Formulating sensitivity kernels of coda waves to seismic velocity changes: Extension to vector waves (1)

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Coda-wave interferometry has been used to detect velocity changes in association with large earthquakes and volcanic eruptions. It is important to determine the region of velocity changes correctly for understanding physical mechanisms to cause the velocity changes. It is the sensitivity kernels of travel times of coda waves to velocity changes that concern with this problem. The sensitivity kernels have been formulated so far based on different assumptions for scalar waves using two-dimensional single scattering and multiple scattering, three-dimensional multiple scattering, and diffusion. However, no formulation has been made for vector waves as far as we know. Hence, we tackle this formulation and derive analytical expressions for two-dimensional cases. The key point in our simple extension to vector waves is the projection of seismic phonon energy into horizontal and vertical components by using the square of the direction cosine of the polarization direction. Thanks to this simple idea, we can derive analytical expressions of the sensitivity kernels by using the two-dimensional single isotropic scattering model for scalar waves, though we can treat either P waves or S waves at a time. Our results show that the sensitivity kernels are different for different components, and accordingly two components show different travel time changes with respect to lapse time. These are theoretically shown by this study for the first time. However, the sensitivity kernels for vector waves have also two clear peaks at a source and a receiver like those for scalar waves. We plan to validate the sensitivity kernels by comparing with finite difference simulations of vector wave propagation. The sensitivity kernels for vector waves are more practical and necessary for us to know how to use different components simultaneously.

Keywords: Sensitivity kernel, coda waves, vector waves

