IONOSPHERIC RESPONSE TO MT.ETNA ERUPTION

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270

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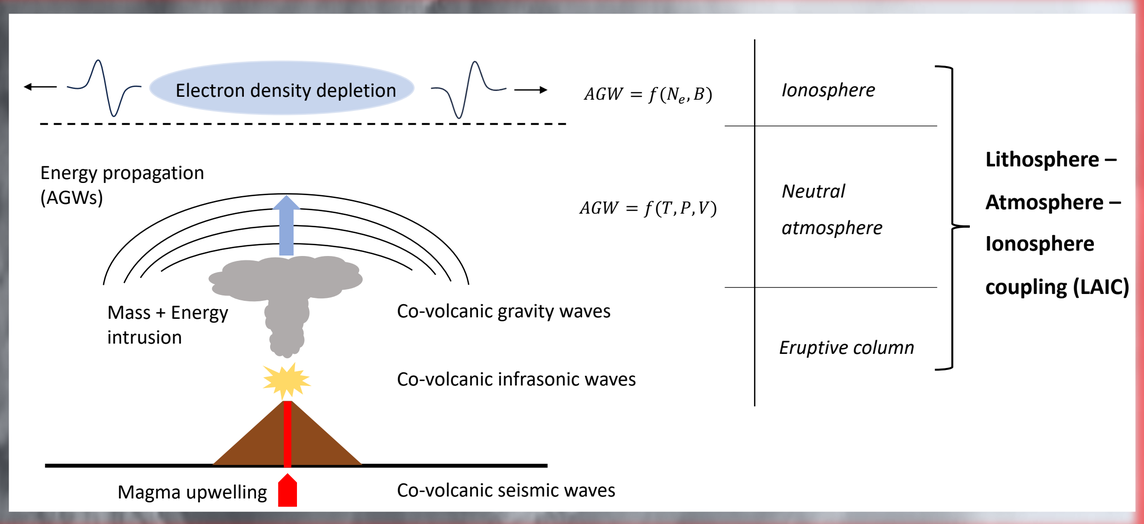
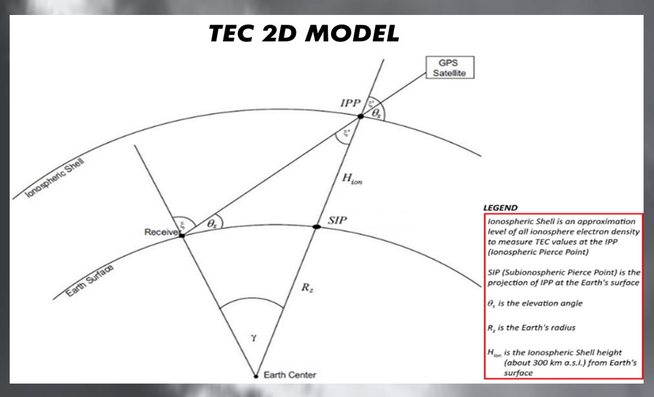
INTRODUCTION

Volcanic eruptions can cause **Acoustic – Gravity waves** (AGWs) propagation in the atmosphere. AGWs can reach the upper atmosphere by triggering **Total Electron Content** (TEC) oscillations in the ionosphere. TEC signatures of volcanic source are called **Co-Volcanic Ionospheric Disturbances** (CVIDs). The ionospheric detection of volcanic eruptions involves the study of atmospheric dynamics and volcanic plumes. The **Lithosphere – Atmosphere – Ionosphere Coupling** (LAIC) is the main approach to study the energy exchange between Solid Earth and Fluid Earth.





METHOD (GNSS – TEC analysis)

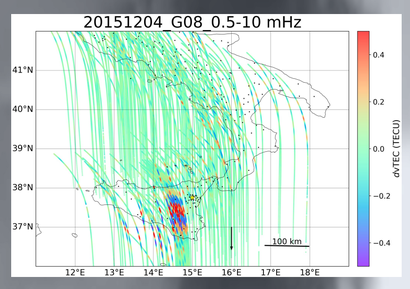
The single time differences between the geometry-free combinations of Global Navigation Satellite System (GNSS) carrier measurements provide TEC estimation in terms of **TEC Unit** (1 TECU = $1 \cdot 10^6$ $e^- \cdot m^2$). **Variometric Approach for Real-time Ionosphere Observation** (VARION) is the algorithm (not the one) to estimate TEC values based on **ionospheric-shell model**. **Fast Fourier Transform** (FFT) and **Empirical Mode Decomposition** (EMD) are some techniques to analyze waveforms and spectral features of TEC signatures.

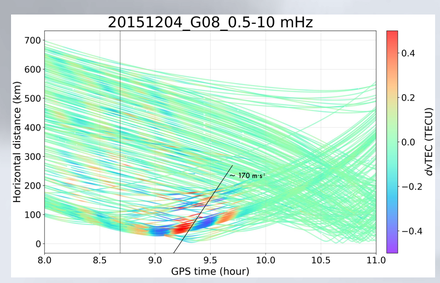
RESULTS

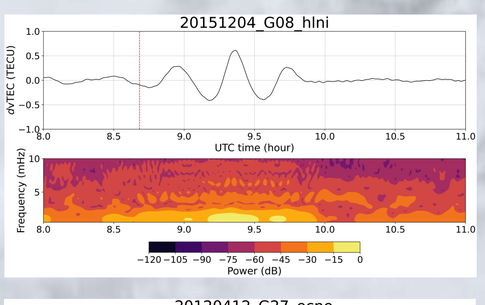
GNSS – TEC analysis of 2012/04/12 and 2015/12/04 lava fountains of Mt.Etna provides **N-shape TEC signatures** in time ranges related to the eruptive activity.

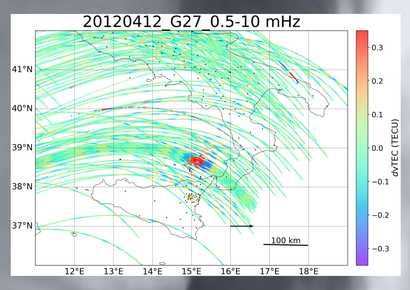
Main features of TEC signatures detected are:

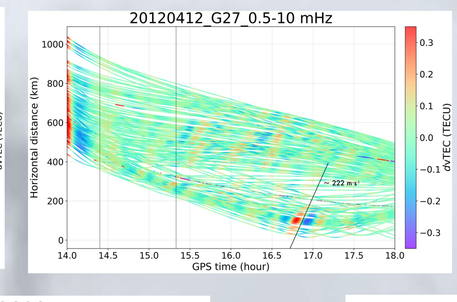
- Apparent horizontal velocity $v_{HA} \sim 170 – 220$ m·s^{-1}
- Frequency $f \sim 0.5 – 1.5$ mHz (FFT & EMD outputs)
- Wavelength $\lambda \sim 40 – 80$ km
- TEC amplitude $A \sim 0.3 – 0.5$ TECU

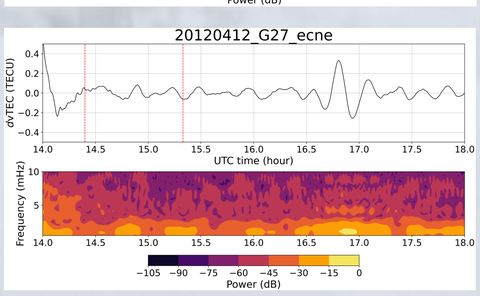


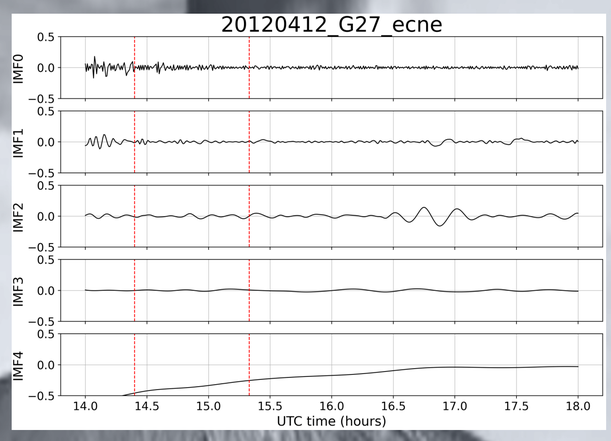


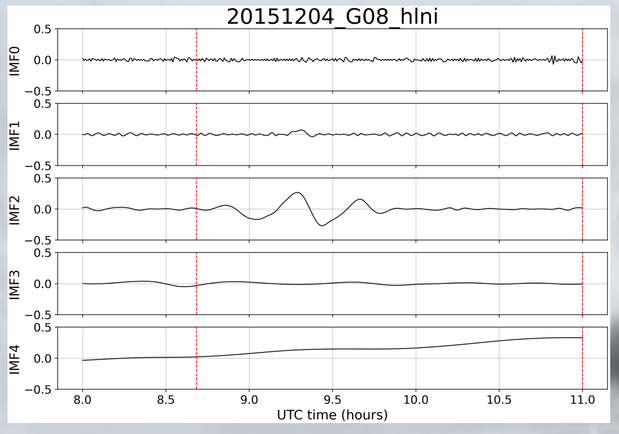












CONCLUSIONS

- Ionospheric disturbances in gravity mode
- Near field TEC signatures (up to about 200 km from Mt.Etna)
- TEC detection in geomagnetic quiet days (Dst ~ - 10 nT)

OVERVIEWS

- Estimation of the ''eruptive column pulse'' in the atmosphere
- Ray tracing of gravity waves
- Research on termodynamic and electromagnetic coupling between neutral atmosphere and ionosphere

OPEN QUESTIONS

- How to relate TEC signatures with the eruptive column uprising?
- Why so different picking times?

Date	Seismo-acoustic start (UTC)	Seismo-acoustic end (UTC)	RMS_seismic (m·s^{-1})	RMS_ infrasound (Pa)	Fountain height (m)	Plume height asl (km)	Total seismic energy (J)	Total acoustic energy (J)	Total thermal energy (J)	Mass Eruption Rate (kg·s^{-1})
2012/04/12	14:24	15:21	$2.82 \cdot 10^{-5}$	2	1950	10	$1.13 \cdot 10^{16}$	$1.72 \cdot 10^{8}$	$1.13 \cdot 10^{14}$	$1.03 \cdot 10^{6}$
2015/12/04	08:40	11:00	$5.54 \cdot 10^{-5}$	14	2600	13	$1.4 \cdot 10^{16}$	$5.5 \cdot 10^{9}$	$2 \cdot 10^{14}$	$1.62 \cdot 10^{6}$