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Spatial concentration of coda energy in the summit region of volcanoes

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In general the energy of the seismic coda becomes uniformly distributed in space at some late lapse time, a fact that is used for example in the coda normalization method. Some recent observations at strato volcanoes, on the contrary, indicate an abnormal spatial concentration of coda energy in the summit regions of these volcanoes. This observed coda localization can be explained by the leakage of energy from the strongly scattering volcanic edifice into the much more homogeneous underlying earth crust. The leakage results in an inhomogeneous distribution of energy in space, where the energy is low near the volcano-crust boundary and large inside the strongly scattering volcano far from that boundary. We present two models for this observation: The first one is based on an analytical solution of the diffusion equation for a scattering cylinder (representing the volcano) embedded in a homogeneous half-space (representing the surrounding crust). The second model is based on a Monte-Carlo simulation of the acoustic equation of radiative transfer. In this simulation we take into account multiple scattering inside the volcanic edifice as well as leakage at the bottom of the volcano into the less heterogeneous crust. Additionally, in this model we also consider the true topography of the volcano by simulating reflections at the free surface, where we use a digital elevation model of the volcano and the Kirchhoff tangent plane method. Both models can explain the observed coda localization. We compare theoretical seismogram envelopes of both models to data of shallow volcano-tectonic earthquakes preceding the 1998 eruption of Merapi volcano (Indonesia).