Mitigating Spatial Bias of Back-projections with the Slowness Enhanced Back Projection

Bao, H.[1], Feng, T. [1], Meng, L.[1],
1 *University of California, Los Angeles, California, USA*

Benefiting from recently development of regional seismic arrays, the back-projection (BP) method images the dynamic rupture process and resolve their geometrical complexities with unprecedented details. Unlike source inversion methods, BP tracks high frequency radiators based on coherent phases of seismic traces without any prior assumptions of fault parametrization or regularization. However, the spatial accuracy of BP suffers from the travel-time errors when using 1D reference velocity model to approximate the real 3D Earth structures. For large earthquakes of hundreds of kilometers in rupture length, the static travel-time correction based on hypocenter alignment (Ishii et al., 2005) is only valid at the vicinity of hypocenters. Empirical interpolations of travel-time correction based on aftershock measurements have been employed to reduce the time errors for BPs of large earthquakes. However, such non-parametric interpolation requires dense and uniform distribution of large aftershocks. Meng et al (2016) proposed a parametric time correction based on the slowness error in the source area. This approach proves to significantly reduce spatial bias of BP using only a couple of large aftershocks. Here we perform the Slowness-Enhanced Back-Projection (SEBP) to image kinematic rupture process of the 2004 M 9.0 Sumatra, 2010 M8.8 Maule, 2011 M9.0 Tohoku-Oki, 2015 M8.3 Illapel, and 2017 M8.1 Mexico earthquakes. The effectiveness of SEBP can be firstly shown by the reduction of root-mean-square (RMS) errors of aftershocks' locations inferred by BP. For example, the RMS error of aftershocks for 2015 Illapel earthquake was reduced from 24.17 km to 8.11 km. Moreover, SEBP produces more accurate estimation of rupture directivities, rupture speeds, and fault geometry. For instance, the rupture length of 2017 Oaxaca earthquake is revised from 150 km to 200 km, and the rupture speed is corrected from 2.3 km/s to 3.1 km/s. Such improvement in fine details is essential for interpreting rupture behaviors and understanding their physics. Our studies demonstrate the effectiveness of SEBP to probe dynamic ruptures of large earthquakes with better spatial accuracy.

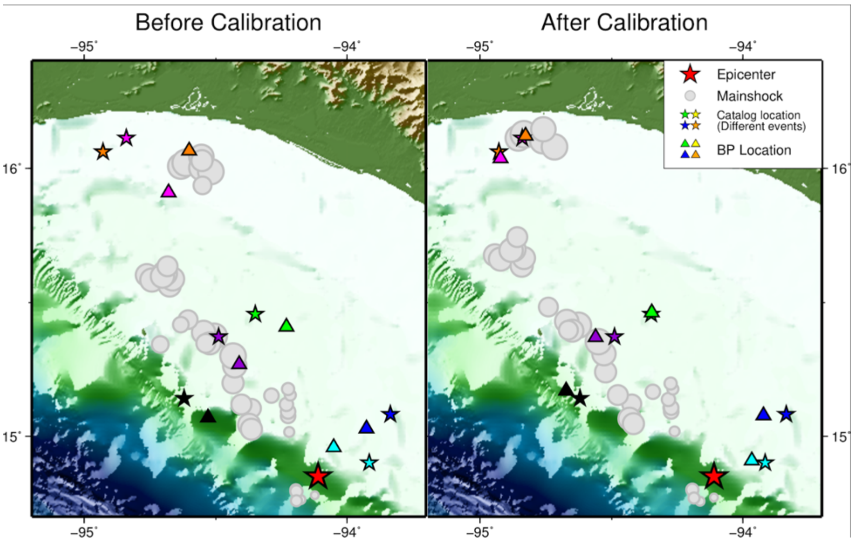

Figure 1. Teleseismic back-projections of the 2017 M 8.2 Mexico earthquake before (a) and after (b) slowness calibration. Big red star: Mainshock epicenter. Smaller colorful star: aftershocks relocated relative to mainshock epicenter using regional P arrival times. Smaller colorful triangle: aftershock locations indicated by Back-projection. Grey circle: high-frequency radiators of mainshock.