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Seismic body wave separation in volcano-tectonic activity inferred by the Convolutive Independent Component Analysis

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One of the main challenge in volcano-seismological literature is to locate and characterize the source of volcano/tectonic seismic activity. This passes through the identification at least of the onset of the main phases, i.e. the body waves. Many efforts have been made to solve the problem of a clear separation of P and S phases both from a theoretical point of view and developing numerical algorithms suitable for specific cases (see, e.g., Küperkoch et al., 2012).
Recently, a robust automatic procedure has been implemented for extracting the prominent seismic waveforms from continuously recorded signals and thus allowing for picking the main phases. The intuitive notion of maximum non-gaussianity is achieved adopting techniques which involve higher-order statistics in frequency domain., i.e, the Convolutive Independent Component Analysis (CICA).
This technique is successful in the case of the blind source separation of convolutive mixtures. In seismological framework, indeed, seismic signals are thought as the convolution of a source function with path, site and the instrument response. In addition, time-delayed versions of the same source exist, due to multipath propagation typically caused by reverberations from some obstacle.
In this work, we focus on the Volcano Tectonic (VT) activity at Campi Flegrei Caldera (Italy) during the 2006 ground uplift (Ciaramella et al., 2011). The activity was characterized approximately by 300 low-magnitude VT earthquakes (Md < 2; for the definition of duration magnitude, see Petrosino et al. 2008). Most of them were concentrated in distinct seismic sequences with hypocenters mainly clustered beneath the Solfatara–Accademia area, at depths ranging between 1 and 4 km b.s.l..
The obtained results show the clear separation of P and S phases: the technique not only allows the identification of the S-P time delay giving the timing of both phases but also provides the independent waveforms of the P and S phases. This is an enormous advantage for all the problems related to the source inversion and location
In addition, the VT seismicity was accompanied by hundreds of LP events (characterized by spectral peaks in the 0.5–2-Hz frequency band) that were concentrated in a 7-day interval. The main interest is to establish whether the occurrence of LPs is only limited to the swarm that reached a climax on days 26-28 October as indicated by Saccorotti et al. (2007), or a longer period is experienced.
The automatically extracted waveforms with improved signal-to-noise ratio via CICA coupled with automatic phase picking allowed to compile a more complete seismic catalog and to better quantify the seismic energy release including the presence of LP events from the beginning of October until mid of November.
Finally, a further check of the volcanic nature of extracted signals is achieved by looking at the seismological properties and the content of entropy held in the traces (Falanga and Petrosino 2012; De Lauro et al., 2012).
Our results allow us to move towards a full description of the complexity of the source, which can be used for hazard-model development and forecast-model testing, showing an illustrative example of the applicability of the CICA method to regions with low seismicity in high ambient noise