Geophysical Research Abstracts,
Vol. 10, EGU2008-A-07812, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-07812
EGU General Assembly 2008

A comprehensive study on automatic classification techniques applied to volcanic tremor data recorded at Mt Etna during the July-August 2001 eruption.

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Mt Etna, Europe's largest active volcano is by now one of the best monitored volcanoes in the world. It has been understood that states of volcanic activity at Mt Etna develop in well defined regimes with variable duration from a few hours to several months. Changes in the regimes are usually concurrent with variations of the features of volcanic tremor, which is continuously recorded as background seismic radiation. This strict relationship is useful for the monitoring of volcanic activity in any moment and in whatever condition. The continuous acquisition of seismic data entails the accumulation of large data masses which are cumbersome to handle. In this paper we investigated the development of tremor features and its relation to regimes of volcanic activity, applying automatic classification techniques. We present results obtained with both supervised and unsupervised classification methods applied to tremor data recorded during the unrest in July-August, 2001. In supervised classification the classifier learns from a set of examples for which the class-membership is supposed to be known during the so-called training process. Once trained, the classifier can be applied to previously unseen data for which the classification is unknown. The clue of supervised classification strategies lies in the fact that modern techniques allow to resolve classification problems of arbitrary complexity. In other words, if the classification problem is well defined, then it should be reproducible by automatic processing. The excellent results obtained with Support Vector Machines for the unrest in 2001

(ca. 95 % of matching classifications) confirm the validity of the a-priori classification. A slightly inferior score of matching classifications was achieved with Multi-Layer-Perceptrons. In unsupervised classification one tries to cluster data using the a-priori definition of a measure of distance between data vectors. The advantage of this strategy over supervised classification is that no a-priori information about desired class-membership is necessary. This discloses the possibility of unveiling regimes which were not identified a-priori. On the other hand, the measure of similarity has to be rather simple, such as the Euclidean or Mahalanobis distance. In our study of the unrest in 2001, we applied Cluster Analysis using an adaptive determinant criterion. On the whole, the regimes defined in the unsupervised classification form well defined clusters. Besides, a further cluster is identified during the climax of the eruptive activity. Self Organizing Maps (following concepts proposed by Kohonen) allow the definition of clusters ('best matching units') on a small scale. Applying a proper color-coding, it is possible to follow visually the development of the characteristics of the patterns with time. This is particularly useful for the analysis of transitional stages from one to another regime of volcanic activity. After all, we consider supervised and unsupervised classification as complementary tools rather than competing ones. A synoptic interpretation of the various techniques is, in our opinion, an efficacious key for an in-depth understanding of the structure of large, multivariate data sets and their relation to volcanic phenomena.