Geophysical Research Abstracts
Vol. 14, EGU2012-13083-2, 2012
EGU General Assembly 2012

3-D Inverse Teleseismic Scattered Wave Imaging using the Kirchhoff Approximation

K. Liu (1,2) and A. Levander (1)

(1) Rice University, Earth Science, Houston, TX, United States (alan@rice.edu, 001 713 348-5214), (2) Rice University, Applied Physics Program, Houston, TX, United States

We have developed a 3-D teleseismic imaging technique for scattered elastic wavefields using the Kirchhoff approximation. Kirchhoff migration/inversion have been well developed in exploration seismology within the inverse scattering framework (e.g. Miller et al., 1987; Beylkin and Burridge, 1990) to image subsurface structure that generates secondary wavefields caused by localized heterogeneities. Application of this method in global seismology has been largely limited to 2-D images made with 1-D reference models due to high computational cost and the lack of adequately dense receiver arrays (Bostock, 2002, Poppeliers and Pavlis, 2003; Frederiksen and Revenaugh, 2004; Cao et al., 2010). The deployment of the USArray Transportable and Flexible arrays in the United States and dense array recordings in other countries motivate developing teleseismic scattered wavefield imaging with the Kirchhoff approximation for 3-D velocity models for both scalar and vector wavefields to improve upper mantle imaging.

Following Bostock's development of the 2-D problem (2002), we derive the 3-D P-to-S scattering inversion formula by phrasing the inverse problem in terms of the generalized Radon transform (GRT) and singular functions of discontinuity surfaces. In the forward scattering modeling, we extend the method to utilize a 3-D migration velocity model by calculating 3-D finite-difference traveltimes, backprojected from the receivers using an eikonal solver. To demonstrate the relative accuracy of the inversion, we examine several synthetic cases with a variety of discontinuity surfaces (sinuous, dipping, dome- and crater-shaped discontinuity interfaces, point scatterers, etc.). The Kirchhoff GRT imaging can successfully recover the shapes of these structures very well. We compare our Kirchhoff approximation imaging with the Born-approximate results, as well as the common-conversion point (CCP) stacked receiver function imaging for the various synthetic cases, and show a field example using USArray data.