Constructing a 3-D crustal velocity model for Oklahoma using full waveform inversion

Shuo Zhang, The University of Texas at Dallas, shuo.zhang@utdallas.edu
Hejun Zhu, The University of Texas at Dallas, hejun.zhu@utdallas.edu

Over the past decade, the seismicity rate in the state of Oklahoma has increased significantly, which has been suggested as related to saltwater injection during industrial operations. Taking advantage of these induced earthquakes and recently deployed seismometers, we construct a 3-D radially anisotropic seismic velocity model for the crust of Oklahoma by using full waveform inversion. To mitigate the cycle-skipping problem, we first conduct inversion to reduce phase differences, and then switch to waveform fitting in order to further improve the spatial solution of the velocity model. Misfit gradients with respect to different model parameters are preprocessed in order to balance results at shallow and great depths. Relative velocity perturbations in the inverted model allow us to delineate geological provinces in the study region, such as the Anadarko and Arkoma Basins and the Cherokee Platform. In the meanwhile, radial anisotropy in the inverted model indicates deformation within the middle/lower crust of Oklahoma, which might be induced by background tectonic stresses and alignments of anisotropic minerals. Furthermore, several synthetic experiments reveal that the 3-D crustal velocity model enables us to better locate earthquakes that occurred in Oklahoma, especially to constrain the depth, which allows us to better investigate the triggering processes of induced seismicity with saltwater injection.