Radio-quiet ionosonde observations for HF absorption monitoring

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Overview

HF-absorption monitoring with ionosondes

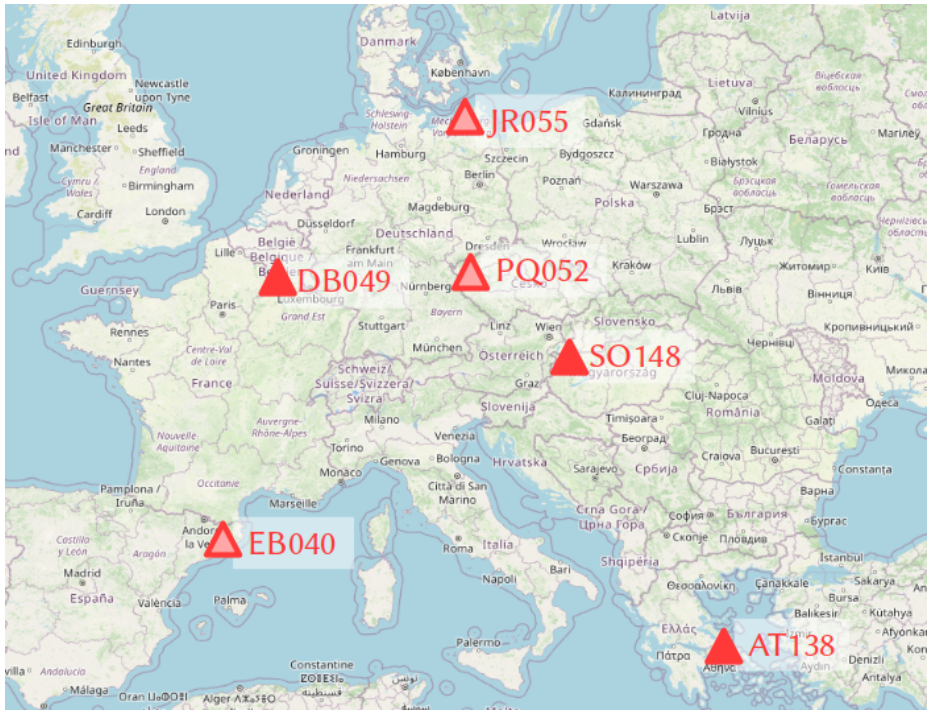
Various techniques are being investigated to monitor HF-absorption with ionosondes:

1. Monitor $f_{\min}$ parameter, the lowest frequency echo in the ionogram: easy to get, but limited information.
2. Echo amplitude monitoring: signal strength of reflection from E/F layer compared, as function of frequency; higher frequencies monitored using OI traces, but still limited to MUF.
3. X- *vs.* O-polarised amplitudes: more complicated data processing, but detailed D-layer observations (up to foF_2).
4. Passive listening (RIOMeter-like technique): should be able to monitor higher frequencies (up to the limit of the instrument).

The experiment

This was a proof of concept experiment, running since March 2024.

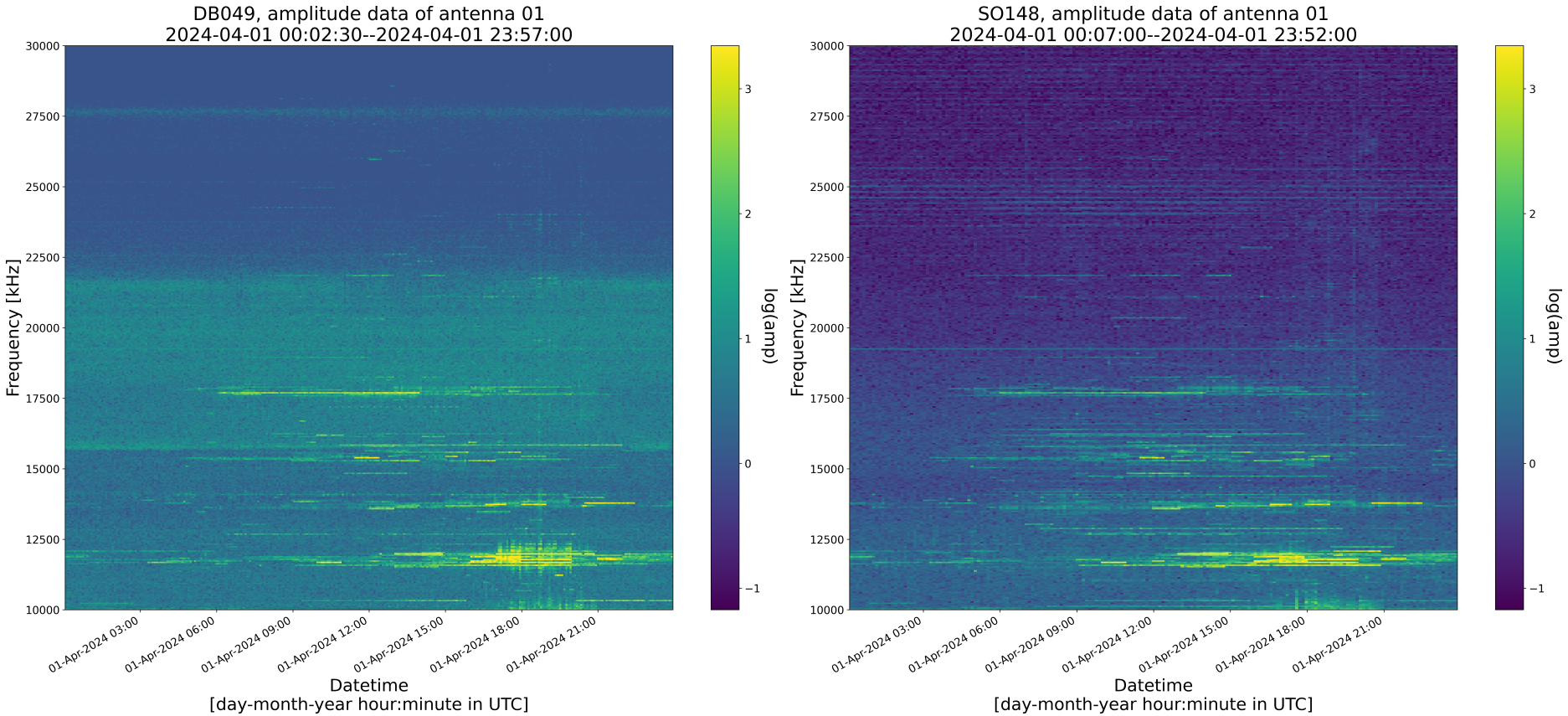
- We use European ionosondes at mid-latitudes.
- Passive listening to frequencies from 10 to 30 MHz.
- No continuous fixed frequency, but spectrum sweep in small steps.
- Ionosonde schedule time is scarce, so very short samples at each frequency.



These data were not originally recorded for this purpose; instrument configuration may still be improved.

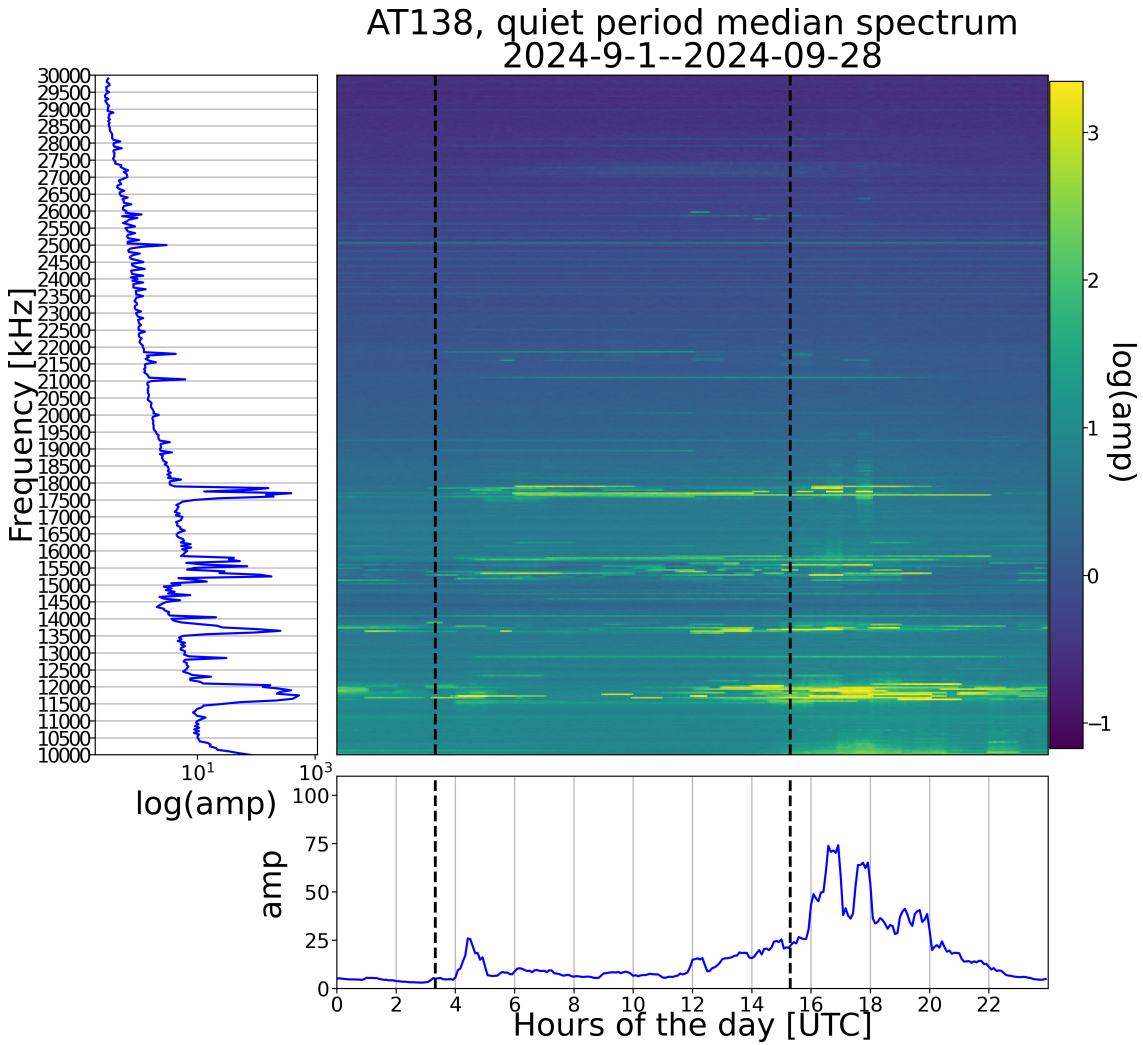
Spectrograms

24 hour spectrogram between 10 and 30 MHz on a quiet day (2024-04-01) at DB049 and SO138.



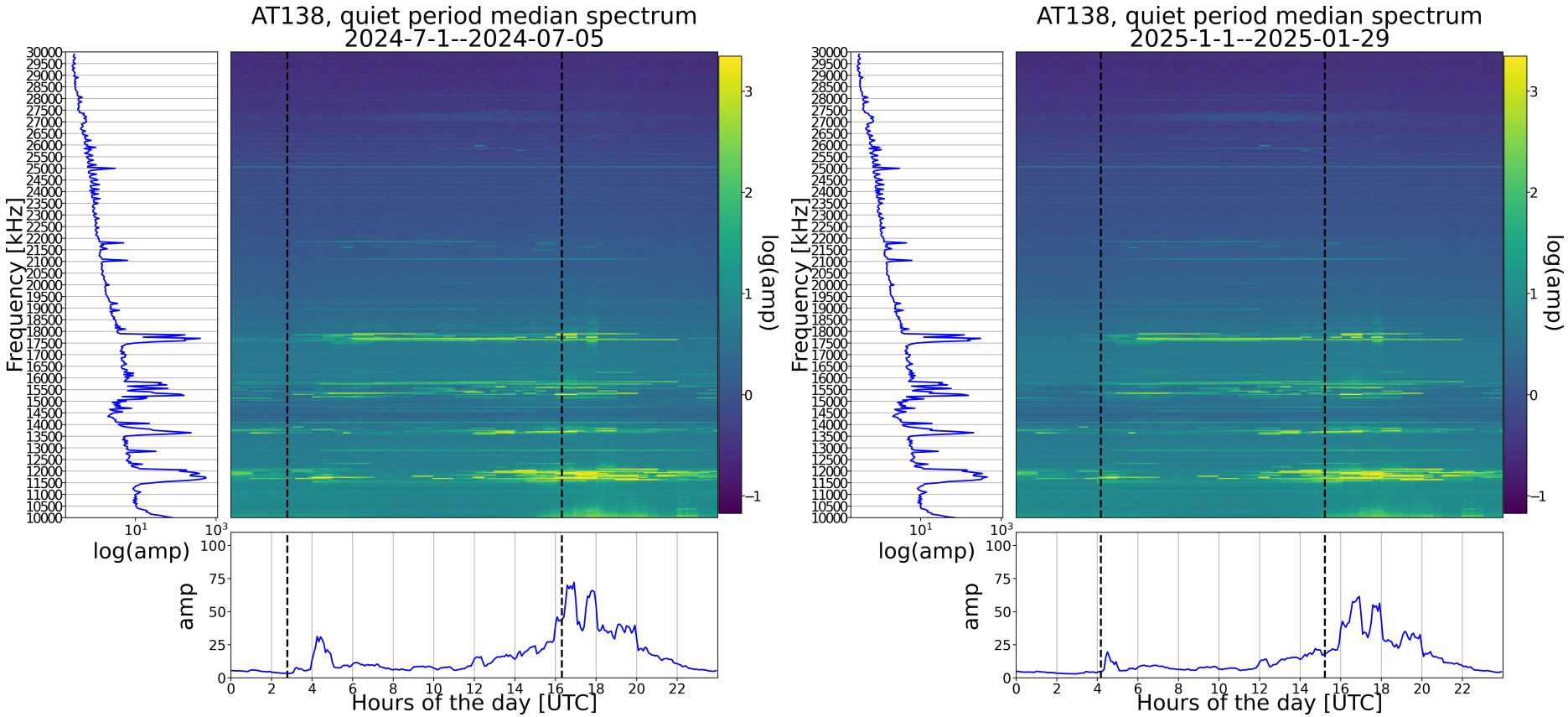
Spectrograms are very similar at different observatories.

Quiet time median behaviour



- Spectrum comprises power-law noise (line-of-sight) + HF broadcast bands (via ionosphere).
- Clear diurnal variation in sky-wave propagation, especially after sunset.

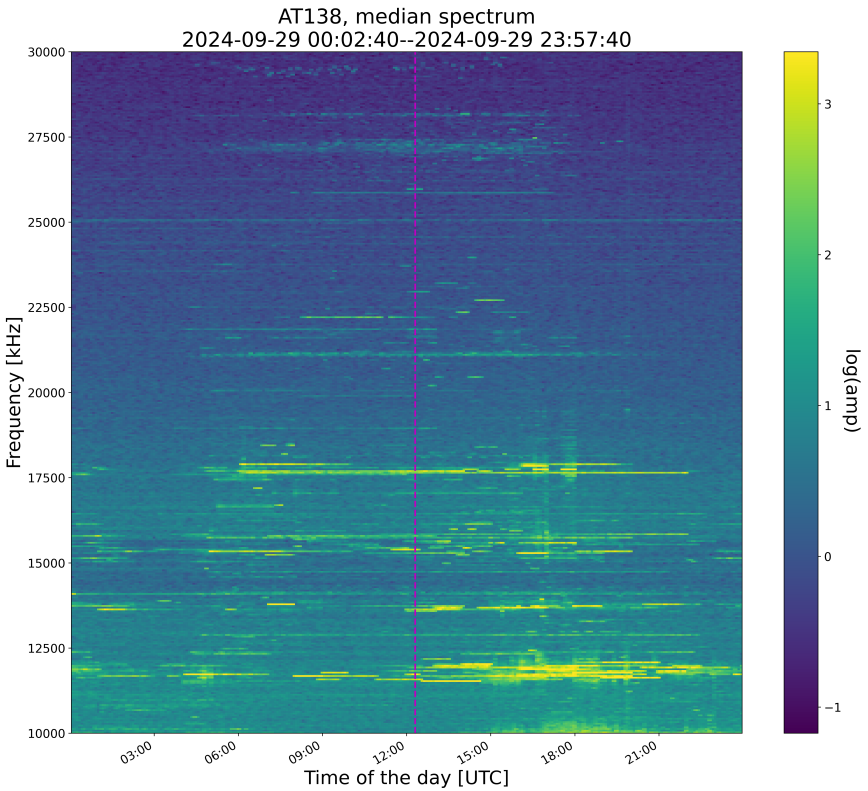
Seasonal variations

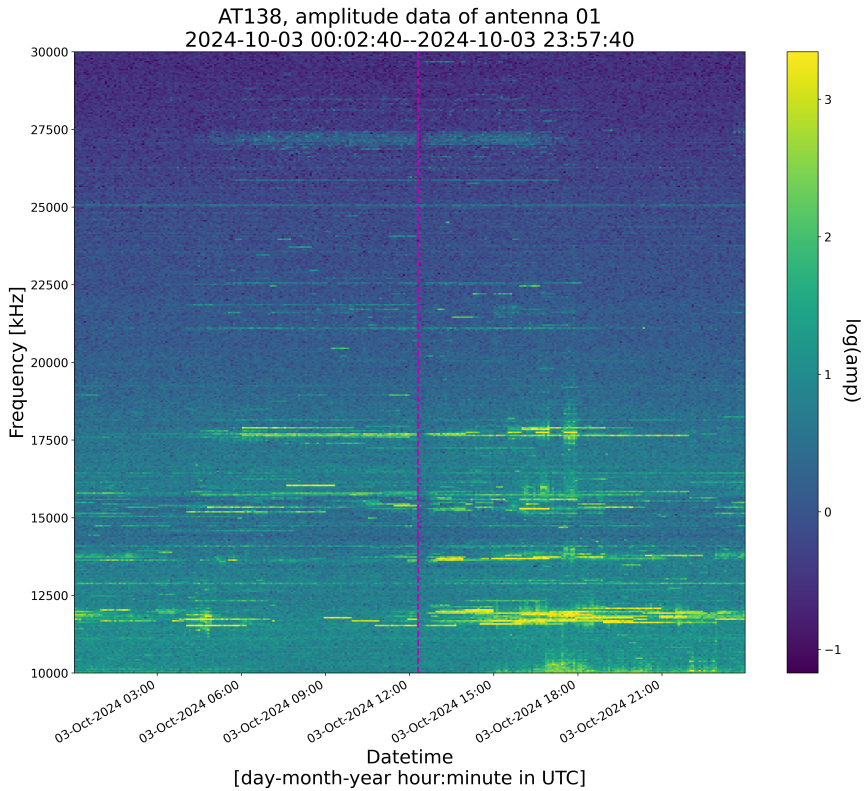


Obviously some differences between seasons, but main patterns are remarkably consistent.

Spectrograms during a major flare

An X9.0 flare occurred on 3 October 2024, peaking at 12:18 UTC.

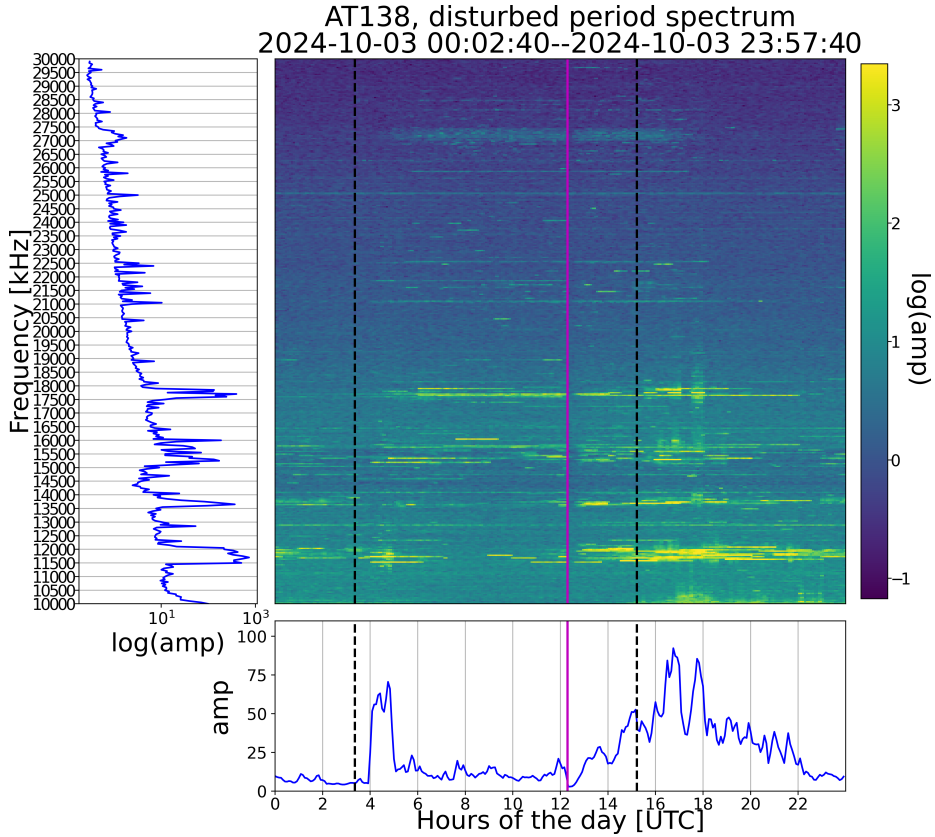


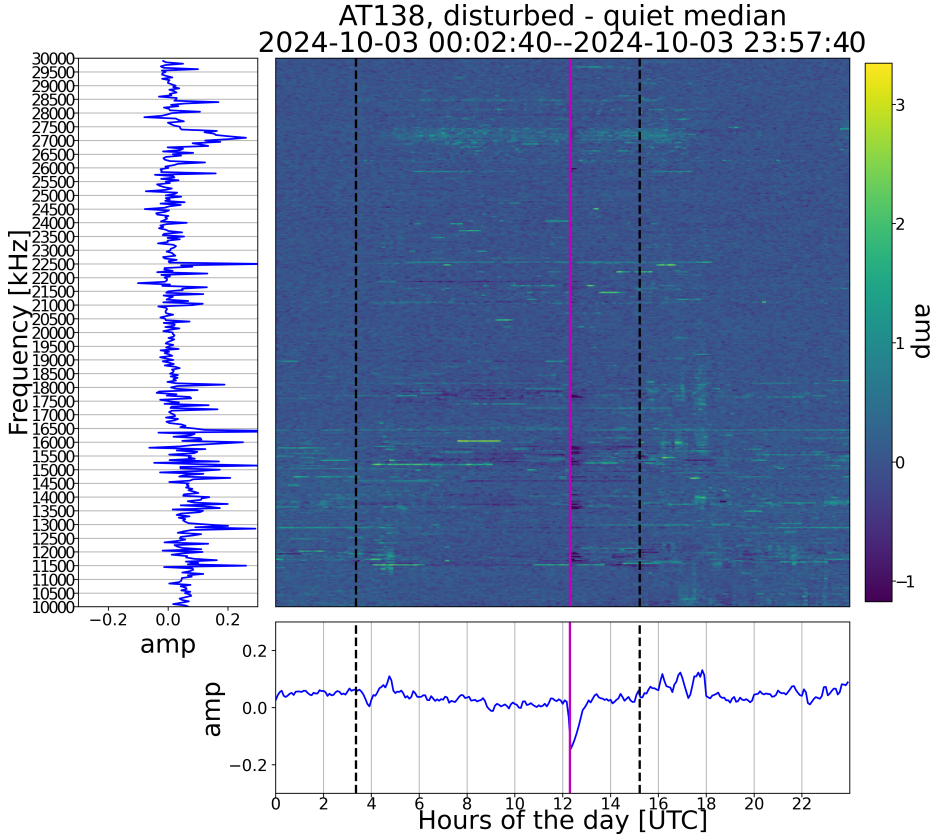


Left: trailing median spectrogram; right: spectrogram on day of flare.

Relative deviations

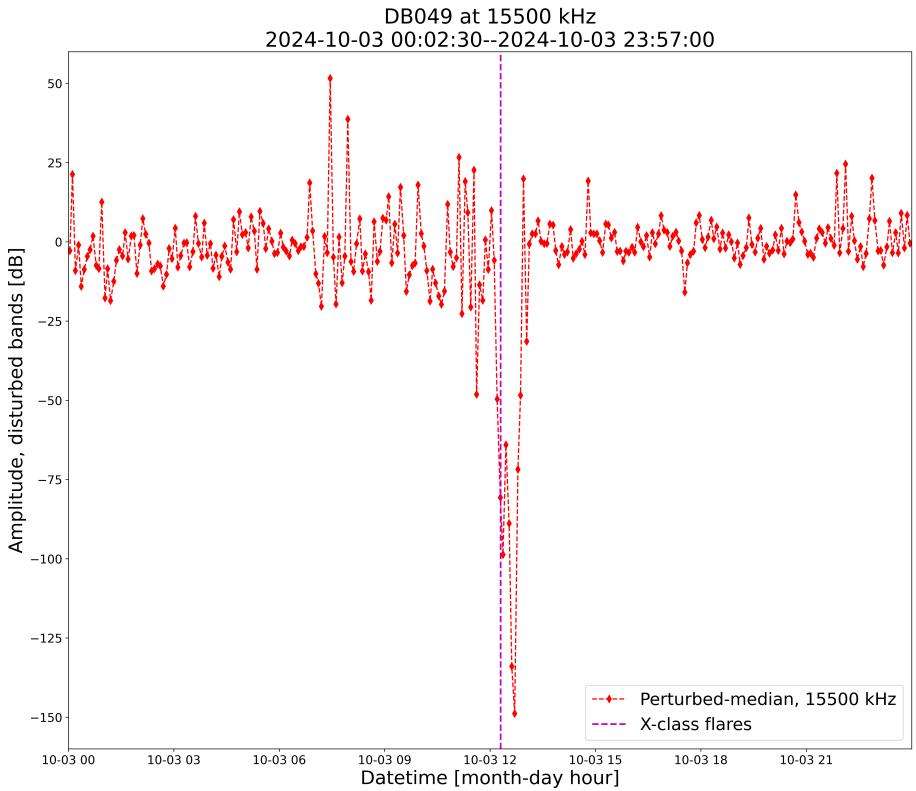
The solar flare effect becomes more obvious when subtracting the median.

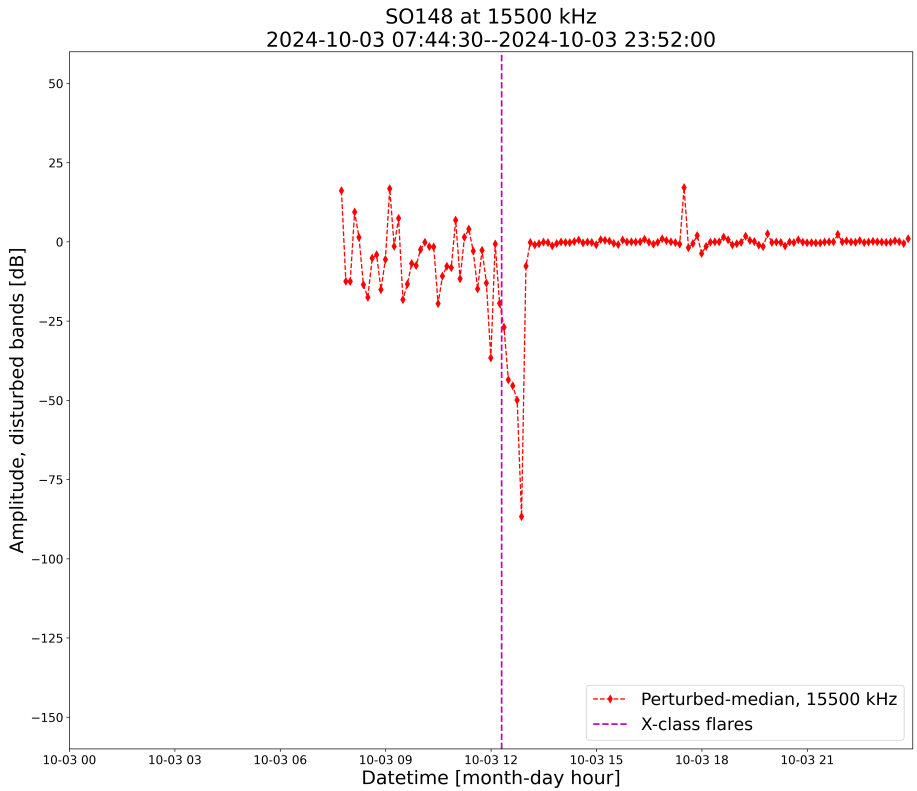




Solar flare effect on terrestrial HF noise

Zooming in on one frequency (15.5 MHz) with significant sky-wave noise.





Deviation from median at DB049 (left) and SO148 (right).

Summary & future work

The main conclusions:

1. Existing HF broadcasters can be used as beacons of opportunity to assess D-layer absorption.
2. Possibility for studies of quiet ionosphere as well as solar flare effects.

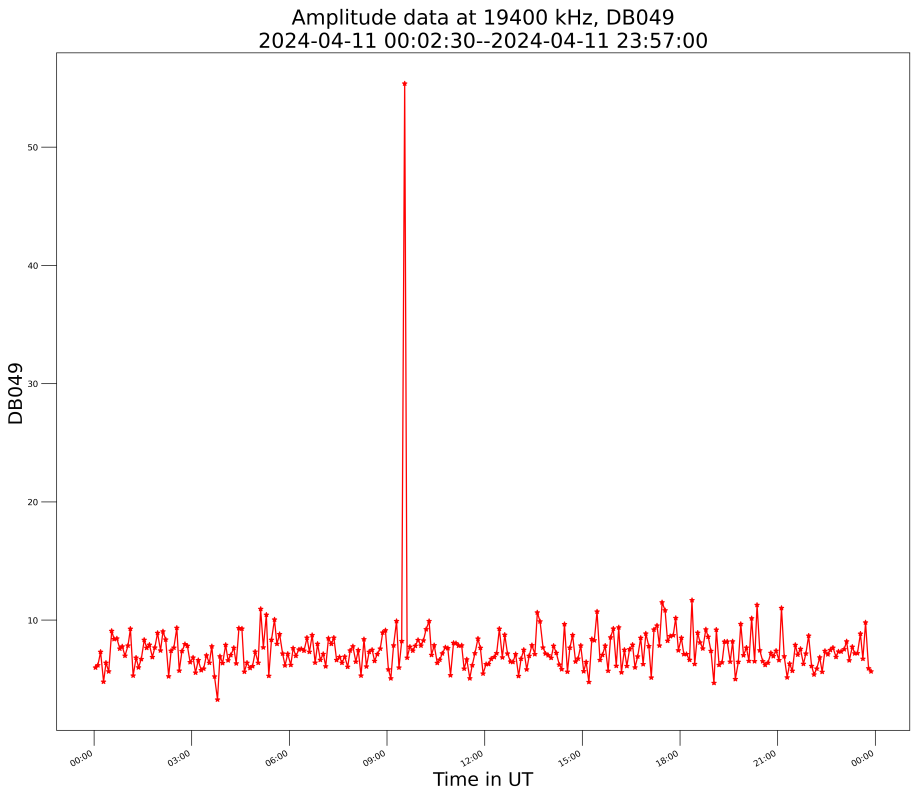
Future plans:

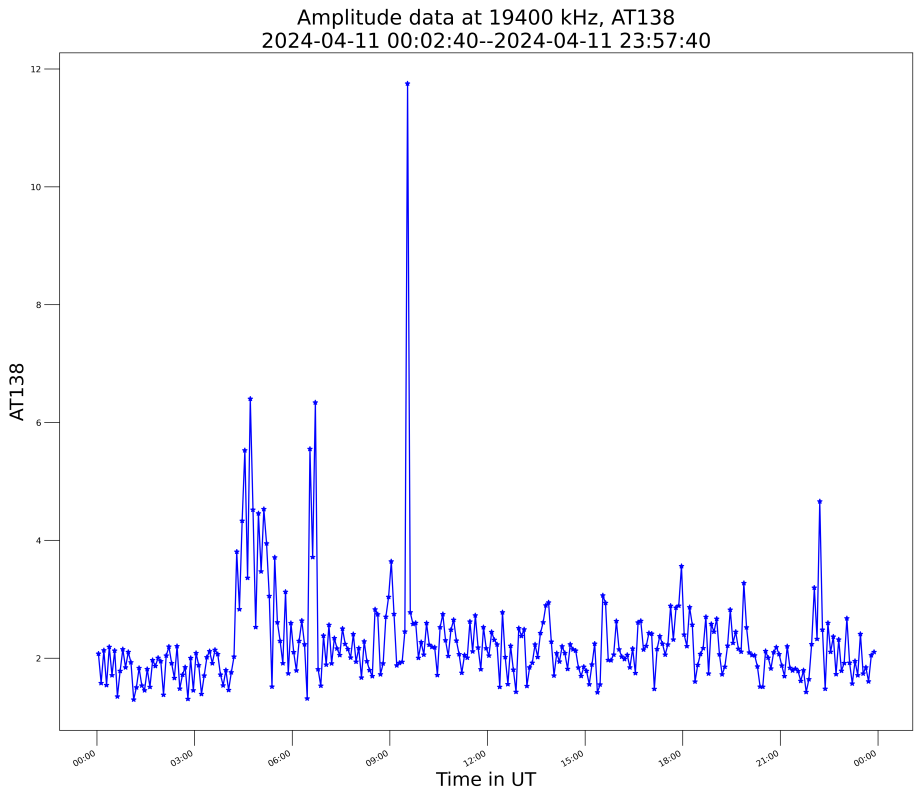
1. Establish detailed quiet-time diurnal variations in function of seasons/frequency.
2. Investigate the reason for quiet time patterns after sunset.
3. Compare effects of flares of different strengths at different frequencies.
4. Optimise instrument configuration & data processing for detecting sky-wave noise.

The end!

Questions, comments, suggestions?

Bonus slide





What is going on here? This spike was only seen at this frequency (19.4 MHz); DB049 and AT138 are 2000 km from each other.