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Multi-scale approach to seismic inverse scattering and applications in Earth's upper mantle transition zone

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We present a program for elastic wave-equation inverse scattering, based on the single scattering approximation, from two interrelated points of view, known in the seismic imaging literature as "receiver functions" (unknown source) and "reverse-time migration" or RTM (known source). We discuss: (i) the development of an anisotropic polarized-wave equation formulation, (ii) the introduction of an (anisotropic) elastic-wave RTM inverse scattering transform, and (iii) the reformulation of (ii) using mode-converted wave constituents removing the knowledge of the source by introducing the new notion of array receiver functions which generalize the notion of receiver functions. We proceed with presenting a framework for inverse scattering via imaging and partial reconstruction with finite sets of events and seismic stations using multi-scale techniques: To carry out the analysis we make use of higher-dimensional curvelets and introduce associated matrix representations for the component operators that make up the inverse scattering transform. We analyze and exploit the properties of these matrices, and arrive at an efficient method for removing the relevant normal operator. We illustrate various aspects of this research program, integrated with mineral physics and thermo-chemical convection, beneath Hawaii.