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Time-resolved seismic tomography and its contribution in the EGS geothermal reservoir of Soultz-Sous-Forêts (France) during hydraulic stimulations

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One major goal of monitoring seismicity accompanying hydraulic stimulation of a reservoir is to recover the seismic velocity field in and around the geothermal site. Several studies have shown that the 4D (time dependent) seismic tomographies are very useful to illustrate and study the temporal variation of the seismic velocities conditioned by injected fluids. However, only an appropriate separation of the data in subsets and a reliable tomographic method allow studying representative variations of the seismic velocities during and after the injection periods.
In 2000 and 2003, two injection tests were performed at the Enhanced Geothermal System (EGS) site of Soultz-sous-Forêts (Alsace, France) for the wells GPK2 and GPK3.
Both stimulation tests produced several thousands of micro-earthquakes with Duration Magnitude ranging from -0.9 to 2.5 in 2000, and up to 2.9 in 2003. The earthquakes were located by down hole and surface seismic stations. The two wells behaved differently during and after the stimulations as has been shown by several authors.
We present here a comparison between new 4D seismic tomographies performed using the two datasets. The velocity models have been obtained using the Double-Difference tomographic method (Zhang and Thurber 2003) and further improved with the post-processing WAM technique (Calo' et al., 2009).
The subsetting of the data was performed by taking into account the injection parameters of the stimulation tests (namely the injected flow rate and the wellhead pressure).
The results show, for both injections, changes in seismic properties strictly correlated with the variations of the hydraulic parameters and referred to the transient changes of the stress regime during the stimulations. The improvement and the reliability of these new velocity models, provides new perspectives for the understanding of mechanical processes that occurred during the stimulations.