Geodetic inversion of complex fault geometries for strong earthquakes

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The fault geometry closely controls earthquake rupture process. Previous seismic inversion of the fault geometry is to derive the multiple-point moment tensor solutions. Because of the trade-off between the moment tensor and rupture velocity, the inversion has high instabilities. In contrast, geodetic inversion has less unknowns, since there is no need to solve for rupture velocity. But from the elastic dislocation theory, the relations between the surface deformation and sub-fault parameters (i.e. strike, dip and rake) are nonlinear. In this study, we develop a linear technique to invert geodetic data for sub-fault moment tensors. From the sub-fault moment tensor solutions, the strike, dip, rake, and their spatial variations can be estimated, which provide valuable information for assessing the complexities in fault geometry. We applied this technique to several significant earthquakes, i.e., the 2008 Mw7.9 Wenchuan earthquake, the 2015 Mw7.8 Gorkha earthquake, and the 2017 Mw6.5 Jiuzhaigou earthquake. The results of the 2008 Wenchuan earthquake suggest that the strike, dip and rake are all variable from southwest to northeast, which are well consistent with the aftershock distributions and mechanisms. The dip variations of the 2015 Gorkha earthquake suggest the earthquake has ruptured a listric fault (dep decreases with depth). Particularly, a dip anomaly appears in the northeast corner of the rupture area, indicating a geometric barrier accounting for the slip gap between the mainshock and largest Mw7.3 aftershock. For the 2017 Jiuzhaigou earthquake, two right-stepping and left-lateral strike-slip segments were distinguished. Accordingly, a compressional step-over was identified between the two segments.