3D stochastic tomography for local earthquakes

Ahmed Jabrane, PhD student MINES ParisTech

Microseismic monitoring consists of locating earthquakes in the imaged structure in order to map faults or fractures. A precise location of earthquakes is therefore essential to carry out reliable interpretations and understand the mechanisms of fracturing. Monitoring has a strong impact since it applies to several scales and in a wide range of fields: induced seismicity (eg geothermal fields, mines, oil reservoirs) but also natural seismicity (eg subduction zones, rifts or volcanoes) . Despite this massive use, earthquake locations are not always reliable. One of the main causes of localization errors is the lack of knowledge of the speed model. It is therefore essential to propose new approaches that make it possible to better constrain the speed model and to take precisely into account the uncertainties of the speed model in the localization of earthquakes. We recently developed stochastic tomography approaches that estimate uncertainties in the speed model with efficient Markov Chain Monte Carlo (MCMC) algorithms (Bottero et al., 2016). These uncertainties can then be propagated to localization errors of seismic events (Gesret et al., 2015). However, these approaches are currently limited to the case where active fire is available (typically in hydrocarbon exploitation) in order to carry out the tomography. However, in many contexts such as geothermal, only natural or induced seismicity is recorded. The objective will be to develop an approach that aims to estimate the uncertainties of the speed model by using a selection of seismic events and then propagate the uncertainties of speed to other events. Selection will be a necessary step as stochastic approaches can only be applied to a limited number of data. An original and parsimonious parametrization of the speed model based on Johnson-Mehl cells (Belhadj, 2016) will be extended from 2D to 3D. The information on the polarization of the wave recorded at the sensor can also be integrated into the formulation in order to better constrain the tomography. We can then envisage an update of the velocity model over time that will allow a reliable microseismic tracking. This approach will be tested and validated on synthetic data before being applied to real data of natural and / or induced seismicity.