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Simulation of co-seismic secondary fracture displacements: effects of rupture propagation method and fault properties

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Using dynamic earthquake simulations, we calculate co-seismic secondary fracture shear displacements induced by dynamic and static stress variations. Our results are aimed at improved safety assessment of underground waste storage facilities, e.g. a nuclear waste repository. We use a model with a pre-defined earthquake fault plane (primary fault) surrounded by smaller discontinuities (target fractures) representing faults in which shear movements may be induced by the earthquake. The primary fault and the target fractures are embedded in an elastic medium. We compare two methods for propagating the earthquake rupture and study how the choice of method may impact on the amount of secondary fault shear displacement. In the first method, which we have applied in previous studies, we apply a time-weakening algorithm with a pre-defined constant rupture velocity (vr). This means that we control the rupture velocity as well as the time over which the fault strength break-down takes place (rt). In the second method, we instead apply the linear slip-weakening law, with which the rupture propagates spontaneously and the strength break-down is a function of fault slip, i.e. the break-down takes place over a pre-defined slip-weakening distance (rcrit). To find appropriate cases for our method comparison, we perform several simulations, which cover wide ranges of vr, rt and rcrit. In addition, by applying spatial variations of fault shear strength, we study how inhomogeneous fault properties may influence the results.