Geophysical Research Abstracts,
Vol. 10, EGU2008-A-11413, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-11413
EGU General Assembly 2008

Long period source inversions in volcanic environments constrained by synthetic tests: preventing misleading interpretations

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Since physical processes in volcanic plumbing systems generate seismological signals on its surface, seismology plays an important role in determining the internal volcano dynamics. Long period (LP) events (f=0.2 – 2 Hz) are of particular interest as they are thought to be directly linked to pressure disturbances occurring within magmatic and/or hydrothermal systems. Although many different models have been proposed to explain these types of events, they all relate LP events to resonance of the fluid-filled cracks and conduits. Following the recent advances in computing power, inverting for LP source mechanisms has become increasingly common. The most critical aspect in such modelling procedures lies in the accurate calculation of the Green's functions. In general, a finer scale shallow structure ($\sim$ hundred metres) lies below the resolution limits commonly exhibited by 3D velocity models of volcanic interiors, thus implying that Green's functions are often not accurate enough for providing a realistic prediction of ground motion at individual recording sites. In volcanic environments, additional difficulties stem from the wavefield interaction with pronounced topography which modifies the wavefield in an often unpredictable manner, and from the finite dimensions of the source located relatively close to the recording sites. In order to examine our ability of obtaining a reasonable solution for the source mechanism by performing a point-source MT inversion in volcanic settings, we use 3D full wavefield simulations in heterogeneous Mt Etna models with topography to generate synthetic signals for the point and extended sources, respectively, and the Green's functions.

Moment tensor plus single force inversions of these synthetics demonstrate the extreme sensitivity of the solution for LP source forces to near-surface volcano structure. In particular, spurious forces and incorrect source geometries are obtained if the top 400 m is poorly constrained. In order to avoid such misleading results, we suggest constraining the possible solutions by as much a priori information as possible.