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Recent developments of seismo-volcanic monitoring systems for magma dynamics investigation and eruptive precursors characterization at Mt. Etna.

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A fundamental goal of volcano seismology is to understand the dynamics of active magmatic systems in order to assess eruptive behavior and the associated hazard. The seismo-volcanic signals are generally considered as an indicator of the internal state of activity of volcanoes. For this reason their investigation can be very useful for both monitoring and research purposes. Because of the peculiar characteristics of the seismo-volcanic signals, new techniques have been developed to investigate their features. Here we will show the most recent techniques applied to monitor and investigate the seismo-volcanic signals recorded at Mt. Etna together with several cases of study of such signals.

First of all, since the volcanic tremor at Mt. Etna is a continuous signal, it is necessary to characterize it, as well as to extract and study the seismic transients (LP, VLP events, VT earthquakes, etc...). To accomplish the extraction task a technique based on the percentile computation on RMS envelope, that also enables to track the evolution in time of the volcanic tremor amplitude sharply reducing the influences of the transients, was developed. In order to investigate the spectral characteristics of the seismo-volcanic signals, likely related to the geometry of the plumbing system and the features of the fluids it contains, both parametric and non-parametric power spectrum estimation techniques are routinely applied. It was shown how at Mt. Etna eruptive activities are sometimes preceded and/or accompanied by changes in the spectral features and waveforms of LP, VLP events and volcanic tremor. Also the wavefield changes of the seismo-volcanic signals can provide information about internal variations of the plumbing system. Indeed, this kind of analysis can be useful to detect even very small variations in location and/or source mechanism. At Mt. Etna several paroxysmal activities were preceded and/or accompanied by variations in the polarization parameters. As volcanic tremor, LP and VLP events are generally related to dynamics of fluid inside the volcanic edifice, the location of their source is a basic information for monitoring volcanoes and also for identifying the elements of the plumbing system. However, the onset of the aforementioned signals is usually not clearly shown on the traces, hence conventional approaches of event location by picking first arrivals cannot be applied. Therefore, different techniques, generally based on grid searching procedures, were developed and applied in real-time or near real-time at Mt. Etna. The volcanic tremor is located by using the spatial distribution of tremor amplitudes, assuming the propagation in a homogenous medium and a seismic amplitude decay with the distance. Other location methods, largely used in seismology to locate LP and VLP events, are semblance and radial semblance methods. A new composite approach, based on the joint use of semblance and amplitude decay techniques, was developed to reliably locate LP events. This method was very effective to track the short migration (a few hundred meter) of the LP source preceding the 2008-2009 eruption at Mt. Etna.

All these techniques applied on seismo-volcanic signals provide very useful information that, together with other geophysical and geochemical parameters, constitute the fundamental knowledge for both eruptive precursors characterization and investigation the magma dynamics.