

SENSITIVITY ANALYSIS OF WAVE-EQUATION TOMOGRAPHY:A MULTI-SCALE APPROACH

Earthquakes, viewed as passive sources, or controlled sources, like explosions, excite seismic body waves in the earth. One detects these waves at seismic stations distributed over the earth's surface. Wave-equation tomography is derived from cross correlating, at each station, data simulated in a reference model with the observed data, for a (large) set of seismic events. The times corresponding with the maxima of these cross correlations replace the notion of residual travel times used as data in traditional tomography. Using first-order perturbation, we develop an analysis of the transform, mapping a wavespeed contrast (between the 'true' and reference models) to these maxima. We develop a construction using curvelets, while maintaining an imprint of geometrical optics reminiscent of the geodesic X -ray transform. We then introduce the adjoint of the transform, which defines the imaging of wavespeed variations from 'finite-frequency travel time' residuals. The key underlying component is the construction of the Fréchet derivative of the solution to the seismic Cauchy initial value problem in wavespeed models of limited smoothness. The construction developed in this paper essentially clarifies how a wavespeed model is probed by the method of wave-equation tomography.