Multiscale heterogeneity of the 2011 Tohoku-oki earthquake by inversion

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Earthquake fault heterogeneity is often studied on a set of subfaults in kinematic inversion, while it is sometimes described with spatially localized geometry. Aochi and Ide (EPS, 2011) and Ide and Aochi (submitted to Pageoph and AGU, 2012) apply a concept of multi-scale heterogeneity to simulate the dynamic rupture process of the 2011 Tohoku-oki earthquake, introducing circular patches of different dimension in fault fracture energy distribution. Previously the patches are given by the past moderate earthquakes in this region, and this seems to be consistent with the evolution process of this mega earthquake, although a few patches, in particular, the largest patch, had not been known previously. In this study, we try to identify patches by inversion. As demonstrated in several earthquakes including the 2010 Maule (M8.8) earthquake, it is possible to indentify two asperities of ellipse kinematically or dynamically (e.g. Ruiz and Madariaga, 2011, and so on). In the successful examples, different asperities are rather visible, separated in space. However the Tohoku-oki earthquake has hierarchical structure of heterogeneity.

We apply the Genetic Algorithm to inverse the model parameters from the ground motions (K-net and Kik-net from NIED) and the high sampling GPS (GSI). Starting from low frequency ranges (> 50 seconds), we obtain an ellipse corresponding to M9 event located around the hypocenter, coherent with the previous result by Madariaga et al. (pers. comm.). However it is difficult to identify the second smaller with few constraints. This is mainly because the largest covers the entire rupture area and any smaller patch improves the fitting only for the closer stations. Again, this needs to introduce the multi-scale concept in inversion procedure. Instead of finding the largest one at first, we have to start to extract rather smaller moderate patches from the beginning of the record, following the rupture process.