Geophysical Research Abstracts
Vol. 14, EGU2012-4620, 2012
EGU General Assembly 2012

Seismic envelope reconstruction in a volcanic caldera: theory, data, and modeling.

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Volcanic envelopes are generally used to infer the properties and to image the structures of volcanic media. The multiple scattering model describes energy propagation through scatterers, and can be used to synthesize envelopes. It does not provide any analytic solution for seismic waves in complex volcanic media, and its limit case, diffusion, is usually preferred to derive scattering parameters. Nevertheless, scientists can employ Monte Carlo simulations of the radiative transfer equations to obtain direct intensity measurements (envelopes).

A typical problem in Monte Carlo simulations is that the description of each scattering event by the single scattering coefficients is inefficient in a heterogeneous (volcanic) medium. We evidence this factor by using real volcanic envelopes; also, we overcome part of the problem including a drastic change in the scattering properties of the area. This allows to synthesize true coda envelopes at Campi Flegrei caldera at first order.

We synthesize the envelopes simulating a drastic change in the scattering properties of the medium. This requires the inclusion of boundary conditions in the a 2D Monte Carlo simulation of the scattered wave-field; these conditions are deterministic in nature, but produce stochastic effects, still described by the radiative transfer equations. The change produces a wave flux in a direction largely different from the incident one, a phenomenon evidenced in real seismic envelopes. Also, the model allows to mark the reach of diffusion in coda waves, at least in a medium without topography. This marker is important for many volcano-monitoring techniques as well as for interferometry.

We check our models by comparison with true data recorded in the whole caldera; the result is a reliable first order model of the envelopes included in the caldera rim, or in its proximities. Outside the rim, the envelopes present greater complexities, requiring the introduction of a new model including turbulence. The synthetics can be employed to check tomography structures - especially for attenuation and for scattering tomography. Also, it can be a basement stone for overcoming linear optics in the description of scattering in highly heterogeneous area.