Data-driven method for seismic source inversion: Potency Density Tensor Inversion

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Seismic waveforms contain information on the rupture propagation process as well as on the fault geometry. The fault geometry should be complex, reflecting the heterogeneity of the underground structure and stress field. The complexity of fault geometry is important for understanding the irregular rupture propagation pattern, stress field and tectonics. In conventional finite-fault inversions, the assumption of an over-simplified fault geometry has led to problems where the solution is distorted by the effects of modelling errors caused by ignoring the complex fault geometry information contained in the data. We have developed a data-driven method for seismic source inversion, potency density tensor inversion, which takes into account the inclusion of fault geometry information in the data.
Tele-seismic body waves are sensitive to perturbations in the focal mechanism solution, including information on the fault geometry, while having low spatial resolution. Potency density tensor inversion has been developed to take advantage of these properties. Instead of assuming a fault plane that approximates the true fault plane, this method estimates the potency density tensor along an arranged model plane by extending the number of basis double couple components from two to five. Within a few years of its development, the potency density tensor inversion has been applied to many earthquakes and has led to the discovery of phenomena such as back-rupture propagations and irregularities in rupture propagation due to perturbations in fault geometry.
As the potency density tensor contains information on the fault geometry, it is also possible to estimate the fault geometry from the inversion results. First, the initial fault model is set, the potency density tensor distribution on the fault model is estimated, and then the spatial distribution of strike or dip is extracted. Next, a new fault model is constructed from the location of the hypocenter and the spatial distribution of strike or dip angle. After this, the fault model is successively updated to obtain the optimum fault geometry and potency density tensor distribution. If the resulting potency density tensor and the reconstructed fault plane coincide, the slip distribution on the fault plane can be obtained directly. Although the application of this method is still limited, it has been successfully applied to the simultaneous estimation of fault geometry and rupture propagation processes in several earthquakes.
Potency density tensor inversion, a new seismic source inversion that exploits the data properties of tele-seismic body waves, is an innovative method that not only extracts information on fault geometry but also reduces modelling errors by expanding the solution space.

Keywords: seismic source process, Data-driven method, inversion