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A new frequency-domain based approach for detecting low frequency seismic events: An application to the Mt. Vesuvius seismicity

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The detection of low energy seismic events and tremor related to volcanic activity in areas characterized by high background noise represents a crucial challenge for monitoring and surveillance purposes. In the last three years, the seismicity of the Mt. Vesuvius (southern Italy) has been characterized by low-magnitude volcano tectonic earthquakes, the most of which are located at depth shallower than 3 km b.s.l., while very few low-frequency earthquakes and tremor episodes are located at about 6-7 km depth. It is well known that magmatic and hydrothermal systems can play an important role in the generation of low-frequency seismic events, which could be important precursors for assessing the reawakening of a volcano. Therefore, our main objective is to develop a methodology for detecting the presence of low frequency (LF) events hidden in the background noise and not identifiable by classical detection procedures. In particular, we suggest a frequency domain approach based on a joint application of coherence analysis among signals from local network seismic stations and parameterization of the amplitude spectra according to the statistical moments. The proposed methodology has been applied to the analysis of continuous seismic signals recorded over three years at Mt. Vesuvius. Spectral parameters, such as central frequency *W,* shape factor *d* and coherence *c*, were evaluated on 30-s windows signals in the frequency range between 2 and 40 Hz. The selection of the signal windows that could potentially contain low-frequency events or tremor signals was performed according to the following criteria: a) $0.45 < \delta < 0.65$; b) 3 Hz < W < 6 Hz and c) c greater than 0.5, which are based on the results of preliminary analyses of the seismicity observed at Mt. Vesuvius. The detected signal windows were visually inspected and compared with the seismic catalogues to eliminate those corresponding to earthquakes occurred outside the area of interest. For the three-years of analyzed data, more than 200 episodes of low frequency signals were identified, 120 of which are not present in the seismic catalog. Most of them appear as low-amplitude tremor episodes, with no clear evidence of P and S phases, hidden in the noisy raw signals but visible at the entire seismic network after proper signal filtering. Compared to the few LF events detected and analysed in the past, our findings suggest that the proposed methodology can be an efficient tool for detecting low-amplitude signals not easily identifiable in the background noise and could

represent an improvement for the monitoring system of the Mt. Vesuvius volcanic area.