

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

Tobias G.W. Verhulst

STCE – Royal Meteorological Institute of Belgium

Role of the ionosphere and space weather in military communications



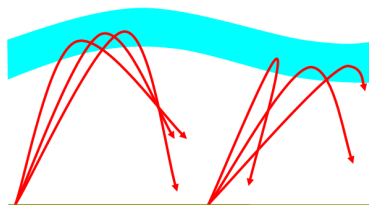
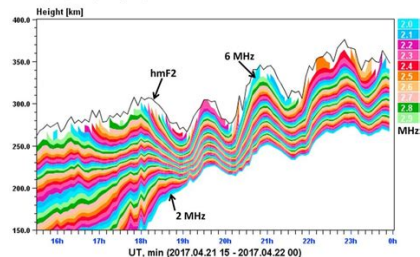
- 1 Travelling ionospheric disturbances
- 2 Radio communication impacts
 - Impacts on HF systems
 - Impacts on trans-ionospheric signals

Travelling ionospheric disturbances

Travelling ionospheric disturbances

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

Cortours, EB44, DPS-40, SAOExplorer, v 3.5.2b7



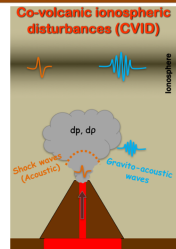
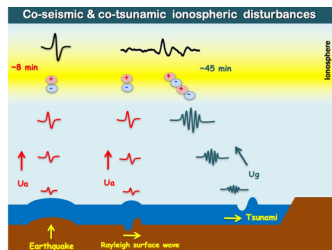
- Large scale TIDs ($\lambda \approx 1000$ km, $T =$ hours): generally caused by geomagnetic storms, travel from auroral regions to low latitudes.
- Medium and small scale TIDs ($\lambda =$ hundreds km, $T =$ tens min.): often caused by atmospheric disturbances travelling up to thermosphere/ionosphere heights.

Generation of MSTIDs

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

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

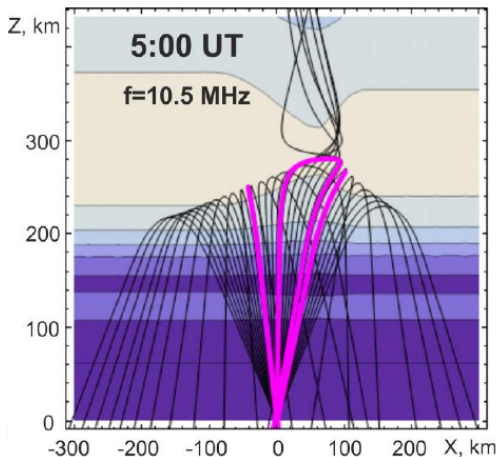
Often very difficult to predict; or even to detect...



Radio communication impacts

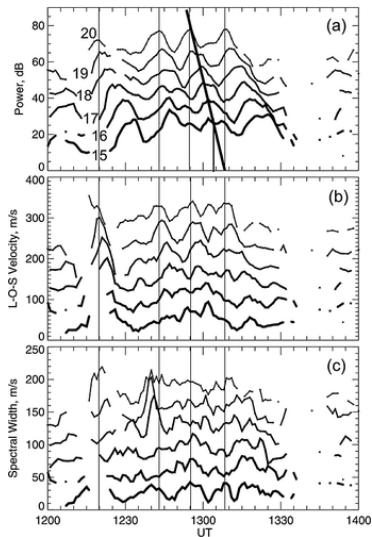
Reality get more complex

This is already looking complicated:



But now the irregularity will also move!

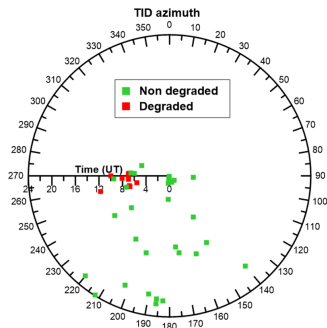
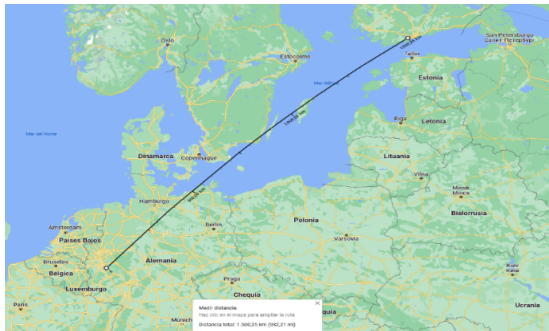
TID effects on reflected HF signals



- 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*.

Further complications...

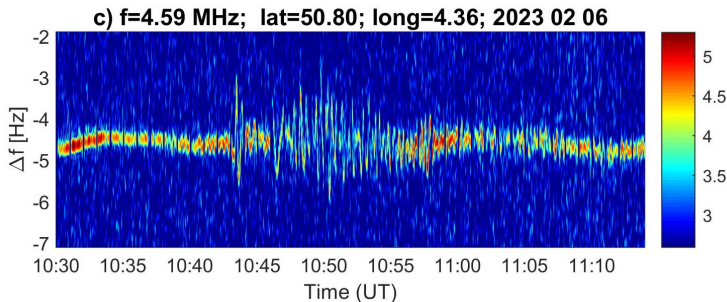
Whether or not a deformation of the reflecting layer will affect operations depends on the details of the geometry.



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

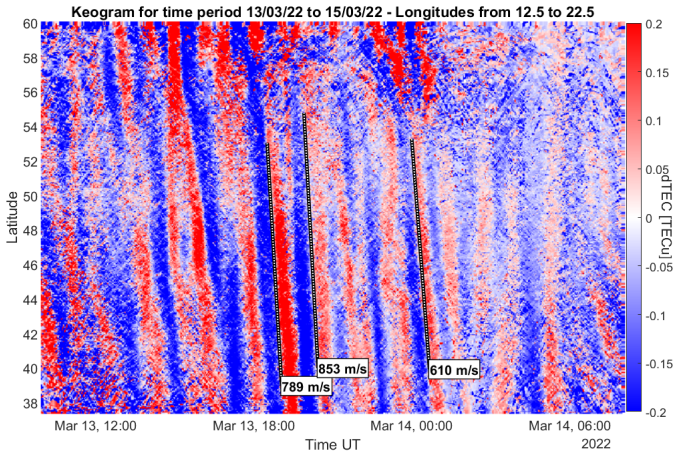
Even smaller scales

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.

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- 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?