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Overview of the TechTIDE project: Warning and Mitigation Technologies for Travelling Ionospheric Identification Effects

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and TechTIDE Consortium (www.tech-tide.eu)

Why do we care about TIDs

TIDs affect all services that rely on predictable ionospheric radio wave propagation.

- HF Geolocation
- HF Communication
- GNSS, Satellite communication, SBAS
- Explosion monitoring

- Large scale TIDs propagate with wavelengths of 1000 - 3000 km, velocity of 300 – 1000 m/s and **amplitude grater than 5-10 TECU**. LSTIDs are associated with auroral and geomagnetic activity
- Medium scale TIDs propagate with wavelength of 100-300 km, velocity of 100m/s and **amplitude of 1 TEC, occasionally 10 TECU**. MSTIDs are mostly associated with ionospheric coupling from below, no clear correlation with geomagnetic activity.

TechTIDE consortium

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EC H2020 COMPET
Space Weather Call
2017

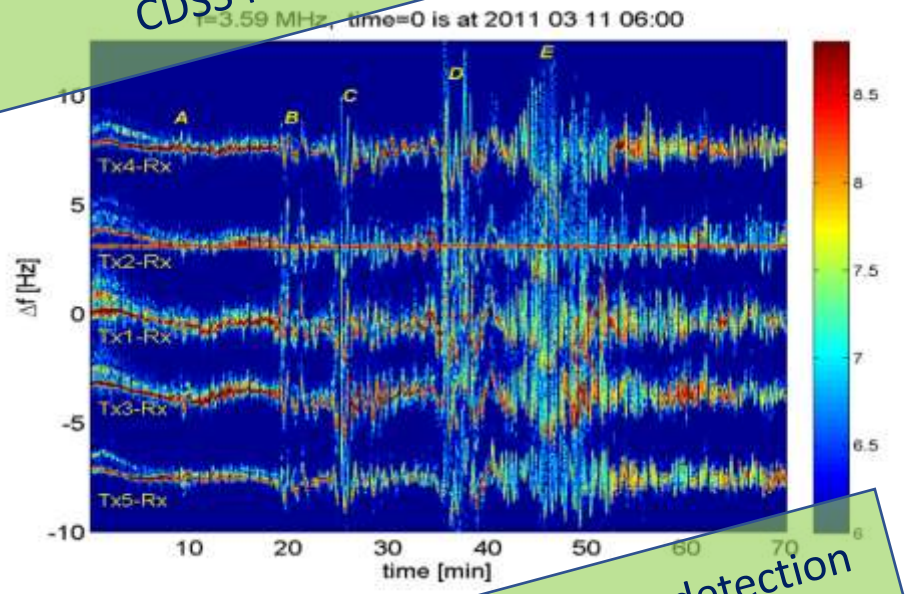
- National Observatory of Athens (NOA), Greece
- Deutsches Zentrum für Luft- und Raumfahrt (DLR), Germany
- Ustav Fyziky Atmosfery AV CR (IAP), Czech Republic

The overarching objective of TechTIDE is to design and test new viable TID impact mitigation strategies for the technologies affected by the TIDs and in close collaboration with operators of these technologies, to demonstrate the added value of the proposed mitigation techniques which are based on TechTIDE products.

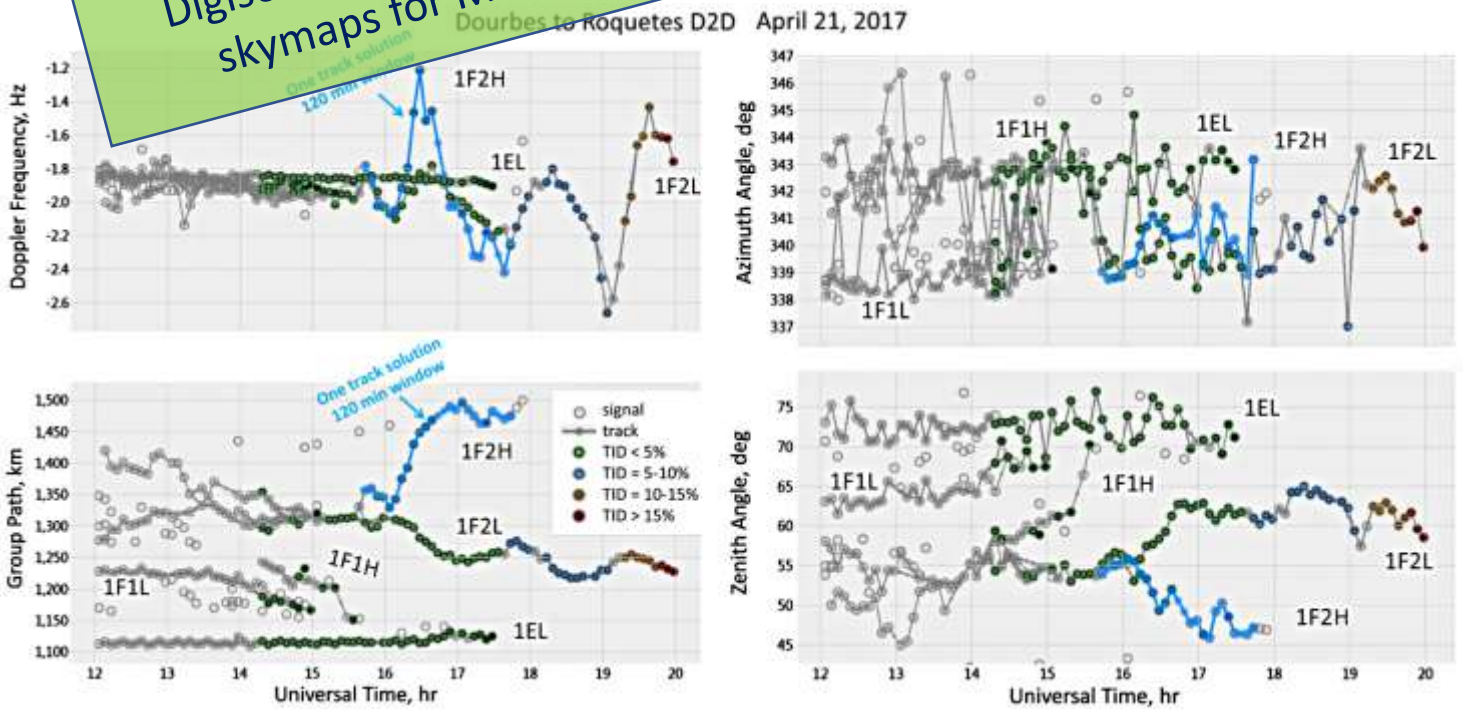
- ...NSULT), France
- Frederick University (FU), Cyprus
- German Federal Police (GFP), Germany

How to detect TIDs?

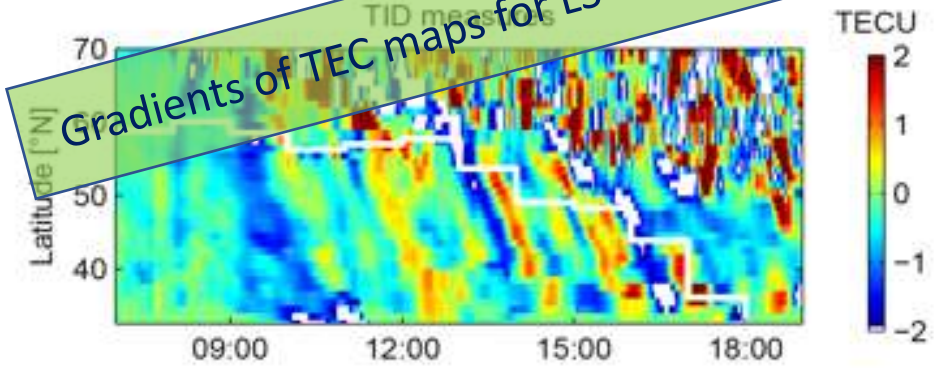
CDSS for MS TID detection



Digisonde – to – Digisonde (D2D) oblique skymaps for MS and LS TID detection



Gradients of TEC maps for LS TID detection



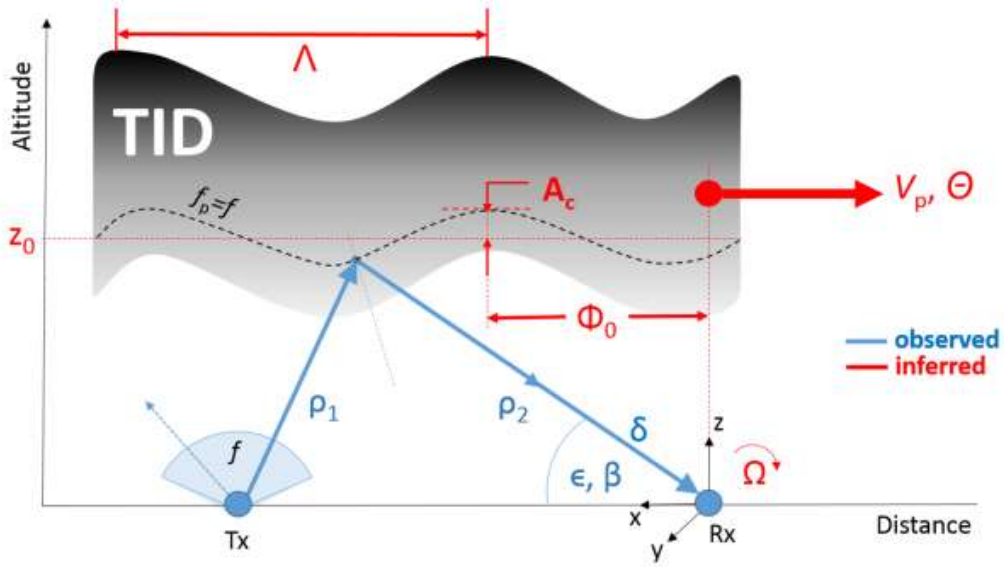
Considerations

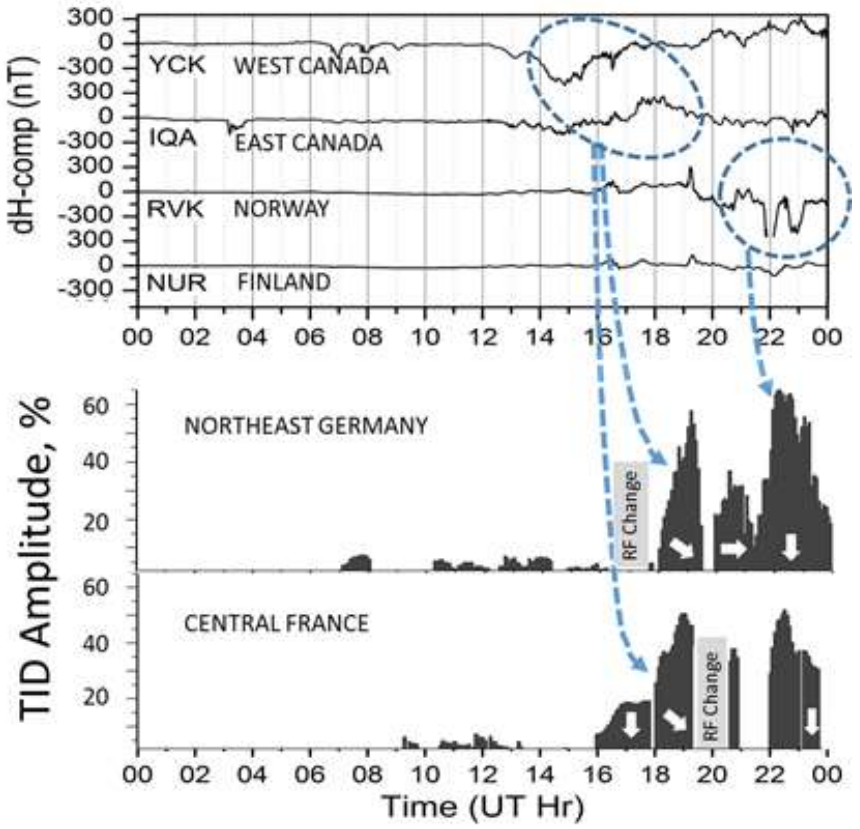
- Each method has advantages and constraints considering the users' requirements:
  - Timeliness: Real-time detection
  - Geographic coverage: local, regional
  - Prediction capability: nowcasting and forecasting
  - Amplitude of perturbation: MS and LS
  - Observed parameter that is perturbed due to TIDs: TEC, Ne(h), HF signal deviation in respect to expected conditions (angles of arrival, Doppler shift)
- There is no method to satisfy all the criteria.
- A combined analysis of results from various methodologies is used to extract a comprehensive information required by the users

TID methodologies for direct identification – D2D

HF-TID method (Reinisch et al., 2018; Huang et al., 2016; Belehaki et al., 2015)

The method is based on the real-time analysis of remote-sensing data from synchronized, network coordinated HF soundings between pairs of DPS4Ds





The method detects **perturbations in space from all possible sources** (solar and lower atmosphere origin) and it is suitable for the identification of **both MS and LS TIDs.**

Input: signal characteristics from Digisonde synchronized operation.

Output: TID velocity, amplitude, propagation direction at the signal reflection point between the stations

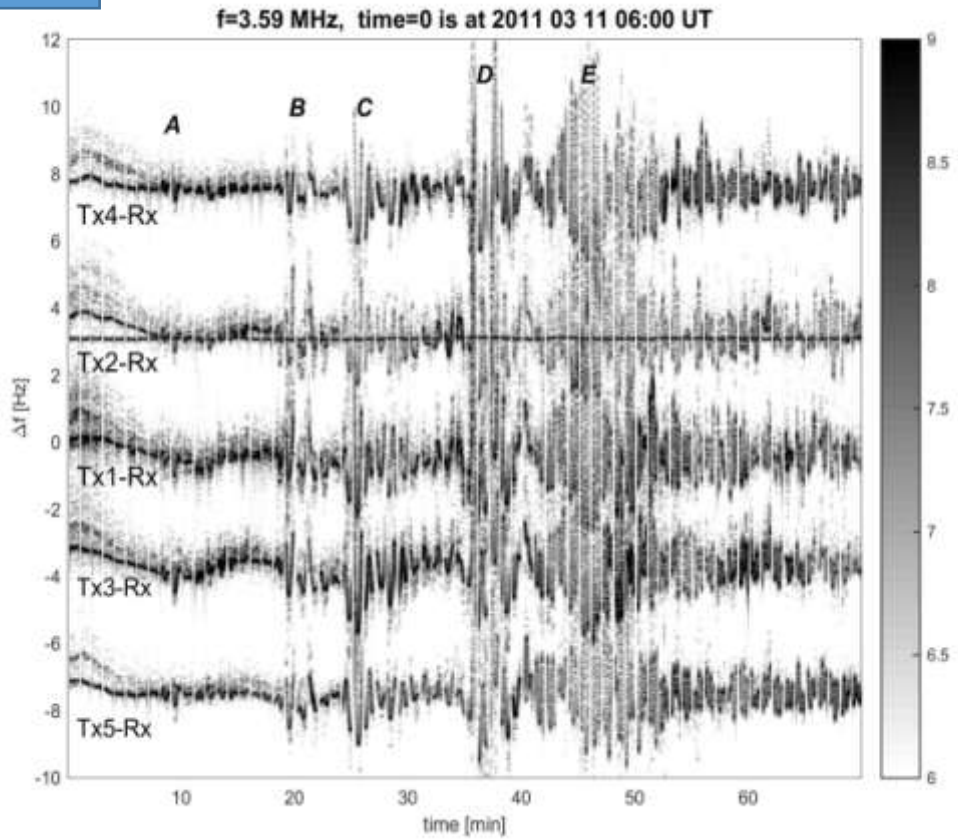
TID methodologies for direct identification - CDSS

CDSS-MSTID detection method (Lastovicka and Chum, 2017)

CDSS method identifies perturbations in space mainly caused by MSTIDs; while it is less sensitive in LSTIDs. The method has been tested with historical data from the networks operated in Europe and S. Africa.

Input: CDSS reflected signals and critical ionospheric characteristics and irregularities (such as spread-F conditions).

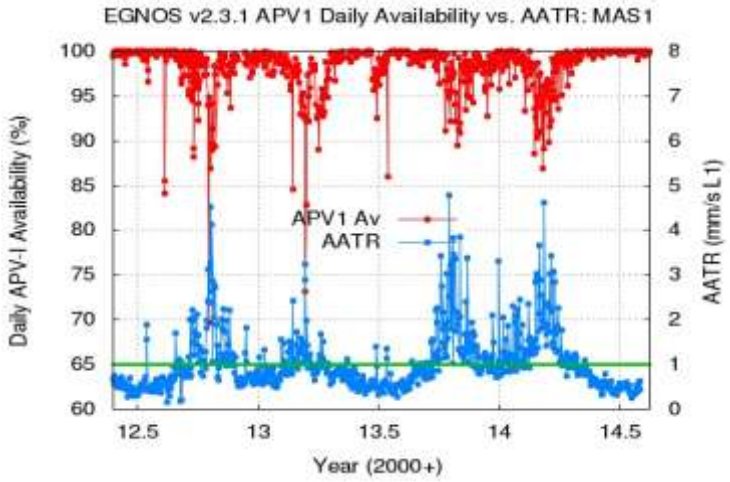
Output: Doppler shifts and evaluation of the signal to noise ratio to provide a confidence level.



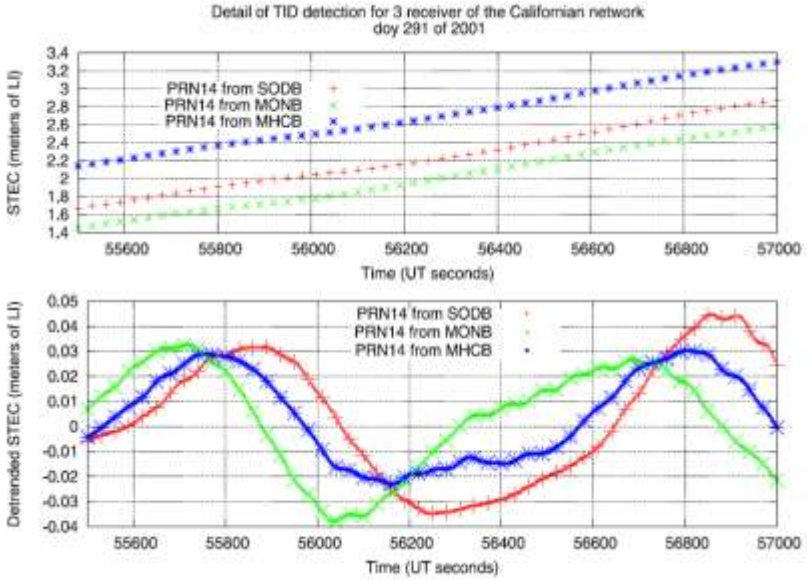
In TechTIDE the CDSS method will be implemented in real-time operation and we expect to have a near-real time system to provide warnings for MSTID activity.

TID verification methodologies: based on GNSS TEC

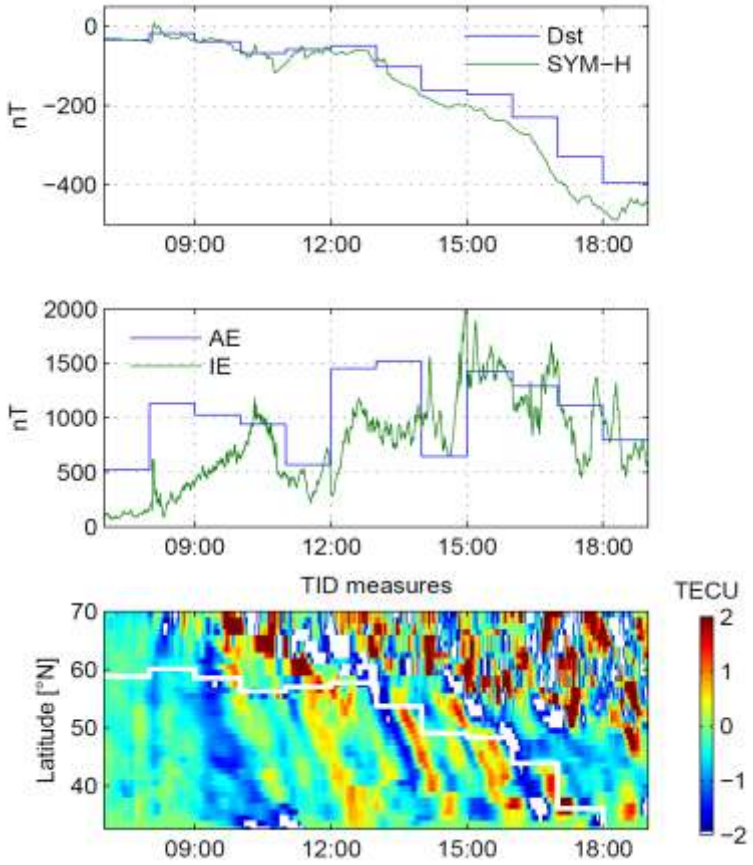
Along Arc TEC Rate (AATR) indicator (Sanz et al., 2014)



Spatial and Temporal GNSS analysis: (Hernández-Pajares et al., 2006)

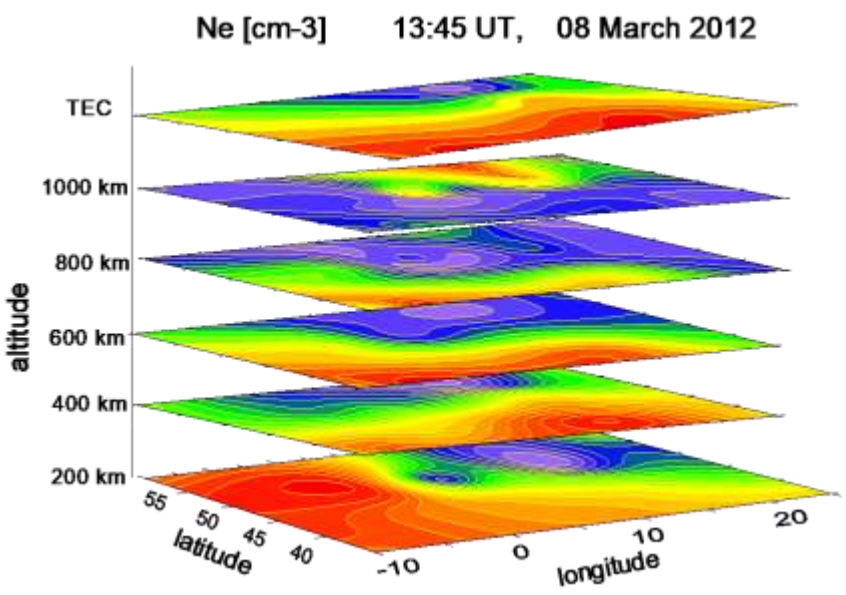


GNSS TEC gradient method: (Borries et al. 2017)

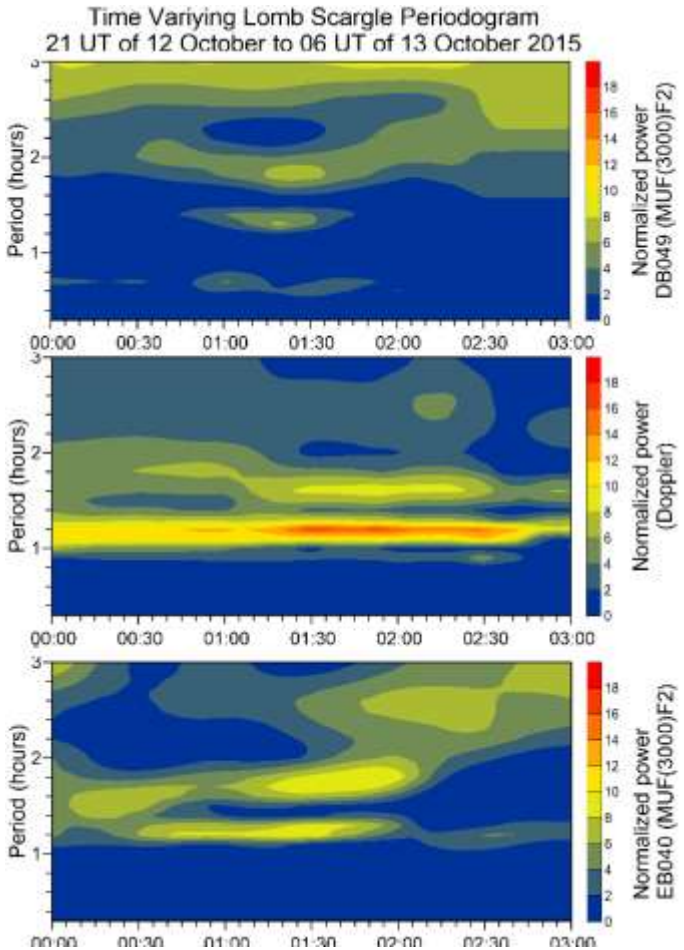


TID verification methodologies: based on DPS VI data

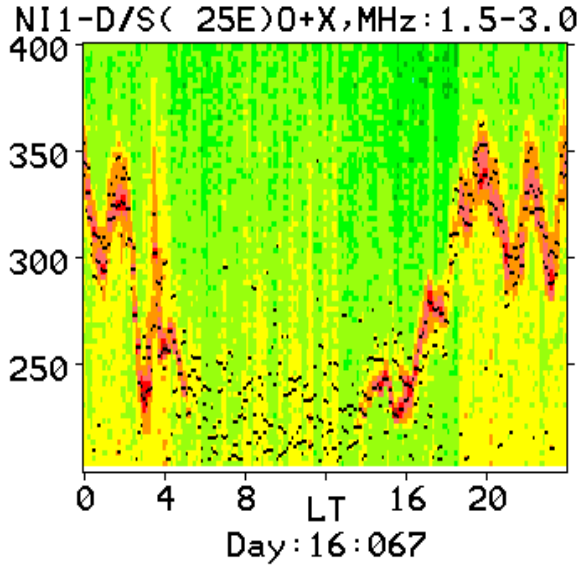
TaD 3D mapping of the electron density:
(Kutiev, et al, 2016)



HF Interferometry method
(Altadill et al., 2017)

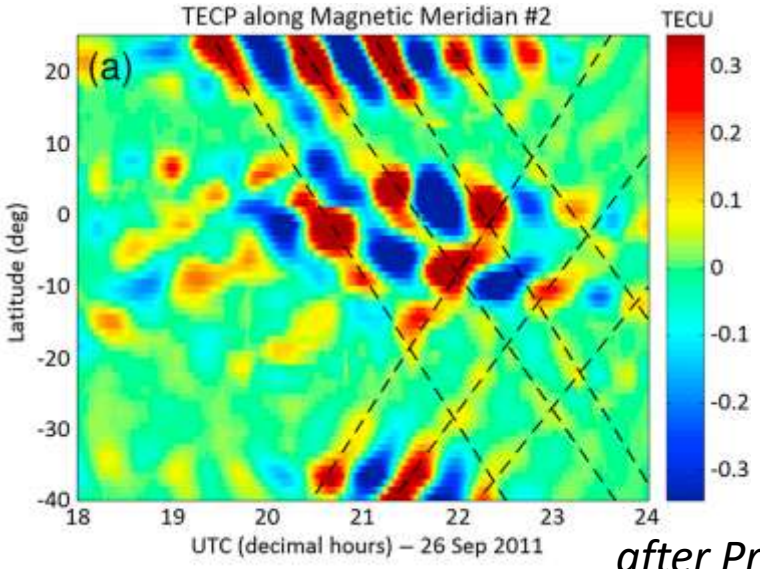


Height-Time reflection Intensity (HTI_ method: Spectral analysis can infer the periodicity of the dominant wave activity over each station.
(Haldoupis, Haralambous et al., 2006)

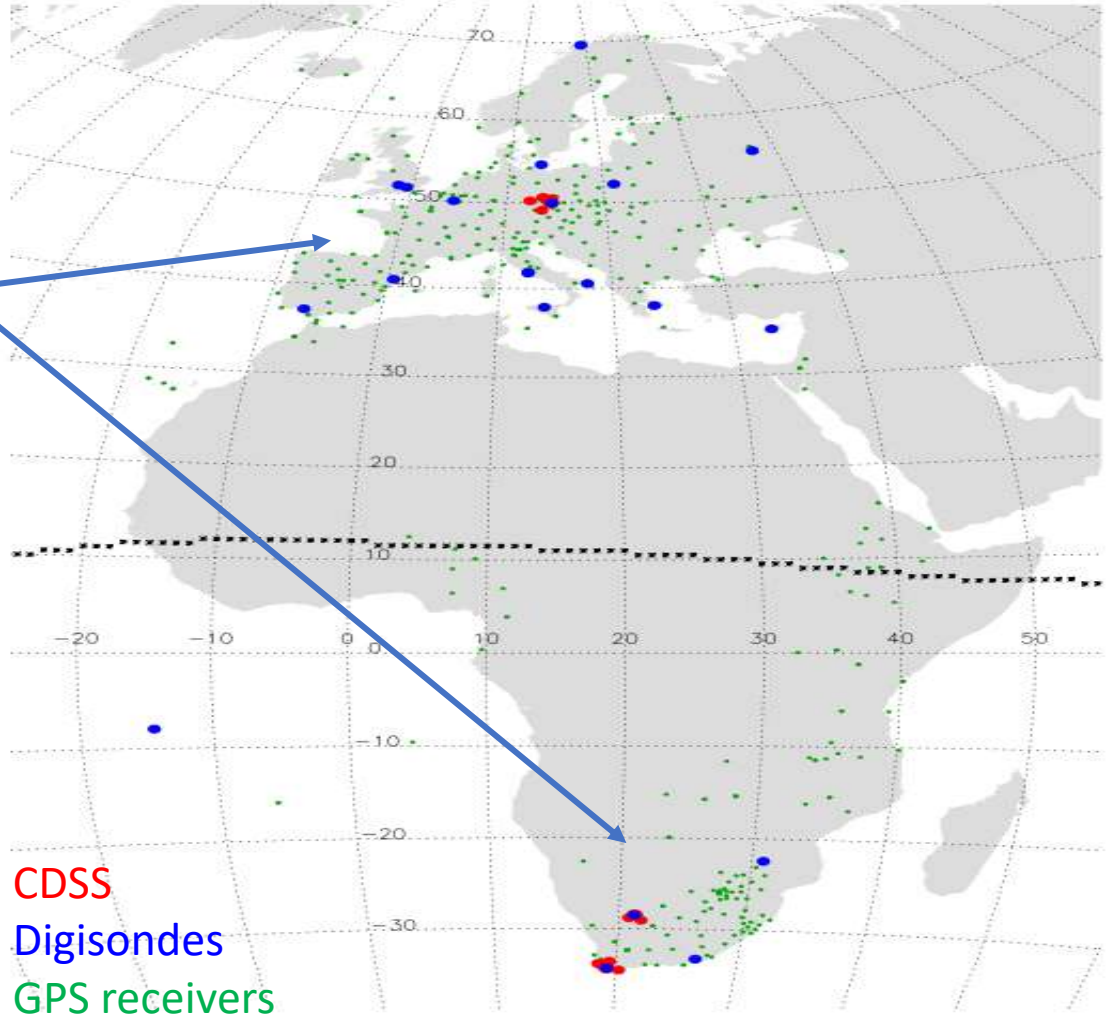


The basic network of TechTIDE monitoring stations

Similar monitoring facilities operate in Europe and South African regions, allowing detection of TIDs simultaneously in the two hemispheres



after Pradipta et al., 2016



TechTIDE key milestones

- January 2019: TID identification codes, open access, in TechTIDE repository -> www.tech-tide.eu
- April 2019: Release of the first TechTIDE system
- May 2019: Organization of the 1st TechTIDE users' workshop
- October 2019: Release of the second TechTIDE system + 2nd TechTIDE users' workshop
- April 2020: Release of the final TechTIDE system + 3rd TechTIDE users' workshop

TechTIDE Project

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