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Complex Effect of Surface Topography on Seismic Travel Times and Amplitudes

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Drastic topography changes have significant effects on the propagation of seismic waves, which leads to perturbations in waveforms and therefore the arrival times and amplitudes of seismic phases. Previous studies have focused on the influence of topography on the peak amplitudes of earthquake-induced strong ground motions in order to make realistic and reliable assessment of seismic hazards. Various of factors contribute to the topography-induced waveform changes, including not only the geometrical shape of the surface itself, but also the path-related incidence directions of the seismic waves which are dependent on the specific source-station geometry, i.e. the azimuth, distance and depth of the earthquake, and the velocity structure. Using the realistic topography of northern Taiwan, with an elevation change of over 6 km across a distance of less than 100 km, we carry out a systematic investigation into the effect of topography on the frequency-dependent seismic travel times and amplitudes. Topography-induced travel-time and amplitude anomalies are measured from accurate synthetics calculated by finite-difference method with and without topography. Results show that topography relief of northern Taiwan can introduce up to 0.5 s and 1.0 s in the travel times of direct P and S waves, respectively, of regional earthquakes, which are significant in tomography inversions for crustal velocity structures.