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# Sensitivity kernels for monitoring structural changes in highly heterogeneous elastic media

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Conventional geophysical imaging techniques rely on single-scattering phenomena. Subsurface images are obtained from primary reflections by assuming simple stratified models of the Earth. However, the Earth shows heterogeneities at different scales causing multiple scattering within the medium and increasing complexity of the wave propagation. These multiply-scattered waves are identified in seismograms as late arriving waves also known as coda waves. Coda waves sample the medium very densely and therefore become sensitive to tiny perturbations of its mechanical or structural properties. This feature makes them ideal for monitoring purposes and has led to the development of the coda-wave interferometry technique.
If the perturbation is due to a weak velocity anomaly, its effect can be measured as a time shift between the perturbed and non-perturbed waveforms. On the other hand, if the perturbation is due to a structural change, its effect is observed as a change in the waveform coherence (decorrelation).

Theoretical expressions have been developed to describe these types of perturbations (Pacheco & Snieder 2005; Larose et al., 2010). In both cases, they are given in terms of sensitivity kernels which indicate how sensitive the coda waves are to detect changes within the medium. Additionally, the kernel plays an important role during the inversion process which aims to obtain the location of the perturbation.

Margerin et al. 2016 show how each type of change (weak and structural perturbation) leads to a particular sensitivity kernel. In the general case, the directionality of the wave propagation is needed to compute such kernels. However, for the case of the decorrelation-kernel the directionality can be neglected under the assumption of isotropically-scattering structural change (i.e. a change of small size compared to the wavelength). In the present work, we show how a numerical approach can be used to build sensitivity kernels in the elastic regime.
In a heterogeneous elastic medium, P and S-waves are constantly converted from one state to another. A discrimination of the intensity contribution for each state is done by an analytical approach (Snieder et al., in prep., 2017) which leads to a derivation of sensitivity kernels for each state individually. Sensitivity kernels are obtained numerically from synthetic data of computer simulations over several realizations of scattering media.
P and S-wave individual contributions to the decorrelation are studied as well as its relative strengths. The S-wave contribution to the sensitivity kernel is found to be much higher than the one of the P-waves, except at early times in the coda, in which case the P-wave contribution dominates. At early times as well, the source mechanism influences the relative strength of the P and S-wave contributions, however at later times this effect vanishes due to the high scattering of the wavefield.