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Time-dependent Seismic Tomography at the Coso Geothermal Area

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Variation of seismic wave speeds with time is an expected consequence of geothermal exploitation, but detecting and mapping such variation is not straightforward. Three-dimensional structure models derived using seismic tomography are subject to ambiguities caused by incomplete data coverage and observational errors, which can easily exceed any real changes in the wave speeds. Simple comparison of tomographic models based on data from different epochs may thus lead to false detections of change. We have studied changes in structure at the Coso geothermal area in southeastern California using microearthquake seismic tomography, but instead of inverting data sets from different epochs independently, we invert them simultaneously, seeking changes in structure that are required by the data. This algorithm, TOMO4D, seeks to minimize the differences between derived models as well as to optimize the fit between observed and predicted arrival times. Tests using synthetic data show that the method is sensitive to small changes in wave speed but suppresses false alarms, i.e., changes in structure that are not required by the data. Recent additions to TOMO4D include the ability to use data from regional as well as local earthquakes and to impose optional constraints on various measures of model complexity. Coso is the seventh largest exploited geothermal area in the world. It is 28 km2 in area, and has a water-dominated reservoir with temperatures up to a maximum of 349慢. The Coso field has produced for over two decades, and currently has 100 production wells up to 3.8 km deep that provide hot water and steam that is generating 170 MW of electricity. In our presentation, we will report in detail on studies of Vp, Vs and Vp/Vs covering the epochs 1996-2006 and 2007-2012.