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An artificial stress asperity for initialization of spontaneous rupture propagation - a parametric study of a dynamic model with linear slip-weakening friction

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Artificial procedures are used to initiate spontaneous rupture on faults with the linear slip-weakening (LSW) friction law. Probably the most frequent technique is the stress asperity. It is important to minimize effects of the artificial initialization on the phase of the spontaneous rupture propagation. The effects may strongly depend on the geometry and size of the asperity, spatial distribution of the stress in and around the asperity, and a maximum stress-overshoot value.

A square initialization zone with the stress discontinuously falling down at the asperity border to the level of the initial stress has been frequently applied (e.g., in the SCEC verification exercise). Galis et al. (2010) and Bizzarri (2010) independently introduced the elliptical asperity with a smooth spatial stress distribution in and around the asperity. In both papers the width of smoothing/tapering zone was only ad-hoc defined.

Numerical simulations indicate that the ADER-DG method can account for a discontinuous-stress initialization more accurately than the FE method. Considering the ADER-DG solution a reference we performed numerical simulations in order to define the width of the smoothing/tapering zone to be used in the FE and FD-FE hybrid methods for spontaneous rupture propagation.

We considered different sizes of initialization zone, different shapes of the initialization zone (square, circle, ellipse), different spatial distributions of stress (smooth, discontinuous), and different stress-overshoot values to investigate conditions of the spontaneous rupture propagation.

We compare our numerical results with the 2D and 3D estimates by Andrews (1976a,b), Day (1982), Campillo & Ionescu (1997), Favreau at al. (1999) and Uenishi & Rice (2003, 2004).

Results of our study may help modelers to better setup the initialization zone in order to avoid, e.g., a too large initialization zone and reduce numerical artifacts.