Bottom-side drivers of ionospheric weather & mid-latitude impacts

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Role of the ionosphere and space weather in military communications

Solar-Terrestrial
Centre of
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Outline

1. Travelling ionospheric disturbances

2. Radio communication impacts
   - Impacts on HF systems
   - Impacts on trans-ionospheric signals

Travelling ionospheric disturbances

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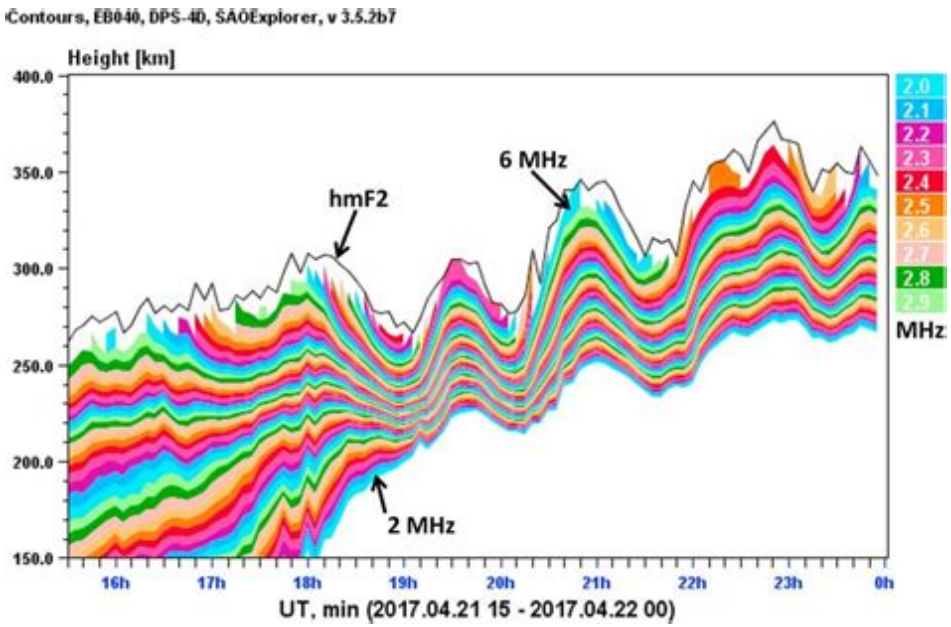
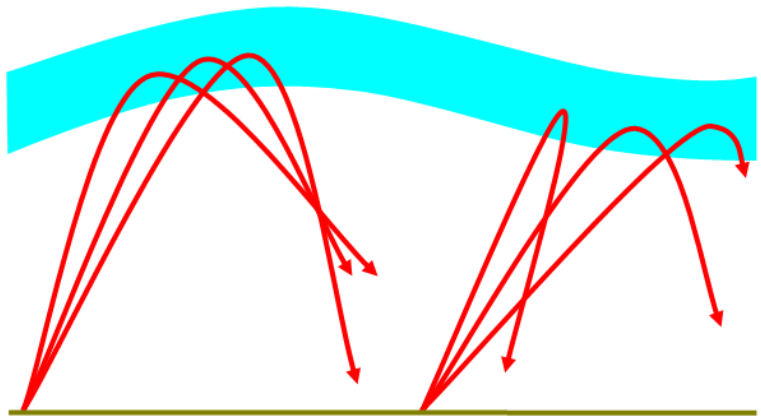
Travelling ionospheric disturbances are various kinds of waves affecting the ionospheric layers. They can move both horizontally and vertically.





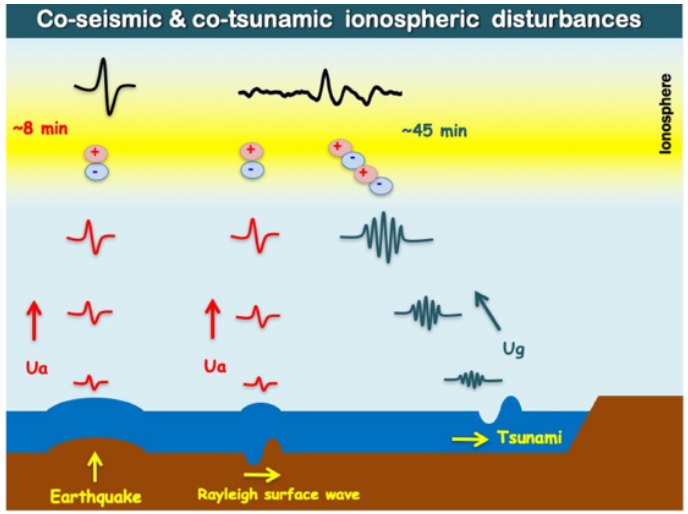
- Large scale TIDs: generally caused by geomagnetic storms, travel from auroral regions to low latitudes.
- Medium and small scale TIDs: often caused by atmospheric disturbances travelling up to thermosphere/ionosphere heights.

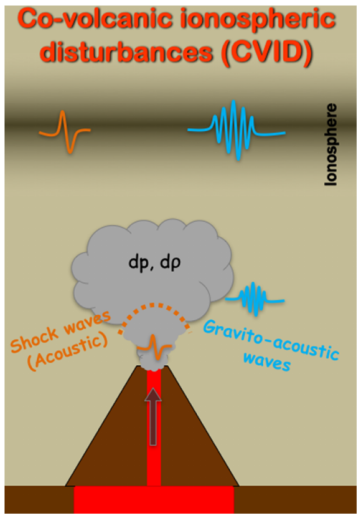
Generation of MSTIDs

A wide range of sources can produce atmospheric disturbances strong enough to reach the ionosphere:

- Impulsive natural events: earthquakes, volcanic eruptions...
- Man-made: very strong (nuclear) explosions, rocket launches.
- Severe (tropospheric) meteorological conditions.
- Sudden stratospheric warming events.
- Sudden heating at passing of solar terminator (also solar eclipses).
- ...

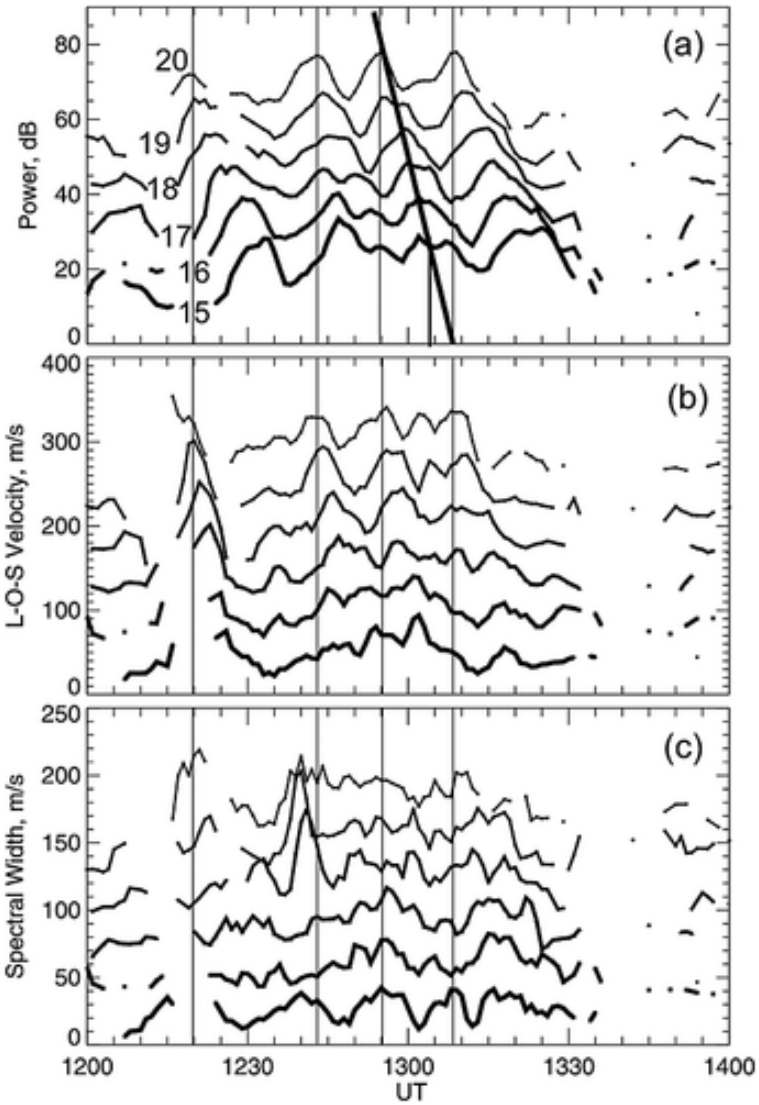
Often very difficult to predict; no fully operational monitoring is available yet.





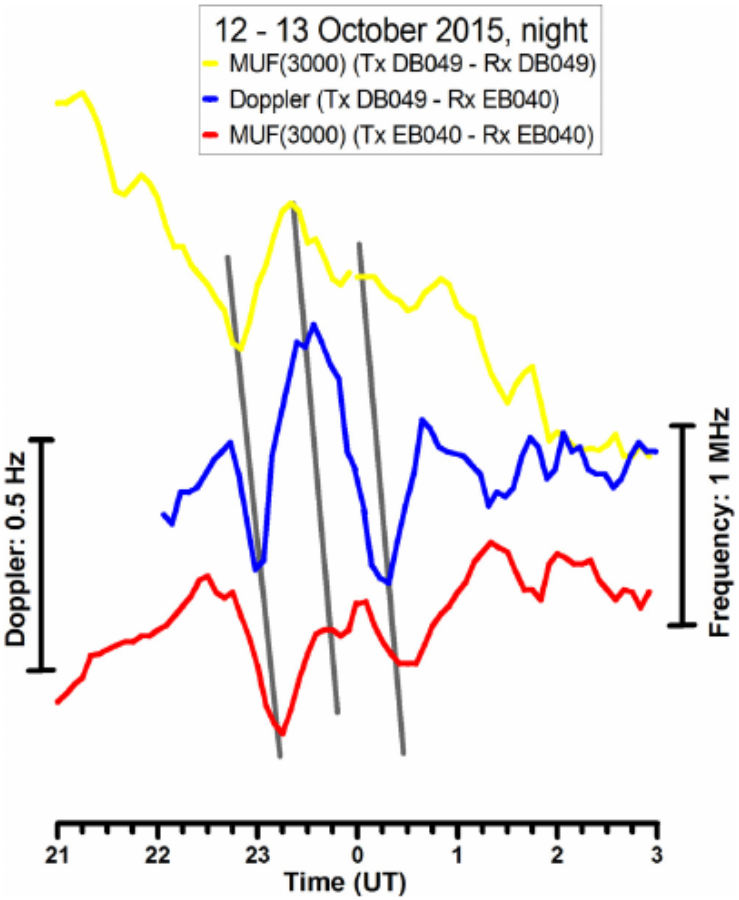
Radio communication impacts

TID effects on reflected HF signals



- Oscillations in the reflecting layer will cause variations in HF signal angle of arrival, Doppler, amplitude.
- Interference between different transmission paths leads to amplification or attenuation of signals.
- Especially a problem for directional system at short distances: *short range catastrophe*.

Why you should not use the MUF

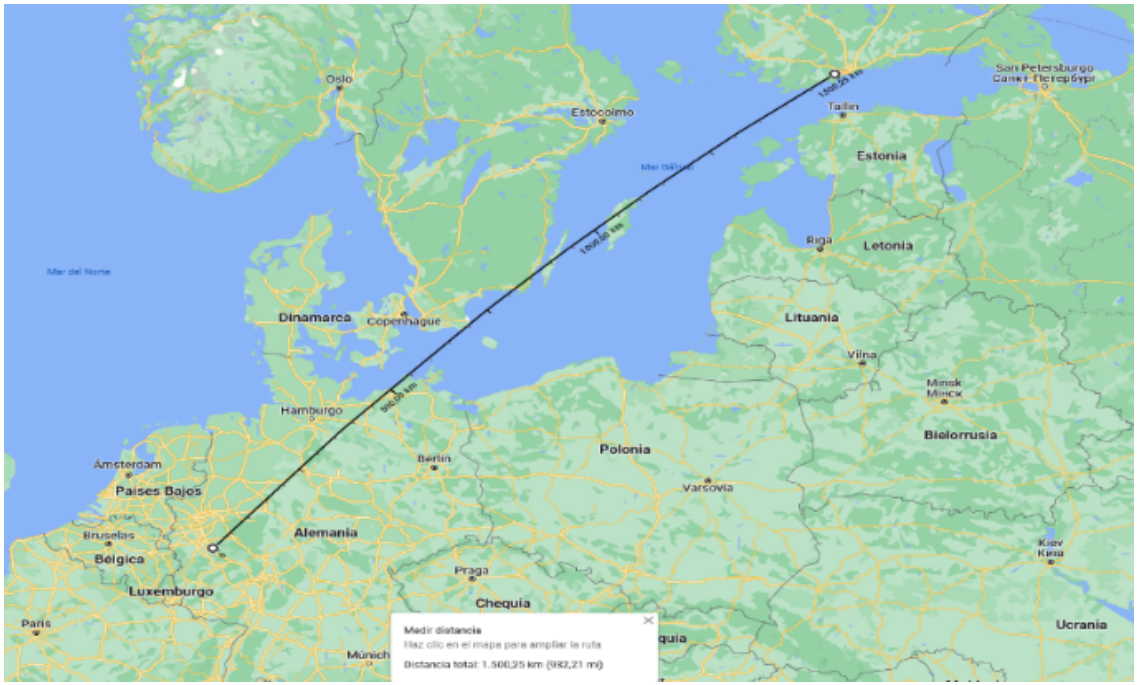


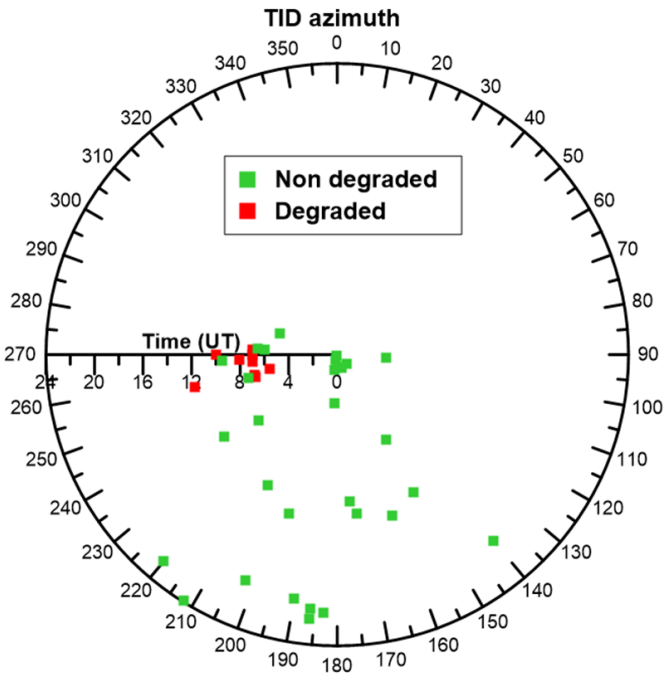
MUF depends on both hmF_2 and foF_2, making it extra sensitive to TIDs: variations can be over 1 MHz.

In practice you should always use somewhat lower frequencies.

Complications...

Whether or not a deformation of the reflecting layer will affect operations depends on the details of the geometry.

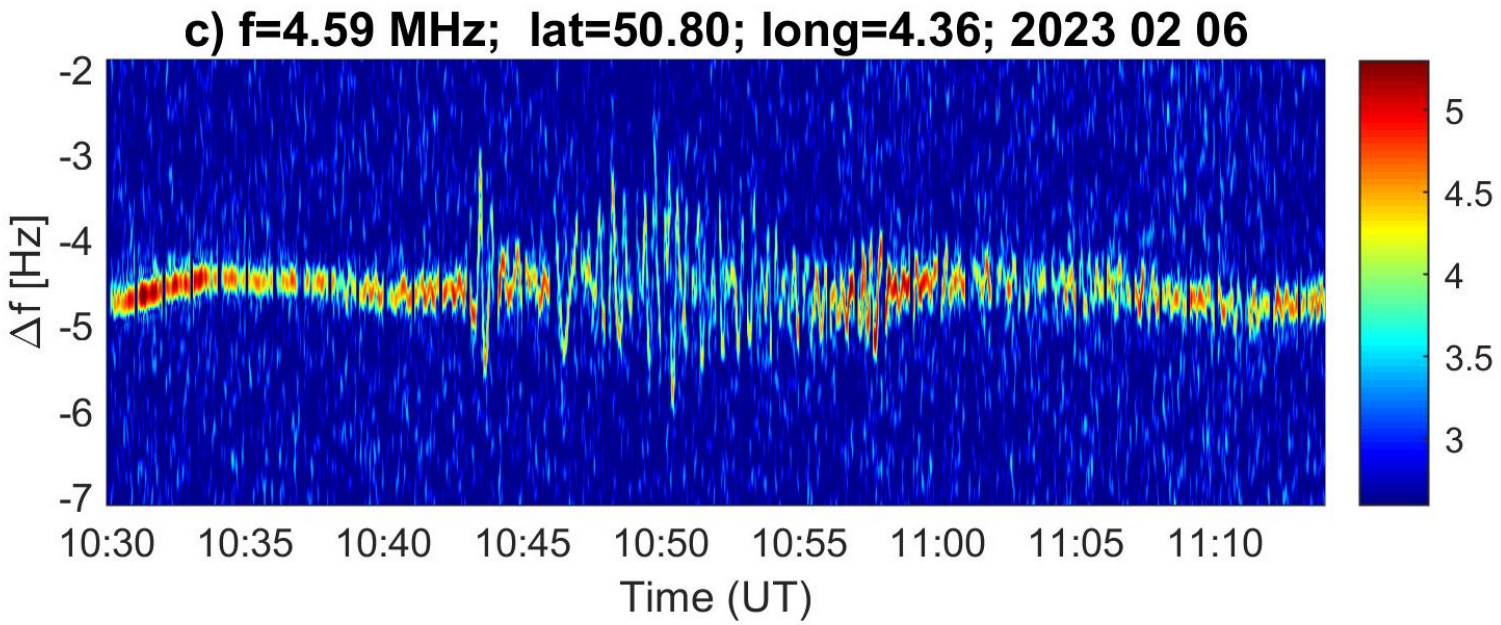




This is still a major topic of ongoing research...

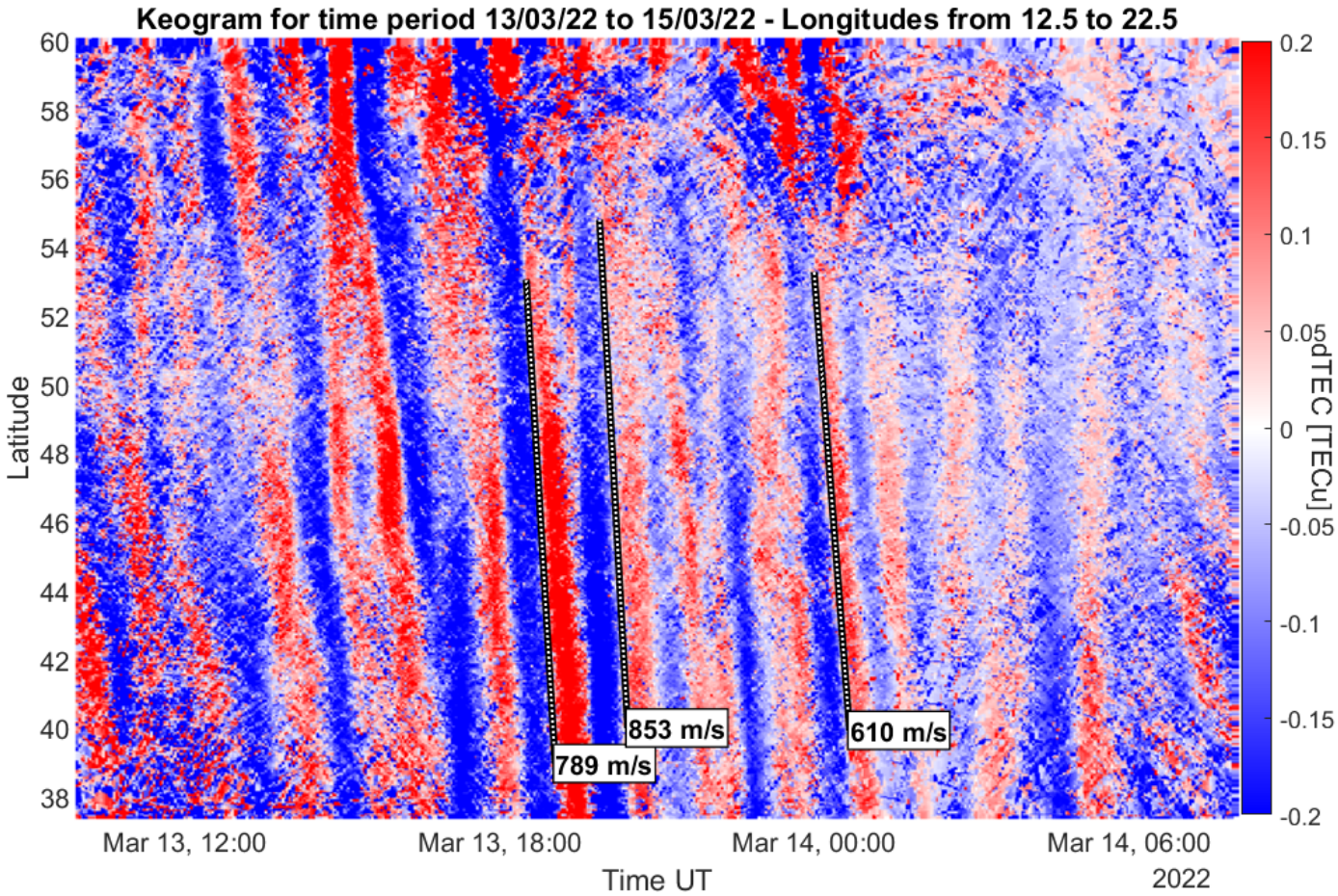
Even smaller scales

Small-amplitude disturbances are present down to shorter time-scales, *e.g.* infrasound.



Those very short disturbances may not cause major problems for most practical applications.

Impacts on trans-ionospheric signals



The delay experienced by trans-ionospheric signals is also affected by travelling disturbances. However: more a problem for GNSS and SAR than for communication, if high precision timing is not important.

Summary

1. Disturbances on the ground and in lower atmosphere can propagate up, causing perturbations in the lower ionosphere.
2. For HF systems, this can cause large deviations from expected propagation paths.
3. For trans-ionospheric signals, also some disturbances (but probably not important for communication systems).

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The end!

Questions?