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Online monitoring and Automatic Classificaton of Volcanic Tremor on Mt Etna.

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Continuous seismic monitoring plays a key role for surveillance of Mt Etna volcano. Besides earthquakes, which often herald eruptive episodes, the persistent background signal, known as volcanic tremor has proven to provide extremely important information on the status of the volcano as changes in the regimes of activity are usually concurrent with variations of tremor characteristics. This strict relationship is useful for monitoring volcanic activity in any moment and in whatever condition (such as day-night, meteo). As continuous recording leads rapidly to the accumulation of large data masses, parameter extraction and automated processing becomes crucial. We therefore developed a software package which allows automatic unsupervised classification near-online. The software package is based on Self Organizing Maps and Fuzzy Clustering, and displays the results of both approaches in a synoptic way. The concept has proven its efficiency during various phases of volcanic unrest in 2007-08, where subtle, nonetheless significant changes in the signal could be evidenced well before they became visible in conventional monitoring.

Automatic on-line classification of patterns needs robust procedures for the extraction of feature vectors from the incoming data stream. We achieve this goal transforming the time series to spectrograms using a gliding window scheme, and taking 10%-percentiles of the amplitude values in the spectrograms. In doing so we widely exclude transient signals (such as earthquakes, explosions, wind gusts, etc) which, in terms of tremor analysis, are considered as a disturbing effect.

The online unsupervised classification is carried out using a data set made up of two pools of patterns. A first reference pool consists of patterns collected during a wide variety of scenarios of volcanic activity – here the ones encountered in 2007-08. The second pool is a ring buffer which is continuously updated with new incoming patterns. Applying the automatic classification to the whole data set the user learns how the new data are related to the scenarios encountered so far. As the classification is carried without supervision it adapts itself to completely new scenarios with patterns never seen before.

The online classifier is now working routinely since October 2009. At the moment it provides a classification every five minutes. A test period is devoted to establishing the most suitable configuration of signal processing, the choice of the most significant seismic stations and the analysis of the behaviour of the classifier under various environmental conditions. Up to now the systems has proven a high degree of robustness to various disturbing sources, at the same time phases of slightly enhanced volcanic activity could be identified by the classifier and confirmed a posteriori by other evidences.