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Moment Tensor Inversion Using the Kiwi Tools: Application to Regional Seismicity in Portugal

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Automatic moment tensor inversions have been applied to earthquakes worldwide since the early 1980s. Since then many techniques have been developed and implemented to perform moment tensor inversions of earthquakes at different scales and in different regions. These inversions typically yield the focal mechanism, magnitude and hypocentral depth of the earthquakes. In some cases, the centroid location is also determined. The finite source of earthquakes has also been studied using several methods. However, fewer attempts have been carried out so far, in order to quickly and automatically determinate extended source parameters.

In this presentation we will focus on the adoption of a recently developed inversion method to perform point and kinematic source inversions at regional distances, and its application to regional seismicity recorded in Portugal and neighboring regions. The algorithm works in different steps. At first, we assume a point source approximation. We initially retrieve the focal mechanism of the earthquake (strike, dip, and rake), the seismic scalar moment M0 and the depth. This inversion step is performed in the spectral domain, by fitting amplitude spectra. Since compressive and dilatation quadrants are not distinguishable, this information is retrieved during the second step, which is carried out in the time domain. Refined latitude and longitude for the centroid, as well as an earthquake origin time, can be also retrieved at this time. The final step of the inversion consists of a simplified finite-fault inversion. We assume the recently proposed eikonal source model, and determine parameters such as the fault plane orientation (discrimination between fault and auxiliary plane), radius (rupture extension), nucleation point coordinates (indicative of directivity effects) and average rupture velocity of the earthquake. This inversion is performed in the spectral domain, including higher frequency during the fitting process, and using a grid walk scheme with an L1 norm. This multi-step approach has the advantage of using different inversion methods, seismic phases and range of frequencies to infer specific parameters. The presented inversion algorithm is implemented with the Kiwi tools, an experimental software package that allows the fast calculation of synthetic seismograms for extended earthquake sources by using Green's function databases.

We will show the application of the inversion algorithm to regional earthquakes recorded by the Portuguese broadband seismic network since 2007. In particular, we will present results for the Mw5.9, 12 February 2007, Cape St Vincent earthquake. For this earthquake we were able to determine not only point-source parameters (focal mechanism, depth, seismic moment and centroid location), but also finite-fault parameters (preferred fault plane, rupture extension and directivity analysis). We assess the robustness of our results by using both regional and teleseismic waveforms, and by performing a bootstrap analysis. We will further present point-source characteristics (focal mechanism, depth, seismic moment and centroid location) of other regional earthquakes of M>3.5. The small magnitude of these earthquakes prevents their study with the third step of the algorithm and consequent determination of finite-fault parameters. We present focal mechanisms for this set of smaller magnitude events. Among these, only four earthquakes have previously published focal mechanisms.