Dynamic rupture simulation of the 2019 M7.1 Ridgecrest, CA, earthquake: Effects of 3-D fault geometry

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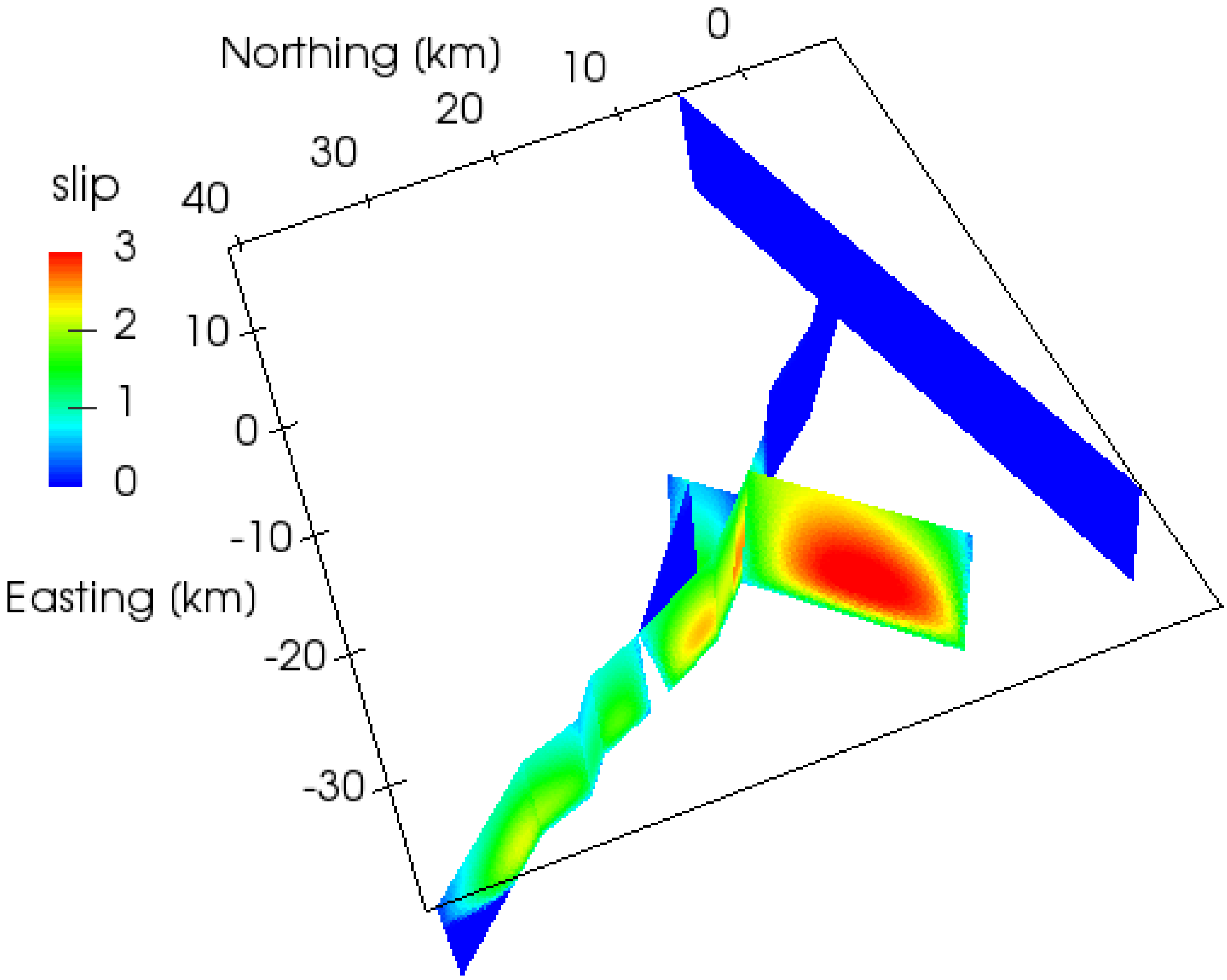
The 2019 M7.1 Ridgecrest earthquake occurred on July 6, 2019, preceded by the M6.4 foreshock on July 4. This earthquake sequence presents observational evidence indicating the involvement of the geometrical fault complexity in controlling dynamic rupture processes. Aftershock distributions clearly show the foreshock rupture propagates through a conjugate fault system with two major fault surfaces. The surface breaks deduced from the InSAR imageries shows several kinks in the main strand of the surface fault, leading to the along-strike variation of the fault surfaces. Although the earthquake seems not to occur on a known major fault, the observed surface breaks appear to match with the previously documented quaternary fault traces (https://earthquake.usgs.gov/hazards/qfaults/) in some part. In this study, we aim to simulate the dynamic rupture process of the Ridgecrest earthquake to understand the effects of the non-planar fault geometry.

We construct our physics-based model considering the 3-D fault geometry, the slip-weakening friction law, and the regional stress field. The 3-D fault embedded in the elastic half-space (Fig.) is constrained based on the aftershock distributions and the InSAR derived surface deformation. The regional stress field is constrained by referring to the previous estimates (Hardebeck and Hauksson, 2001), indicating the predominant N-S compression and the strike-slip regime. The characteristic slip weakening distance Dc is a few tens of cm.

Preliminary simulations confirm the existence of spatially varying potential stress drop (initial tractions) on the fault surfaces, which can play important roles to control the dynamic rupture process. The NE-SW trending conjugate fault broken during the foreshock oriented optimally in the applied regional stress field, while the NW-SE trending main fault broken during the mainshock is also in the optimal orientation. The simulations demonstrate the dynamic rupture transfer among multi-fault segments and the rupture sometimes hesitates on misoriented segments, which may explain the occurrence of the foreshock.


Northing (km)
0
10
20
30
40
slip
3
2
1
0
10
0
-10
-20
-30
Easting (km)