CHARACTERIZING EARTHQUAKE SOURCE PHYSICS WITH SOURCE SCANNING ALGORITHMS

F. Massin[1], A. Malcom[1]
[1]*Memorial University of Newfoundland, St. John's, Canada.*

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Earthquake swarms that lack a clear main-shock are particularly difficult to explain and characterize for hazard assessment. These events could be triggered in the vicinity of a local perturbation from many sources, natural or not, with implications for our understanding of the rupture characteristics of earthquakes. We tackle the problem of understanding perturbing mechanisms, by investigating the location, mechanism and extent of earthquake ruptures. Ultimately we are interested in estimating the stress field and pore pressure that control the mechanical instabilities of earthquakes and clustered seismicity sequences. In this preliminary study, we investigate the potential of shift and stack methodologies for the probabilistic analysis of focal mechanism determination and relative earthquake location.

Shift and stack methods for earthquake location, or source scanning algorithm (SSA), are based on three steps: 1) pre-calculation of travel time grids (also defining the hypocenter solution space), 2) calculating a characteristic function of the body-wave arrivals from continuous data, with signal processing methods, 3) the shifting and summation of the characteristic functions in each grid cell, with shifts defined by the pre-calculated travel times. Ideally, the power recovered by the entire network as a function of time can be used for simultaneous event detection and location. Although the SSA method shows promise for automatic detection and location of events, it is limited by the precision of the pre-defined grid.

We extend this approach to focal mechanism determination with slight modifications. We first pre-calculate the polarity distribution for all double couple orientations. Then polarity corrections are applied to the first motion wavelets (as extracted with SSA) from all possible mechanisms. For the optimal orientation, the wavelets with downward first motions are multiplied by negative polarities and thus all wavelets stack constructively. Finally, the probability of each double couple orientation is estimated by stacking the modified wavelets.

In the classic approach, the hypocenter position and double couple orientation are estimated by taking the maximum of gridded objective functions (i.e. the amplitude of the stacked characteristic functions and wavelets). To overcome the limitation in hypocenter precision mentioned above, we investigate inversion schemes and relative location procedures. We first study a simplified approach for relative location using reference events. To do so, we consider the classic relative location scheme of an event compared to several reference events in which the travel time differences of each event pair as a function of azimuth is a sinusoid.

References