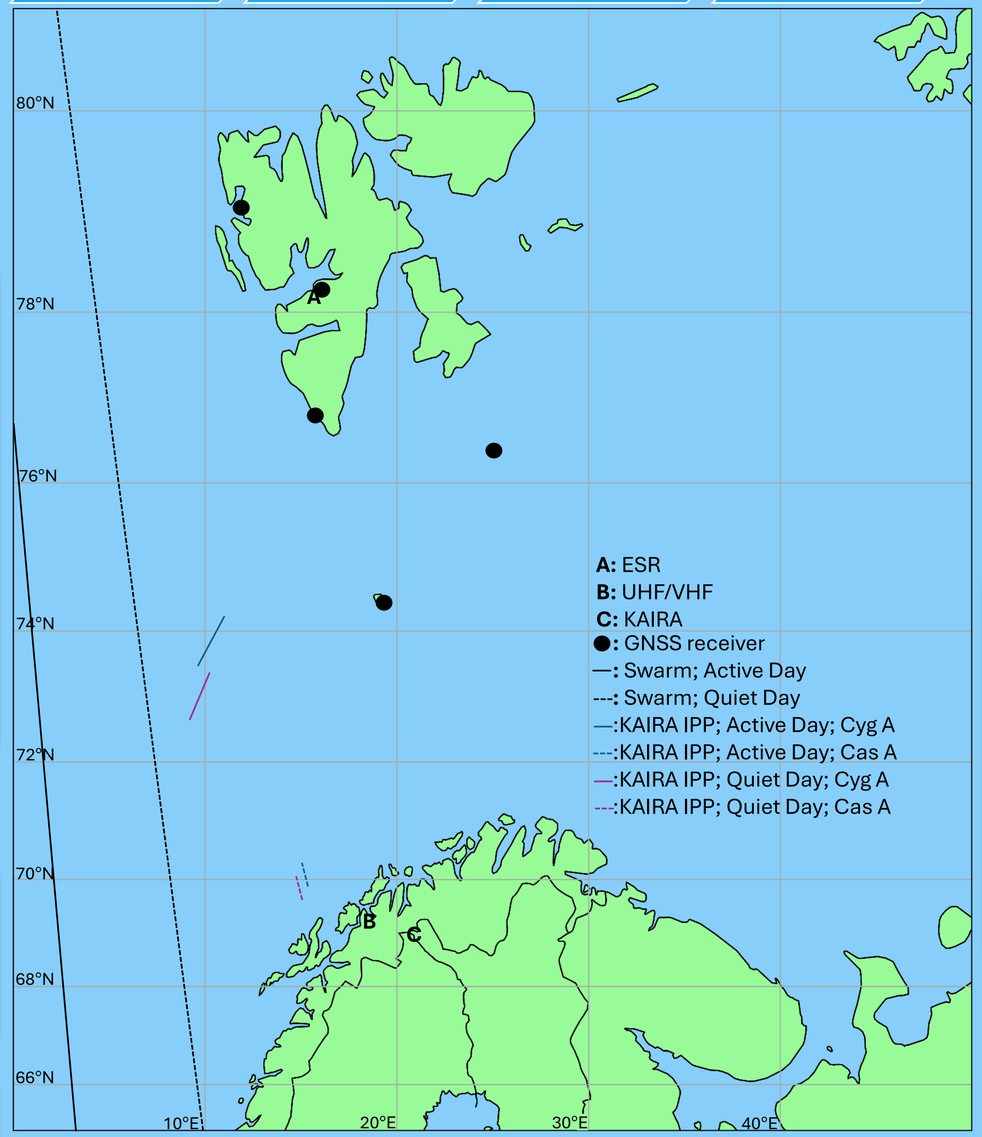


Swarm B data electron density data is shown for both days across the time periods where they pass through the map FOV. The electron density measurements are lower on the quiet day in comparison to the active day with more variation seen in the gradient densities on the quiet day.

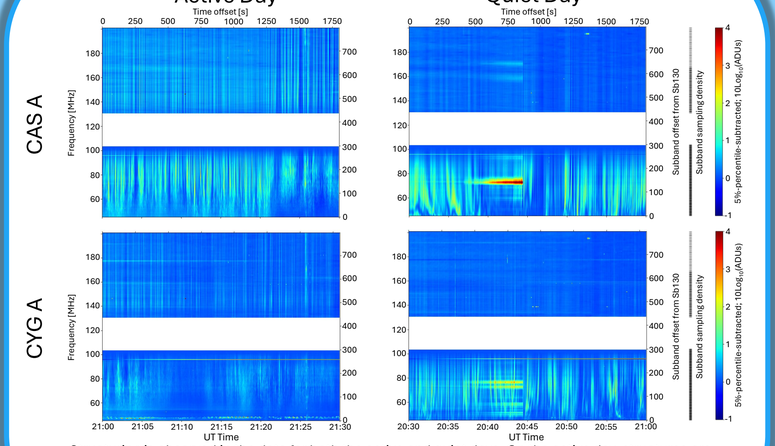
Acknowledgements

The SIPS Special Programme was generously awarded 72 hours of experimental time using the EISCAT radars. The authors also recognise and greatly appreciate the contributions of the EISCAT staff in the running of these experiments. The authors also recognise and appreciate the generous contributions made by Antti Kero and Derek McKay in facilitating and running SIPS with KAIRA. The GNSS data was generously provided by Kjellmar Oksavik.

Large-scale structures → Generation of instabilities → Smaller-scale irregularities → GNSS Scintillation

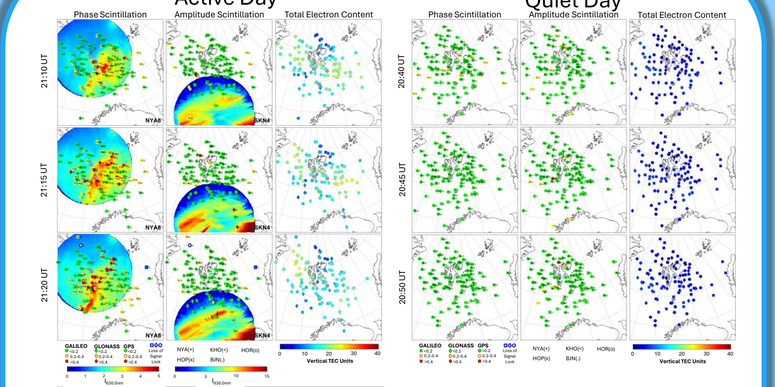


Kilpisjärvi Atmospheric Imaging Receiver Array (KAIRA)



Structuring is observed in the data for both the active and quiet days. On the active day, structures are observed across the full frequency range with CAS A as the source and some structuring is seen in CYG A, particularly at the beginning of the period. On the quiet day, structuring is also seen but this is now predominately below 100 MHz and it does not appear to be as finely structured as the active day data. Note that there is some RFI on the quiet day at approximately 20:37-20:45 UT.

GNSS Scintillation



On the active day, both phase and amplitude scintillation is observed, primarily across Svalbard. There is higher TEC values over Svalbard at this times that intensifies over the east and west with respect to time. The most intense phase scintillation occurs in similar locations to the structuring identified in the NYA6 all-sky imagery. On the quiet day, there is a low TEC for the whole time period. Scattered phase and amplitude scintillation is seen at times but this is low in comparison to the active day.

Conclusions

Structuring across multiple scale sizes is observed using a suite of ground-based instrumentation. While these results are in the preliminary stages, there is already evidence of structuring across different scale sizes with the progression of time. The next steps in this investigation is to identify which features across all the instrumentation are responsible for the observed scintillation from GNSS and determine the scale sizes of these features.

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