Links between volcano seismicity and small-scale deformation of the volcanic edifice - exploring new ways of detecting small static deformations

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Deformations of volcanic edifices have been measured and analysed in numerous studies involving different methods and techniques. Thus far, these studies, including GPS and differential InSAR methods, are limited to larger scales, either temporally or spatially, or both. Hence while we can observe higher rate and/or stronger seismicity with increasing inflation or deflation rate over weeks or months, we cannot yet relate the individual volcano-seismic events to small, spatially limited static deformations.

In volcano seismology, seismic events are usually characterised as volcano-tectonic (VT), long-period (LP) and very long period (VLP) events and tremor. VT events are short and impulsive and appear to have brittle failure sources and thus present an equivalent to tectonic earthquakes. LP and VLP events and tremor are commonly thought to have fluids and resonance involved in the source process, but they are still not completely understood. The complexity of the volcanic edifice and the fact that many events are recorded in the near-field make it difficult to locate event sources and to distinguish actual source properties from path effects.

We are trying to explore new ways of detecting small, spatially limited static displacements in the summit region to get a better understanding of how and when deformation takes place and to understand the relationships between deformation and individual seismic events. This can give us valuable clues to the processes involved in generating different types of volcanic seismicity and their connection to the evolution of the volcanic edifice. As a first step, we are investigating possibilities of using broadband seismometer data to retrieve static displacement information. This will require looking at seismic data in a more detailed way, but could enable us to perform this kind of analysis for many existing datasets.

We are currently undertaking (i) analytical/numerical experiments using a variety of source models and seismometer response functions (ii) physical laboratory experiments with step tables, applying well-defined displacement steps on different types of seismometers and tiltmeters. These results are being used to constrain possible deformation related signals observed in a high-density temporary seismic network installation on Mt Etna, Italy, in 2008.