Focal Mechanism and Uncertainty Estimation in Data-Sparse Settings

An assumed double-couple focal mechanism can be inferred by inversion of observed body wave amplitudes when given waveform data from one three-component seismometer with *P*, *SV* and *SH* signals. Since *P* and *S* waves have different noise levels, asymmetry of uncertainty in the observed data propagates to the estimated source mechanism parameters. For the general case where we need to interpret relative amplitudes rather than absolute amplitudes, inversion leads to an entire class of focal mechanisms which produce body waves whose amplitude vectors, represented in 3D space, point in the same direction as the observed amplitude vector. This approach is especially useful for data-sparse regions because it accounts for amplitudes, polarities and uncertainties in a simple and geometrically elegant way.

Most existing methods for focal mechanism inversion use some form of brute force, commonly grid search. We have developed a hybrid of brute force (random search) and directed search (gradient descent) methods to trace out the best-fitting class of mechanisms in different 3D spaces capturing parameters like strike, dip and rake or T-axis and P-axis orientations. Gradient descent with randomly sampled starting points not only allows for the computation to be time efficient, but also for systematic exploration of multiple minima. We show that some parameter spaces can capture these classes of mechanisms in a more concise and interpretable way, as well as provide an advantage when propagating the associated uncertainty using Monte-Carlo methods.

The broad aim of our research is to demonstrate the utility of the new inversion and uncertainty estimation methods compared to others commonly used, provide an analysis of the pros and cons of our method and show example cases using data from Uganda: focal mechanisms of East African rift earthquakes which occurred before and during a dense deployment of temporary seismometers.