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Numerical simulations of scattered seismic waves at a volcano using an elastic lattice method

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We simulated seismic waves at a volcano using a three-dimensional elastic lattice method (ELM). In this method, an elastic sold is represented by interconnected springs arranged on a cubic lattice. ELM is equivalent to a fourth-order finite difference method and has the advantage in the treatment of the free surface with topography compared to a finite difference method. We used a computational domain having lateral dimensions of 15 x 15 km and a vertical extent of 6 km with a grid spacing of 15 m. We used a point source of a tensile crack mechanism at a depth of roughly 2 km beneath the summit and distributed stations on the surface of the volcano with an interval of 750 m. We simulated waveforms with the frequency up to 10 Hz using a von Karman type random medium and the topography of Cotopaxi volcano, Ecuador. For three parameters of a von Karman autocorrelation function, we fixed the rms value of 0.05 and order of 0.5 and varied the correlation distance between 0.05 and 1.5 km. We estimated rms amplitudes of the envelopes of simulated vertical waveforms filtered in 0.2-2, 1-6, 3-8, and 5-10 Hz bands. The spatial distributions of the rms amplitudes show distortions of radiation patterns depending on both frequency and correlation distance; The distortion becomes significant as the frequency increases and the correlation distance decreases. The distorted pattern using a smaller correlation distance is more consistent with observed waveforms at Cotopaxi volcano. The topographic effect alone is not enough to reproduce the observed features. These results imply the importance of small scale medium heterogeneities in the generation of scattered waves at Cotopaxi and other volcanoes.