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Lower Ionospheric turbulence variations during the recent activity of Etna Volcano, Sicily in December 2018

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Introduction

Mount Etna is located close to the eastern coast of Sicily (λ = 14.99 °E, φ=37.75 ° N). With a height of ~3330m, it is considered as the highest volcano of Europe's mainland while it is classified among the most active volcanos globally. Its activity has started back in the middle Pleistocene and it is characterized as a composite volcano (cone-shaped mountain). Its eruptions are mostly of strombolian type (moderate bursts of expanding gases). The last eruption of Etna volcano took place on 24 December 2018 while two days later (26 December, 02:19 UTC) an earthquake of M=4.8 occurred ~15km to the ESE of the volcano, causing damage to the nearby city of Catania. In this paper, we investigate the ionospheric turbulence from TEC observations before and during this recent activity of Etna's Volcano.

Observational Data

To this purpose we use the TEC estimates provided by IONOLAB (http://www.ionolab.org) (Arikan et al. 2009) for 5 mid latitude GPS stations of EUREF network which cover epicentral distances from the active area ranging from 359.083km to 2327.287km, for the periods between 07/11/2018 to 05/01/2019. The selected GPS stations have about the same latitude and are expected to be affected equally from the Equatorial Anomaly as well as from the Auroral storms. Fig. 1 displays the locations of the five GPS stations (blue triangles) and the epicentre of the main shock. The IONOLAB TEC estimation system uses a single station receiver bias estimation algorithm, IONOLAB-BIAS, to obtain daily and monthly averages of receiver bias and is successfully applied to both quiet and disturbed days of the ionosphere for station position at any latitude. In addition, TEC estimations with high resolution are also possible (Arikan et al. 2009). IONOLAB system provides comparison graphs of its TEC estimations with the estimations of the other TEC providers of IGS in its site. In this work only TEC estimations in perfect accordance among all providers were used. The TEC values are given in the form of a Time Series with a sampling gap (resolution) of 2.5 minutes.

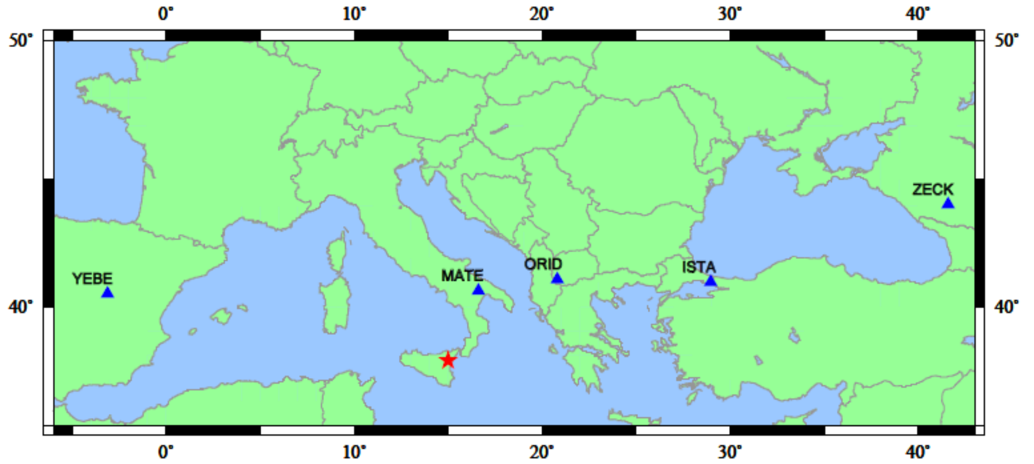

Figure 1. The sites of the EUREF Stations (blue triangles) and the Etna Volcano (red star).

Data Analysis

The observational data, which constitute a time series are analysed using Fast Fourier Transform analysis. From the slop of the logarithmic power spectrum diagram of a segment we can recognize whether the contributed variations to the spectrum are random or periodical. If they are random the slop will be 0, which correspond to the white noise, or -2 which correspond to the Brownian walk, otherwise the slop will be different the so called Fractal Brownian walk. This means that we can trace the presence of periodical variations in the logarithmic power spectrum of TEC variations. This method was successfully applied in our previous work (Contadakis et al. 2015) in order to find the frequency content of TEC turbidity. It is realized that the upper frequency limit f_o of the spectrum of TEC variations increases as we approach the source of the ionospheric turbidity modulation, in our case the earthquake preparation activity.

Results and discussion

The results of this investigation are summarized in Figures 2 and 3, and indicate that the High- Frequency limit f_o, of the ionospheric turbulence content, increases as the site and the moment of the Volcano event occurrence is approaching.

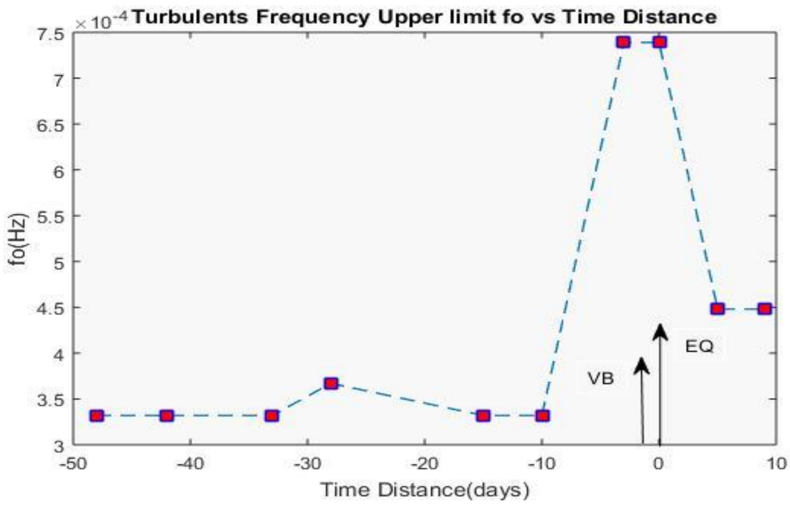

Figure 2 Ionospheric Turbulent Frequency Upper limit, f_0. The arrows indicate the time of the eruption and of the earthquake occurrence.

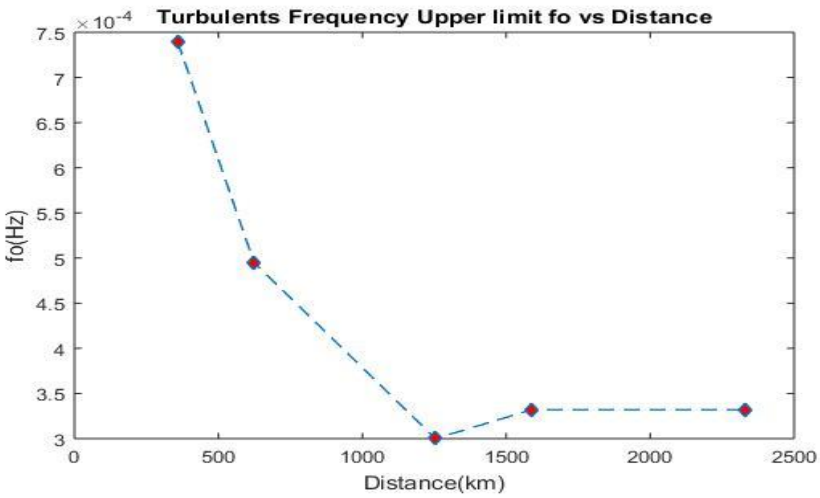

Figure 3 Turbulent Frequency Upper limit, f_0, over the Network stations around the eruption days

We conclude that the LAIC mechanism (Hayakawa 2011) through acoustic or gravity waves could explain this phenomenology. That is, tectonic activity during the volcano eruption produces anomalies at the ground level, which propagate upwards in the troposphere as Acoustic or Standing gravity waves. These Acoustic or Gravity waves affect the turbidity of the lower ionosphere, where sporadic Es-layers may appear too, and the turbidity of the F layer. Subsequently the produced disturbance starts to propagate in the ionosphere's wave guide. Thus, observing the frequency content of the ionospheric turbidity we will notice a decrease of the higher limit of the turbitity frequency band, as a result of the differential frequency attenuation of the propagating wave.

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