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Effect of crustal stress on surface slip of dynamic rupture on an earthquake fault by means of numerical simulations

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Numerical simulations of dynamic rupture propagation on a vertical strike slip fault in an elastic medium were conducted to examine the effects of crustal stresses on a coseismic surface slip. We first assumed a simplified model (model A) and a more realistic one (model B) of the crustal stress fields. We introduce a critical depth, Ds, at which the shear stress on the strike-slip fault is relatively low in the shallower part. In the model A, a normal stress on the fault is uniformly 120 MPa, and the share stresses in the shallower and deeper parts are zero and 70 MPa, respectively. In the model B, the stresses in the shallower part obey the standard model of depth dependences of the maximum and minimum principal stresses proposed by Tanaka (1986). The stresses in the deeper part are the same as those of the model A.
Secondly, the dynamic rupture propagations in the two stress field models are simulated assuming a slip-weakening friction law. A 3-D finite-different code formulated by Kase and Kuge (2001) is used for simulations. The simulation results in the model A clearly show that the critical depth, Ds, strongly controls the surface slip: the small difference of Ds causes a large difference of the surface slip in cases of Ds < 3 km. The simulation results in the model B show a remarkable phenomenon in the case of Ds = 4 km: a secondary rupture with a slip of about 10 cm is triggered at the earth surface and stops at a shallower depth than Ds, while a main rupture started from the deepest part of the prescribed earthquake fault stops around at Ds of 4 km. Thus, a region without a rupture between the main and secondary ruptures remains. It suggests that the secondary rupture in the simulation is a possible cause of the actual surface slip of about 10 cm observed along the surface.

Keywords: surface rupture, crustal stress, multitude of surface slip, dymamic rupture propagation, finite difference simulation