Mitigating the spatial biases of back-projection imaging using a “station-based” slowness calibration

Han Bao

UCLA; USTC(Univ of Sci and Tech of China)  eniesbao@mail.ustc.edu.cn

The back projection (BP) approach has been widely used for earthquake source analysis, especially for imaging the complexity of the dynamic rupture of recent megathrust earthquakes. However, in the previous studies of several large earthquakes, such as 2004 M9.0 Sumatra and 2015 M7.8 Nepal earthquakes, the propagation directions and speeds differ significantly between the BPs of arrays located in different continents. This discrepancy indicates that the conventional BP approach suffers from spatial bias in source locations. In order to improve the accuracy of BP imaging, a new aftershock-based correction was introduced into the BP approach to account for uncertainty of the ray parameter (slowness) caused by approximating the 3D velocity structures with a 1D reference model. Such calibrations rely on calculating the spatial derivatives of travel times between aftershocks. However, the inferred slowness may inherit additional errors from the uncertainty of aftershock locations and origin times in routine earthquake catalogs. To circumvent this issue, here we present an alternative approach to compute the slowness anomalies. Instead of computing the spatial derivatives of travel times on the source side, we calculate the travel-time derivatives between nearby stations along a similar ray-path. We seek to test such approximations by imaging various synthetic rupture scenarios based on travel times predicted by a 3D global P-wave velocity model (LLNL-G3D). We find that the BPs calibrated by the “station-based” slowness correction achieve similar performances in mitigating the spatial biases seen in un-calibrated BPs. We therefore consider the “station-based” slowness calibration approach an important addition of the back-projection analysis.