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Depth sensitivity of coda waves to velocity perturbations of an elastic heterogeneous medium

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In the context of the localization of weak changes in a heterogeneous elastic medium, we investigate the sensitivity of multiple scattered waves to local velocity perturbations occurring in a layer at depth.

To generate synthetic seismograms for our study, we simulate the propagation of a pulse in a 2D elastic half space with random velocity fluctuations. A 2D spectral-element solver (specfem2D) allows us to calculate the impulse response before and after a slight perturbation of the velocity in a thin layer (less than one wavelength). We perform a parametric analysis of the observed relative velocity change dv/v versus the depth position of the thin layer.

The relative velocity change dv/v in the coda of the seismograms is estimated by comparing the phase of the diffuse waveforms with and without velocity perturbation.

When analysing the apparent velocity variations dv/v versus depth of the perturbed layer, we can discriminate two different regimes: one for a shallow and one for a deep perturbed layer. The sensitivity of dv/v decays rapidly with depth until approximately half the Rayleigh wavelength. The later part of the curve shows a decay with a much longer characteristic distance.

We interpret the first regime as the footprint of the 1D depth sensitivity of the first mode of the surface waves. For perturbations at larger depth we propose a model based on a 2D diffusion regime in the bulk.