

IONOSPHERIC ANOMALIES ASSOCIATED WITH EARTHQUAKES



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The objective of this research is
to identify the occurrence of
ionospheric irregularities before
large earthquakes.

Search relevance

There is evidence of the possibility of predicting earthquakes, one of them is in the GPS tool that shows us great results in the VTEC fluctuation before great earthquakes and the correlation of gravity waves in these fluctuations.

Other information

- 1) The gases released from the ground during the movements before the great seismic shock modulate the properties of all atmosphere.
- 2) Soil movements excite gravity waves that propagate upwards.
- 3) Changes in geoelectric potential.
- 4) Underground electrical currents (before and after).

Methodology

GPS
Data Rinex
Ephemerides



Program LPIM
TEC - VTEC

Python

Average quiet days
upper and lower wrap
VTEC off the wrap, we
have anomalies

Fluctuation of VTEC
Suggests gravity waves
(Wavelet)

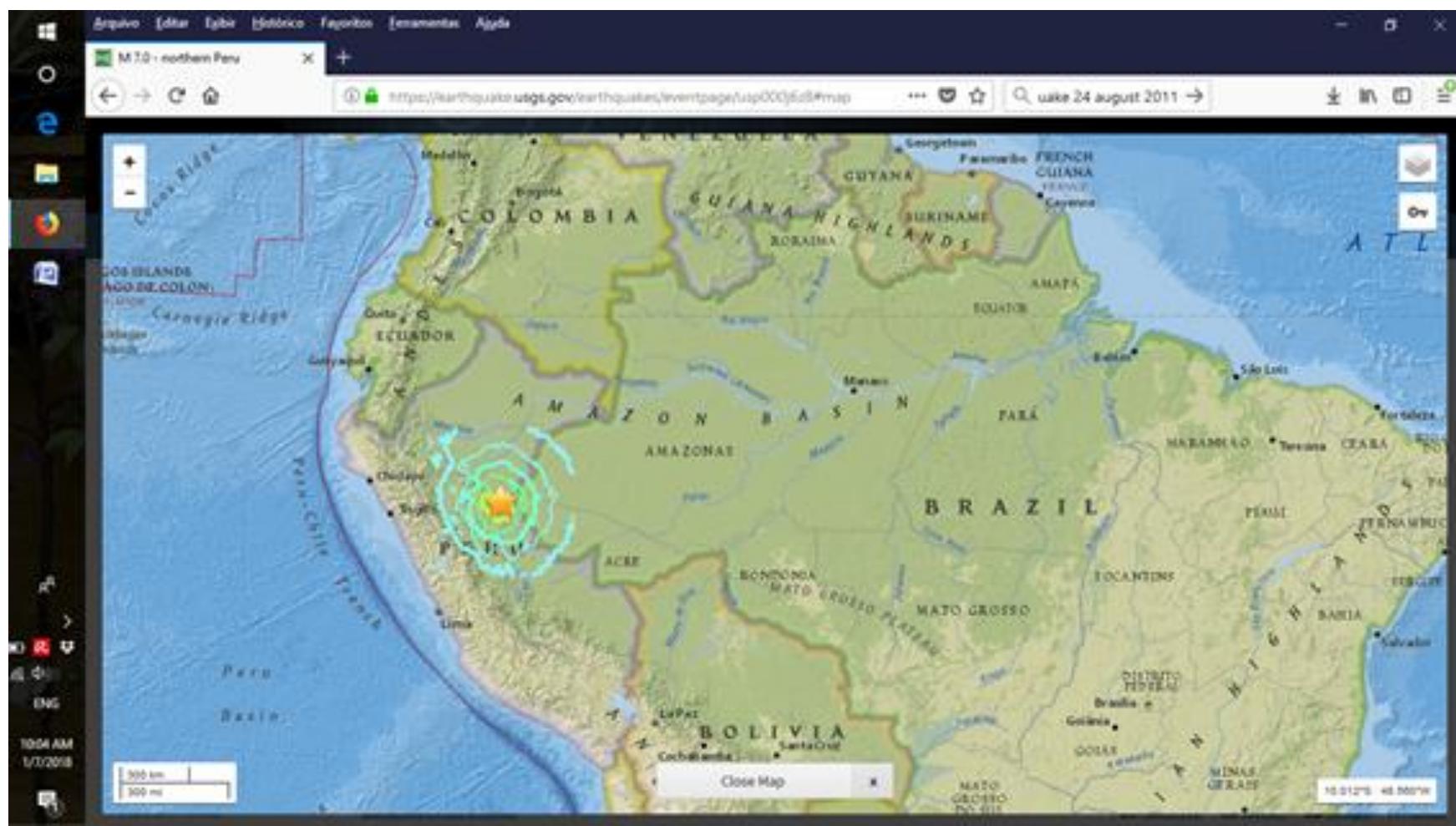
Earthquake analyzed

- Country: Peru
- Date: August 24, 2011
- Time: 17:46 UTC
- Magnitude 7.0
- Epicenter: Near the city of Pucallpa
- East Center of Peru - Amazonian Plain
- Depth: 145,1 Km
- Day 236

GPS receivers used (IGS Network)

- Riop (Riobamba – Ecuador)
- Qui3 (Quito – Ecuador)
- **Areq (Arequipa – Peru)**
- Bgta (Bogotá – Colômbia)

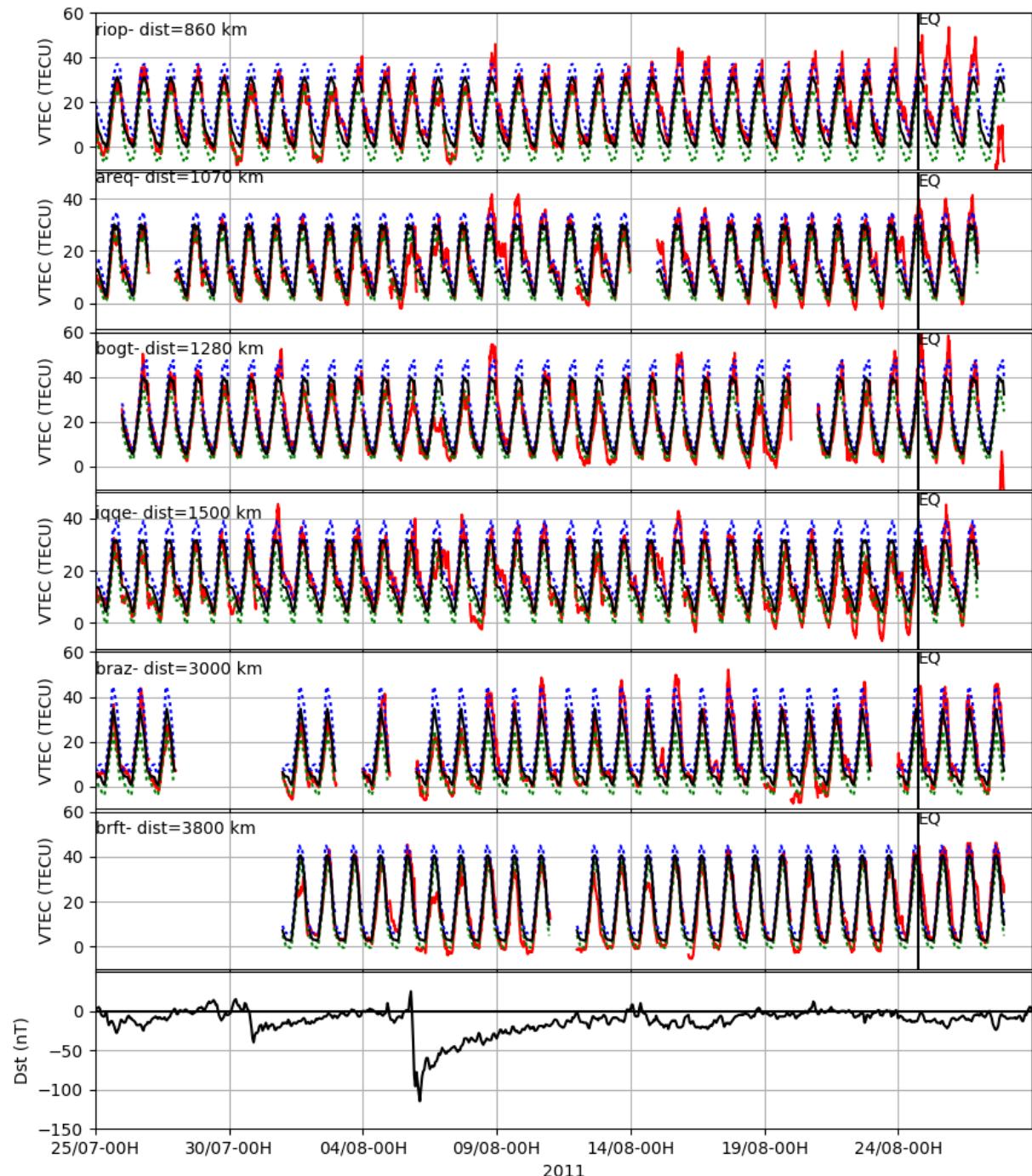
Earthquake location



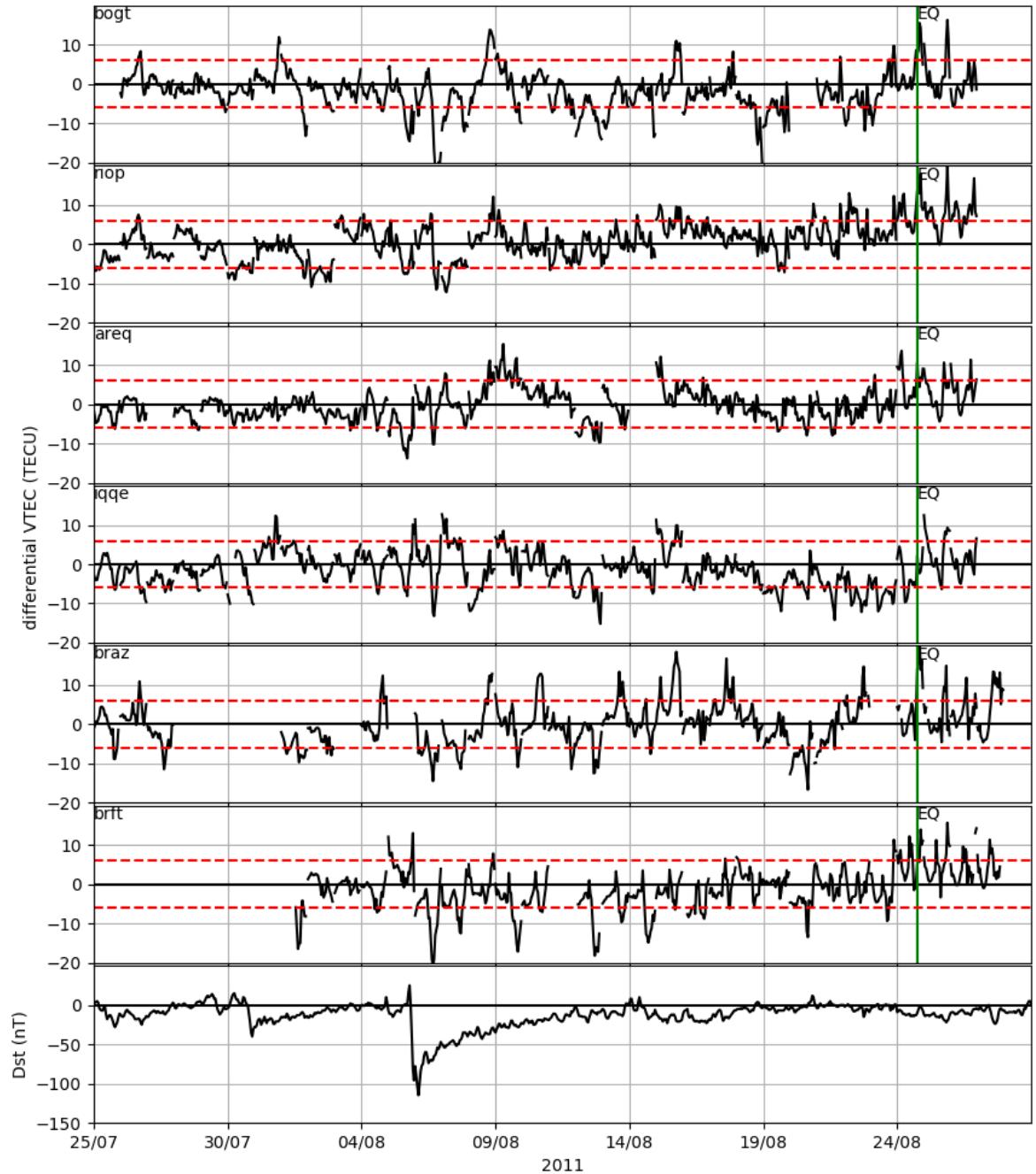
Preliminary results

Graphic 1

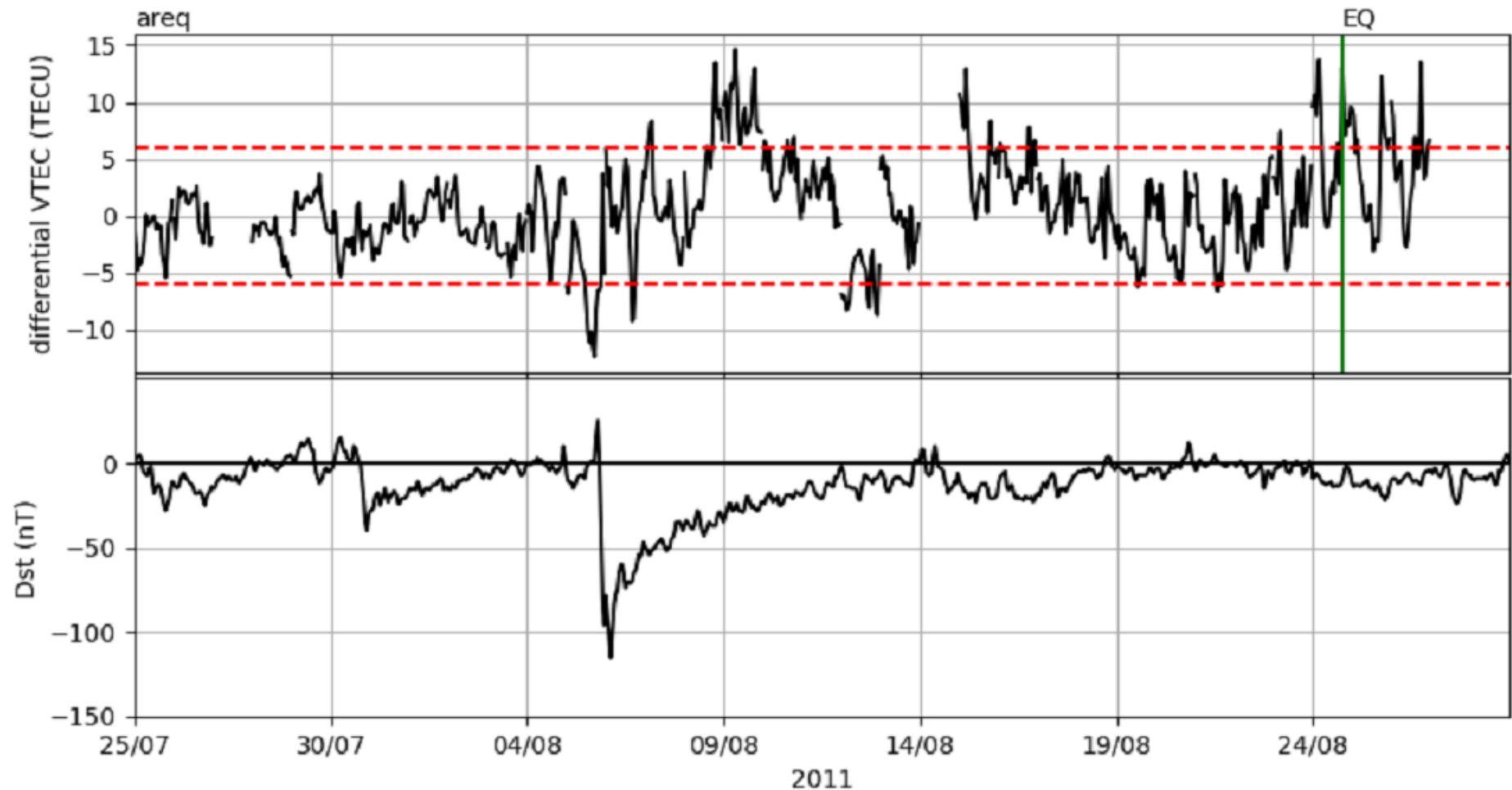
The following graph used the VTEC fluctuations to plot a mean of the calm days (black line), with upper wrap in blue color and lower in green, using a data dispersion (RMS - PYTHON). What is inside the wrappings will be considered normal behavior of the VTEC for that region, the red color is the line of observation, where you can see the exits of the wrappings, thus considering an unusual VTEC fluctuation, which may indicate a precursor of an earthquake. We used data from several GPS receivers near the epicenter. The RIOP station (Riobamba - Ecuador) 860 km from the epicenter shows fluctuations of the VTEC a few days before the earthquake. Another factor is to observe the DST index (nT) indicating the arrival of a geomagnetic storm that may cause fluctuations in the VTEC.



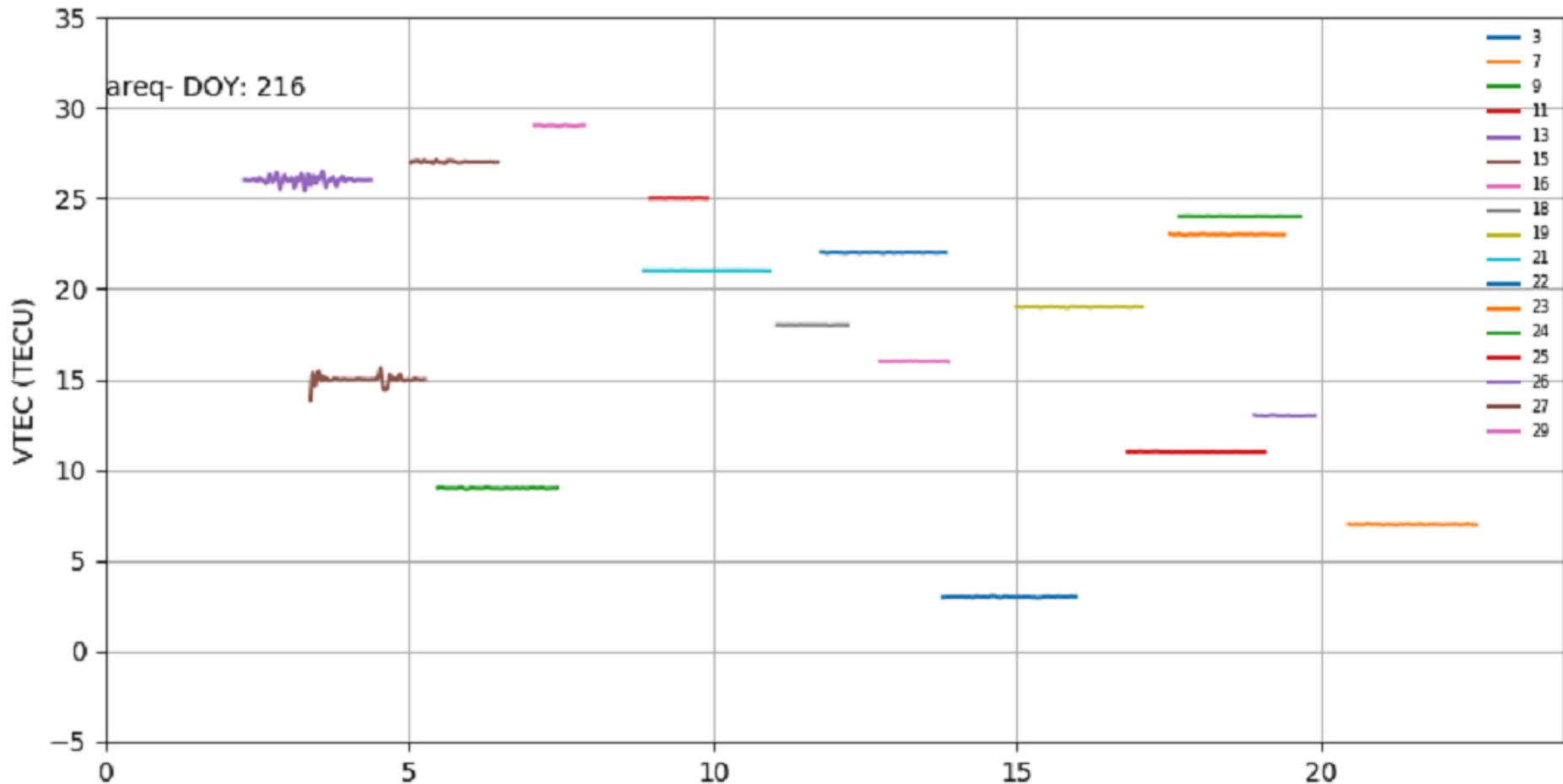
Graphic 1 presented otherwise, red dashed lines are the upper and lower envelopes, facilitating the display.



Zoom receiver Areq

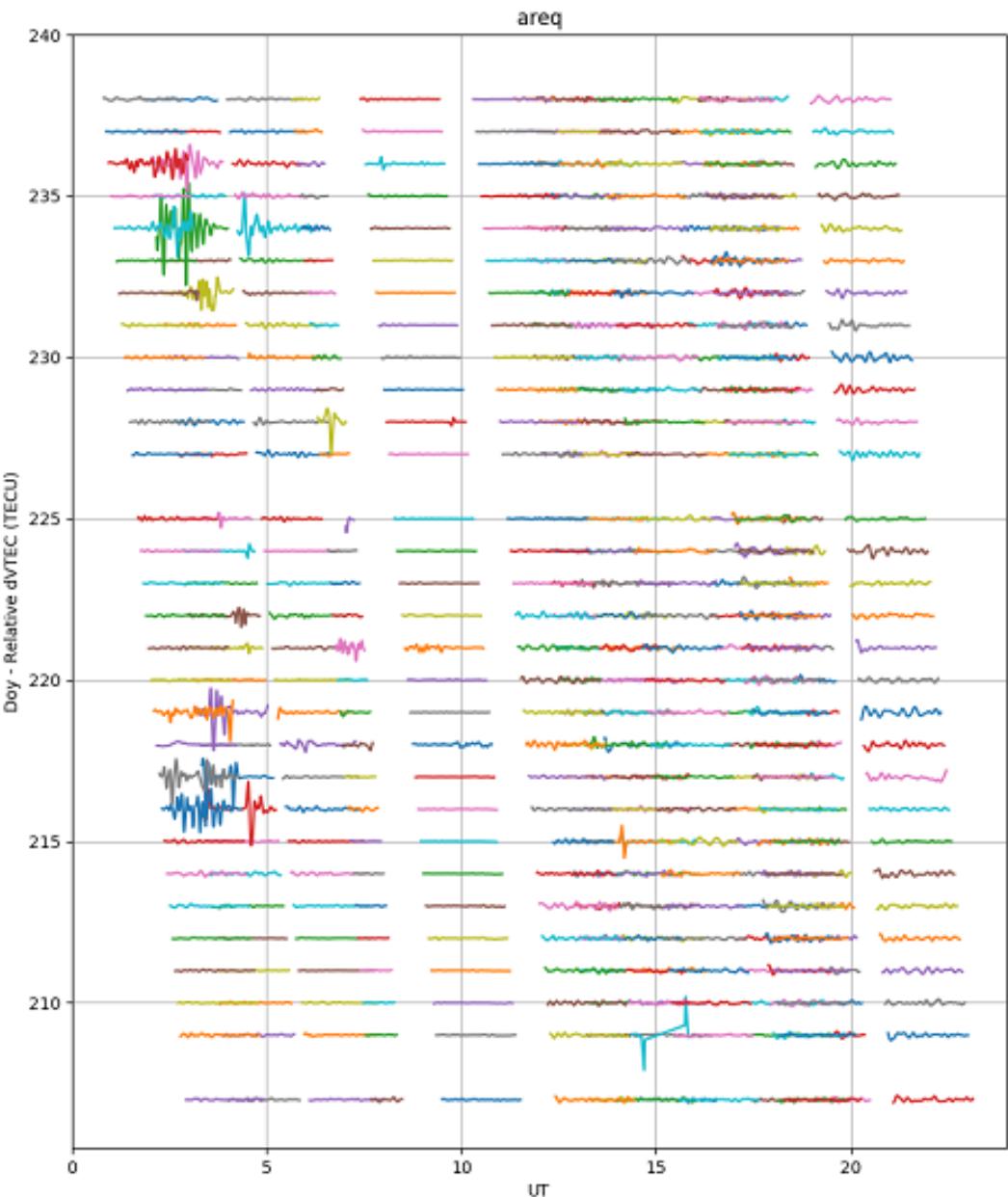


Each color represents a satellite

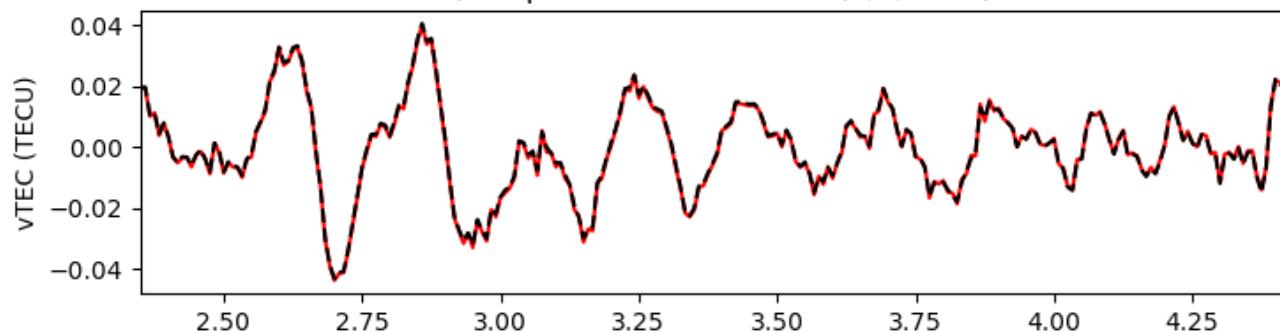


Receiver Areq (Arequipa - Peru)

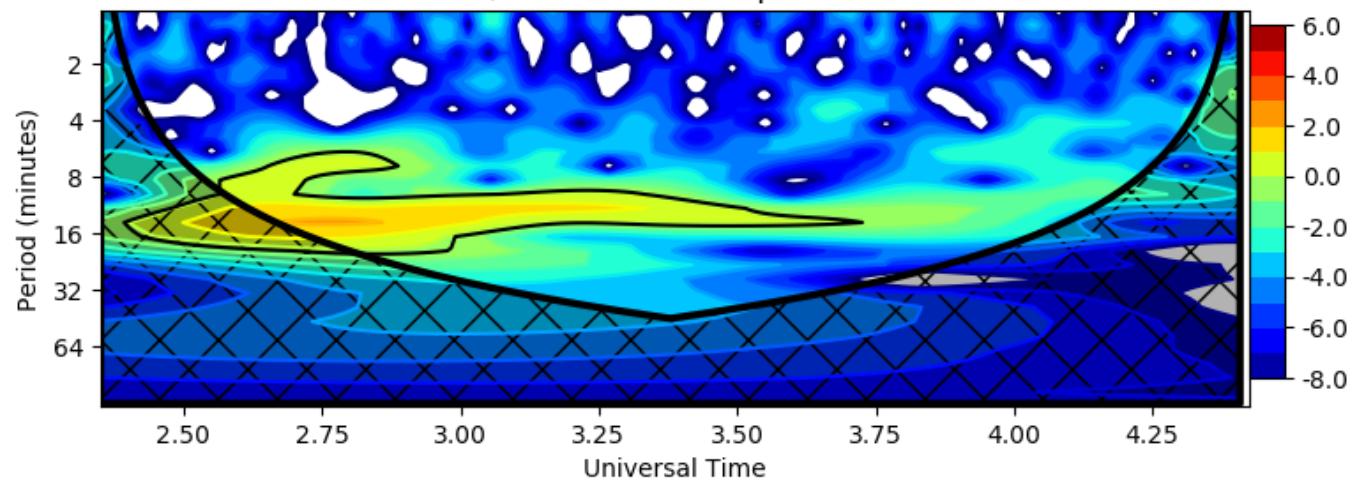
- Doy 216 Geomagnetic storm.
- Doy 234 fluctuations suggests GW
- Doy 236 fluctuations suggests GW before earthquakes



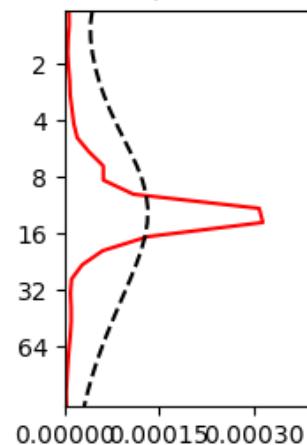
a)areq - PRN:26 DOY: 215 (3/8/2011)



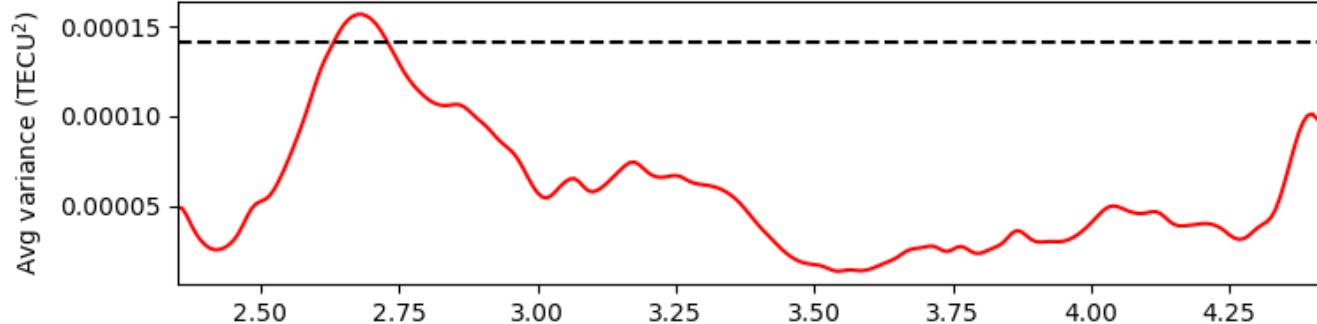
b) Wavelet Power Spectrum



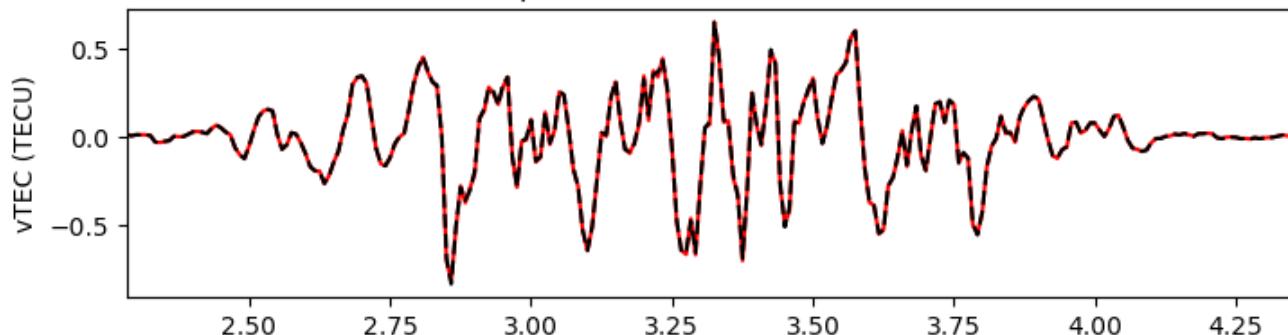
c) GWS



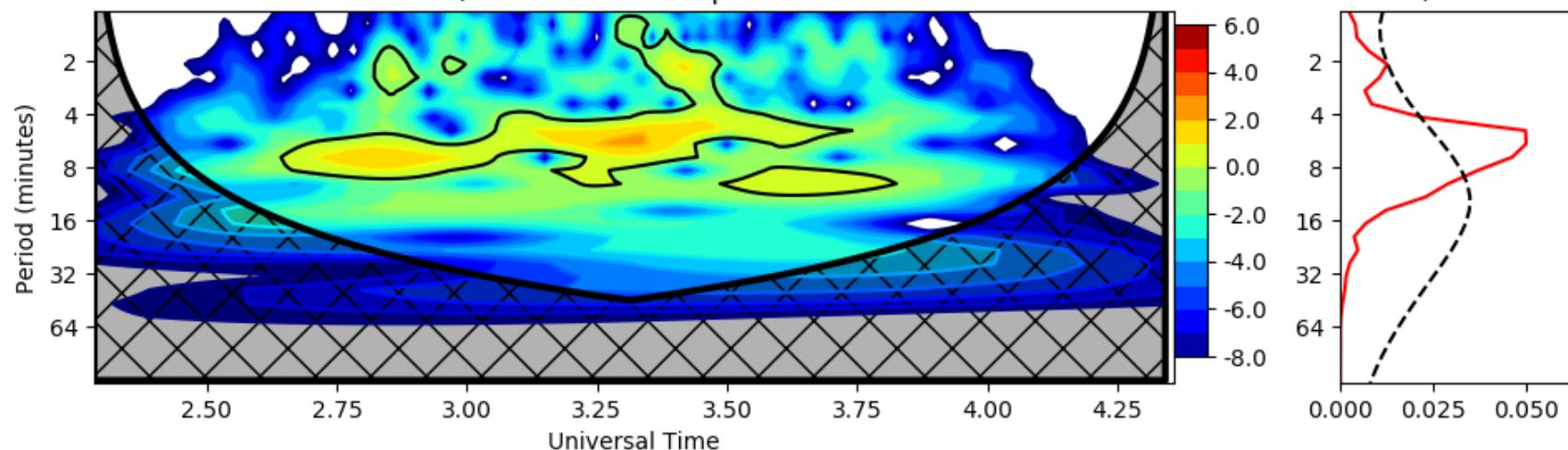
d) Scale-average Time Series



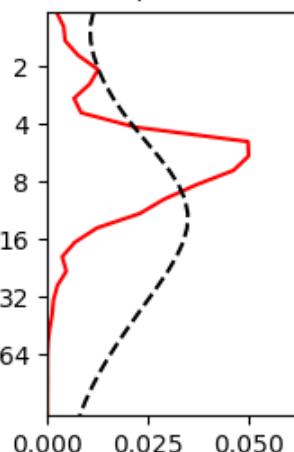
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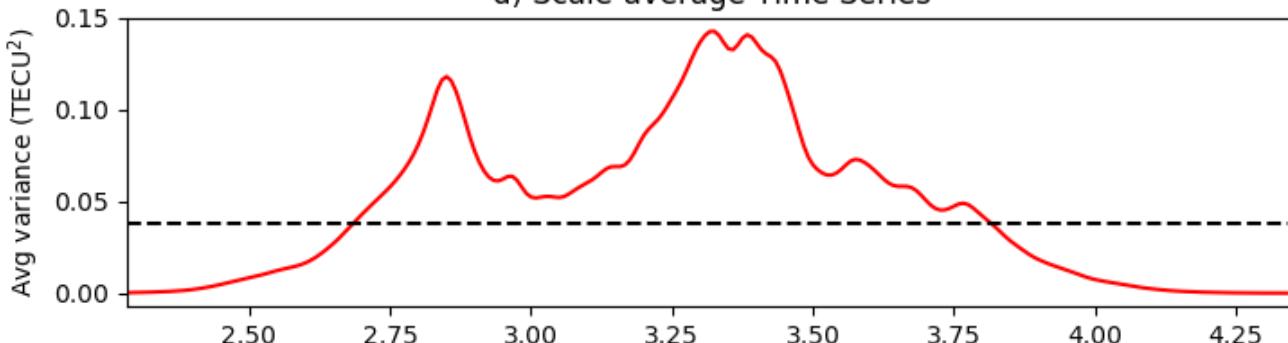
b) Wavelet Power Spectrum



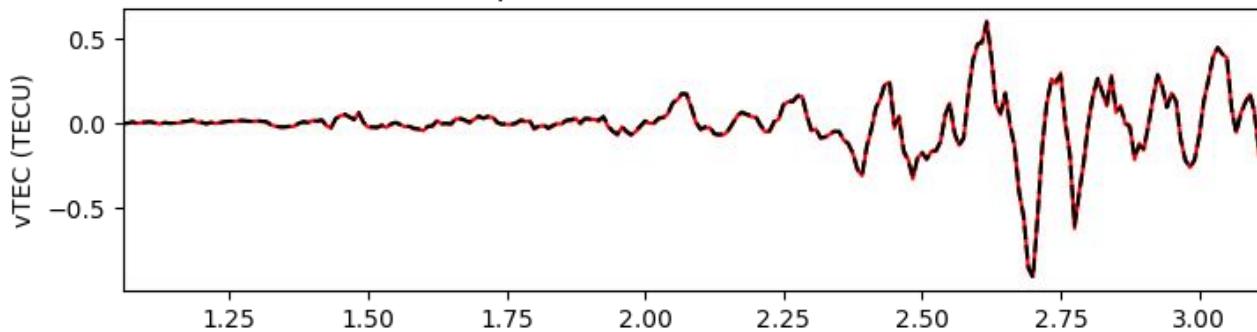
c) GWS



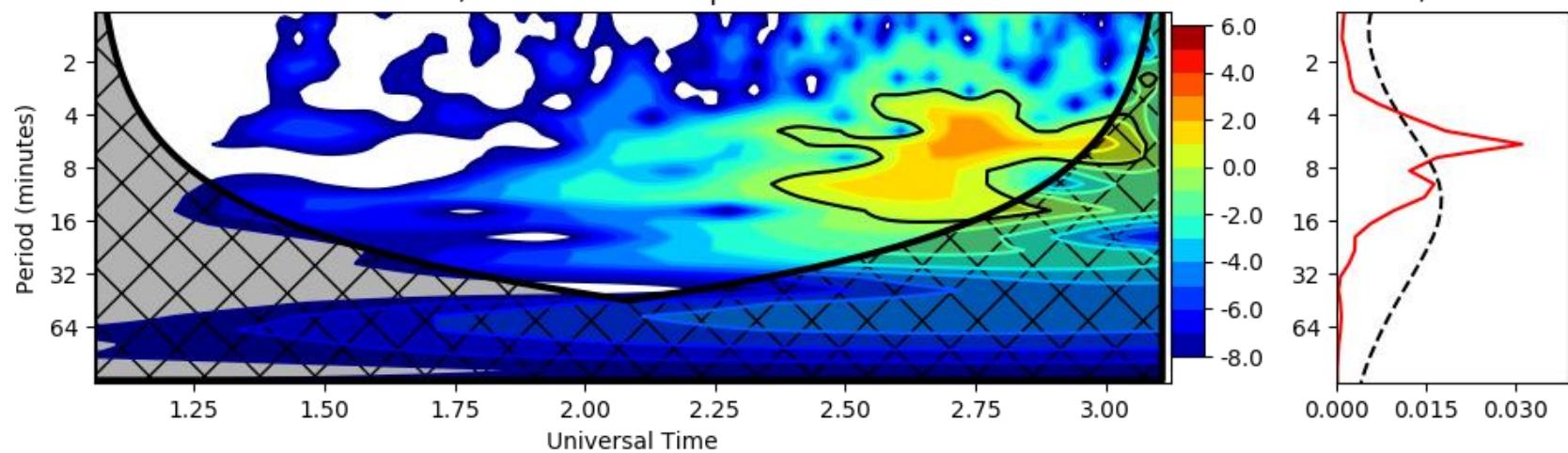
d) Scale-average Time Series



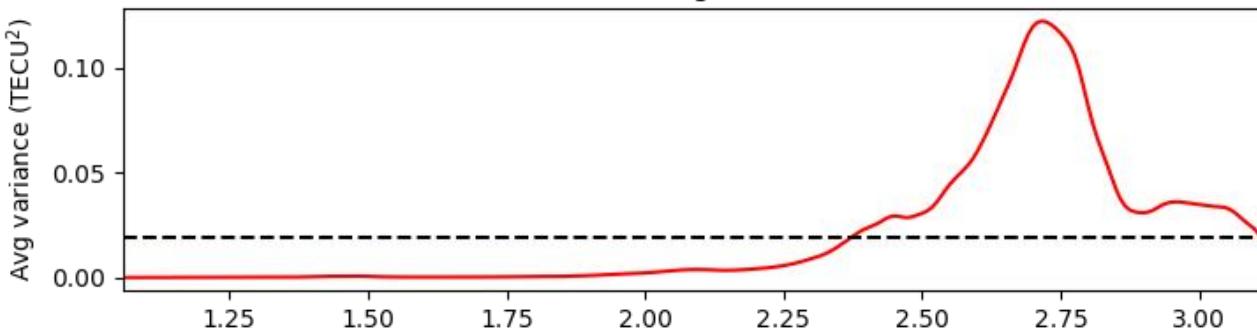
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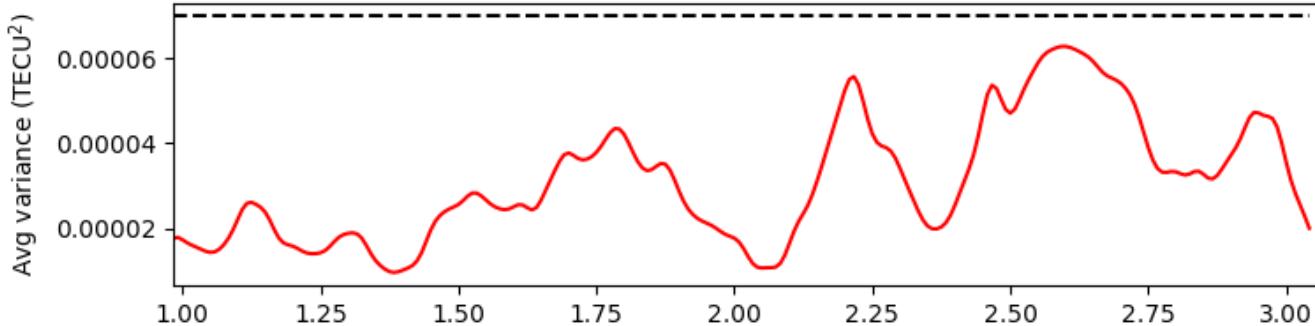
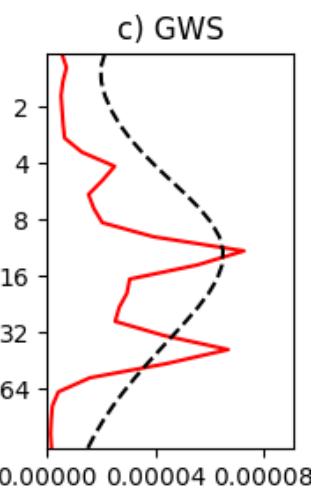
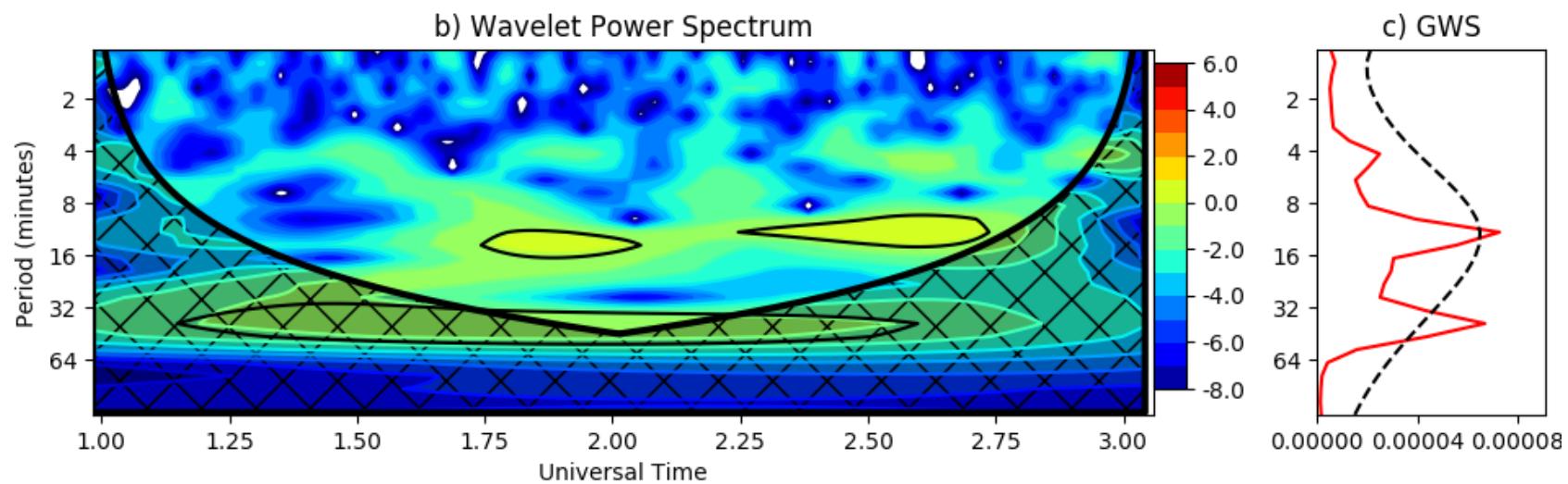
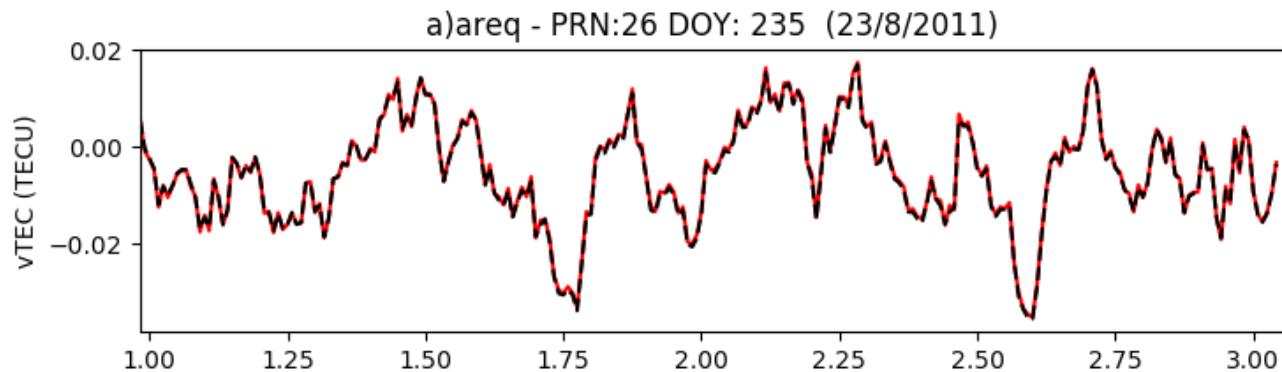


b) Wavelet Power Spectrum

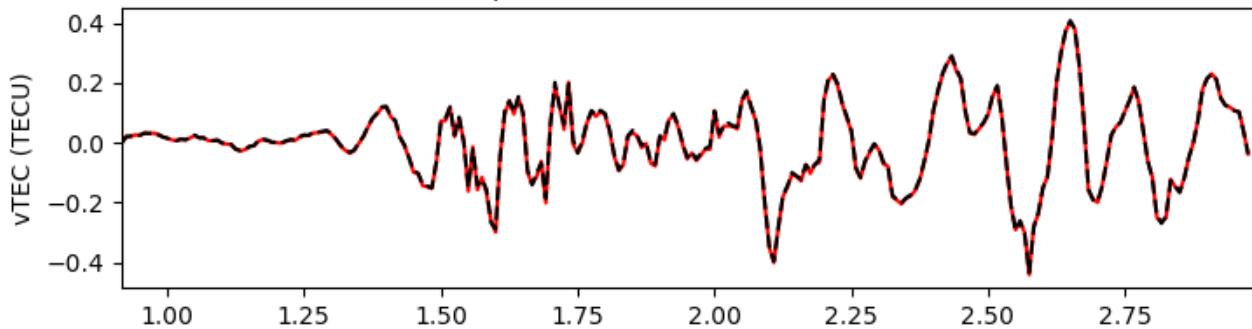


d) Scale-average Time Series

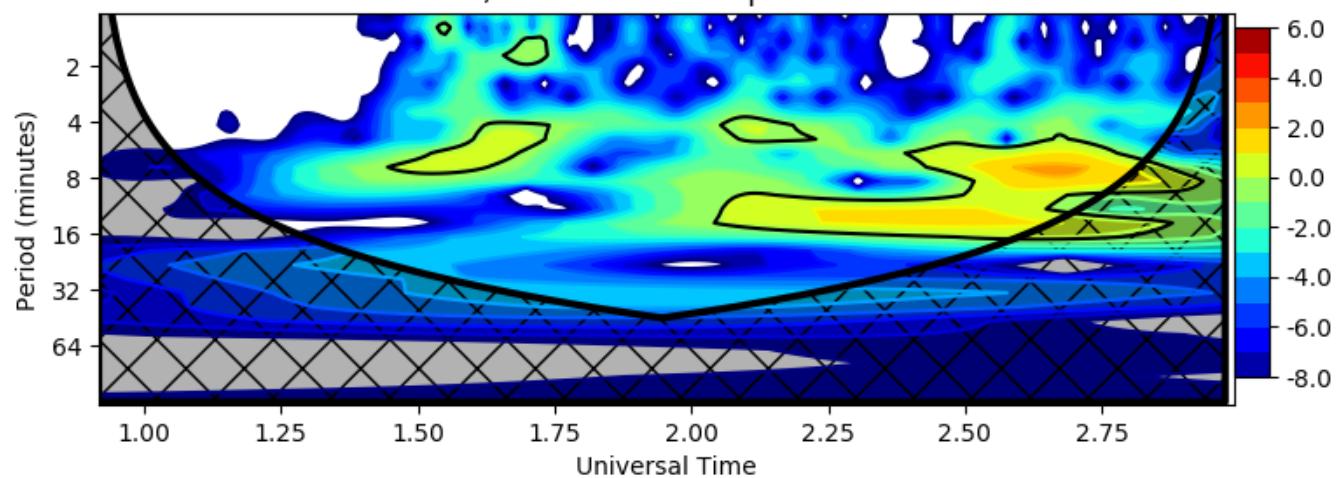




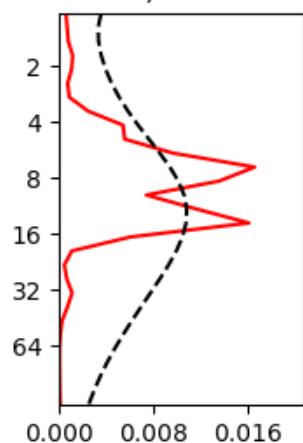
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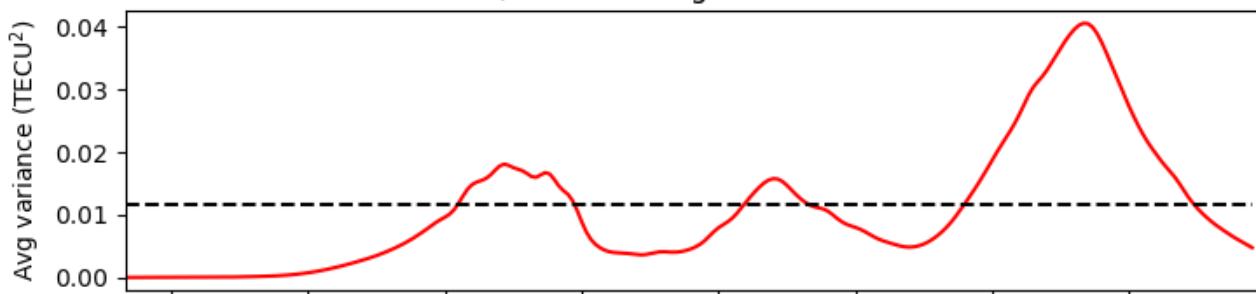
b) Wavelet Power Spectrum



c) GWS



d) Scale-average Time Series



Challenges

- To investigate the level of detectability of pre-seismic signals: obtaining reliable chronological, ionospheric and geomagnetic series before, during and after earthquakes.
- Better understanding of noise characteristics of measurements: systematic comparisons between ionospheric data derived from GPS and from terrestrial and spatial magnetic data.
- Investigate non-seismic sources of ionospheric disturbances to better separate them from seismic sources.

Thank you for your attention.

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