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Machine Learning analysis of seismic signals recorded at Stromboli Volcano

Darius Fenner, Georg Rümpker, Horst Stöcker, Megha Chakraborty, Wei Li, Johannes Faber, Kai Zhou, Jan Steinheimer, and Nishtha Srivastava
Frankfurt Institute for Advanced Studies, Seismology & Artificial Intelligence, Germany (fenner@fias.uni-frankfurt.de)

At Stromboli, minor volcanic eruptions occur at time intervals of approximately five minutes on average, making it one of the most active volcanoes worldwide. In addition to these mostly harmless events, there are also stronger eruptions and paroxysms which pose a serious threat to residents and tourists. In light of recent developments in Machine Learning, this study attempts to apply these new tools for the analysis of the time-varying volcanic eruptions at Stromboli. As input for the Machine-Learning approach, we use continuous recordings of seismic signals from two seismometers on the island. The data is available from IRIS and includes records starting in 2012 up to the present.

One primary challenge is to label and classify the data, i.e., to discriminate events of interest from noise. The variety of signal-appearance in the recorded data is wide, in some periods the events are clearly distinguishable from noise whereas, in other cases relevant events are obscured by the high noise level. To enable the event-detection in all cases, we developed the following algorithm: in the first step, the seismic data is pre-processed with an STA/LTA-Filter, which allows detection of events based on a prominence threshold. However, due to the diversity of signal patterns, a fixed set of hyperparameters (STA- and LTA-window length, prominence threshold, correlation coefficient) fails to reliably extract the relevant events in a consistent manner. Therefore, the (time-varying) noise level of the recordings is used as an additional key indicator. After this, the hyperparameters are optimized. The automatic adaptation is then used for labeling the continuous seismic data.

After extracting the events based on this approach, a machine learning model is trained to analyze the recordings for possible patterns in the interval times and the event amplitudes. This study is expected to provide constraints on the possibility to detect complex time-dependent patterns of the eruption history at Stromboli.