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Seismic energy envelopes in volcanic media: in need of boundary conditions

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The total intensity flux produced by a seismic wave-field propagating in a volcanic medium and recorded at a seismic station is more than a simple mixture of a coherent (direct) intensity and an incoherent (fluctuating) scattered intensity. Data envelopes recorded at Campi Flegrei caldera show evidence of diffusion as well as steep amplitude increases in intermediate and late coda. Their behaviours can be explained by the presence of inhomogeneous scattering for energy propagating in the shallower crust and an earthquake geometry approximating an extended source. We show the results of a simulation with an unbounded statistical model, considering anisotropic scattering interactions and realistic parameters for a volcanic caldera. Then, we propose the inclusion of a diffusive boundary condition in the stochastic description of multiple scattering, in order to model intermediate and late coda intensities as well as the sharp intensity peaks at some stations in the caldera. Finally, we show that a reliable 2D synthetic model of the envelopes produced by earthquakes vertically sampling a small region can be obtained including a single drastic change in the scattering texture of the medium. These boundary conditions are diffusive, i. e. the boundary must have more scattering potential than the rest of the medium, so that the secondary sources on its interface(s) enhance coda intensities.
We achieve a good first-order model of high-frequency (18 Hz) envelope broadening adding to the Monte Carlo solution for the incident flux the secondary source effects produced by a closed annular boundary, designed on the caldera rim signature at 1.5 km depth. At lower frequencies (3 Hz) the annular boundary controls the intermediate and late coda envelope behavior, in a way similar to an extended diffusive source. In our interpretation, the anomalous intensities observed at several stations and predicted by the bounded Monte Carlo solutions are mainly due to the diffusive transmission-reflection from the caldera rim, and are controlled by its varying thickness. This is not the best fit model for the caldera, nevertheless it represents a new approach for the generation of coda waves in highly scattering media.