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Broadband moment-tensor inversion of long-period events on volcanoes: example from Turrialba volcano

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Seismic events on volcanoes form a spectral continuum, from the high-frequency (> 10 Hz) tectonic-like events to ultra long period events with dominant periods longer than 100s of seconds. Long-period events (LP) are characterised by the dominant frequencies between 0.5 and 2Hz and relatively simple waveforms. They are mainly located within the first several hundred meters below volcano summit and are thought to reflect the dynamics of the shallow magmatic and/or hydrothermal plumbing system. It is still puzzling if they are generated by the pressure perturbations within fluid-filled cracks and conduits, or by a more classical faulting model in the extremely weak material, where the role of fluid is to modulate overall stress rather than being directly involved in the source generation process.
So far, several moment-tensor (MT) inversions of LP events have been performed. A typical MT solution comprises a tensile crack source mechanism, and a pulsing or resonating source-time function (STF). However, due to generally small magnitudes of these events (a small S/N ratio), only the most energetic part of the signal is used in inversions. More precisely, the low frequency limit of the STF is determined by the lowest frequency of the most energetic part of the recorded waveform (usually about 0.3 - 0.5 Hz). Since it is extremely difficult to recover longer period ground displacements from such small-amplitude velocity records by using classical instrument response removal approach, it is almost impossible to infer if the obtained STF represents the real displacement in the source or it is just its band-limited representation.
Here we used a good-quality dataset recorded near the summit of Turrialba volcano and applied some of the techniques used for the “baseline correction” in the strong motion seismology. In this way we managed to recover very low frequency part of LP signals, i.e. much lower than usual 0.3-0.5 Hz. Although the velocity records processed in this way did not differ significantly to the classically processed waveforms, the striking difference can be observed in the displacement, where the static shift was successfully recovered at the stations close to the source. Consequently, the obtained MT solution was the classical earthquake “ramp” function, rather than a pulsing or oscillating waveform. This is the first result of this kind, which will hopefully contribute to a better understanding of these puzzling events. In addition, extending inversions towards very low frequencies makes the solutions less sensitive to large uncertainties in the shallow velocity models (which is a huge problems in volcano seismology).