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Decomposition of high frequency Strombolian tremor and reconstruction of asymptotic dynamics

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We study the seismic tremors selected from seismic signals recorded by broadband three-component seismometer network installed at Stromboli volcano in 1997. Starting by previous studies on explosions obtained by Acernese et al. (2003, 2004), we want to prove that Strombolian signals, tremor and explosions, in high frequency band ($>$0.5Hz) are similar in time and frequency domain with only difference in the amplitude enhancing. In fact, tremor and explosions are similar because their behaviours are generated by the same complex processes of magma flow and turbulent degassing. We have adopted different techniques: parametric and non parametric spectral analysis; Independent Component Analysis (ICA), a technique of Information theory used to decompose, if it is possible, recorded series into statistically independent signals; polarization filtering; methods to reconstruct the phase space starting from scalar time series; trajectory space analysis to estimate the variety of dynamical systems present in the data. ICA has been applied to tremors showing that the wavefield is a linear superposition in time domain of three components characterized by well defined frequency bands (respectively 0.8-1.2Hz, 2.5-3.2Hz and 3.5-5.5Hz). The application of a polarization analysis on tremor is difficult due to the low SNR, evidencing a scattered field. Polarization analysis in the 0.8-1.2Hz band shows, as a preliminary result, a wavefield polarized, prevalently, in radial direction (high rectilinearity coefficient) with respect to the crater even if the station T4 shows a different polarization direction due at site effects. The source is superficial. The next step is to analyse the dynamics of volcanic tremor in order to extract from the seismic recordings the information on the dynamical system that rules the volcano. Trajectory space analysis, considering different tremors (histories) recorded at one station of the array (T1), suggests that the dynamic process underlying Strombolian tremors is the same for all the events. The

signals, in fact, exhibits a very small scaling region, made of few points covering less than one order of magnitude implying that no true scaling is recognizable. Moreover, the reconstructed phase space has established that the tremors are associated to a low dimensional dynamical system, in good agreement with the previous results of the explosions at Stromboli in the same frequency bands. In particular, the dimension of this system tends toward 4.2 for different time windows of 30s, 60s and 90s. Finally, if we apply this technique at the signals, filtered in the frequency bands individuated via ICA, the dimension, furthermore, decreases. In particular, the dimension of the signal, filtered in the band 0.8-1.2Hz, tends toward 2.3. This result is very impressive because we have obtained a similar result for the explosions, suggesting that the transition mechanism from explosion to tremor is the same.

References

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