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Impact of coseismic off-fault damage on the overall energy budget.

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In the brittle part of the crust, deformation is usually perceived to be the result of displacement along fault planes, whose behaviors are controlled by their frictional properties. However, fault zones not only consist of a narrow fault core where slip occurs, they are also surrounded by a complex structure which is of key importance in the mechanics of faulting, hence in determining the overall energy budget. Indeed, as pointed out by the numerous field, geophysical, mechanical and laboratory observations, if the behavior of fault zones is intrinsically linked to the properties of the main sliding plane, it also depends on those of the surrounding medium. In parallel, fault displacements may induce a substantial change in the physical properties of the surrounding medium. As a consequence, to improve our understanding of active fault zones, fault slip and the evolving physical properties must be studied as a unique system of stress accommodation and no longer as two distinct entities. To tackle this problem, we have developed a micromechanics-based constitutive model, thermodynamically argued, that can determine the inelastic behavior at macroscopic scale that arises from structural rearrangements at microscale. It is therefore the compulsory tool to emulate the strong coupling between the bulk and the fault that prevails during earthquakes. With this code, we can reproduce the strain rate sensitive, non-linear stress-strain relationship that leads to off-fault damage as a seismic event is propagating. We explore different scenarii and we show that there is a unique off-fault damage pattern associated with supershear transition of an earthquake rupture, that is also observed in the field. We define, in return, the impact of damage on the propagation of the earthquake in itself and the generated waves. We conclude by assessing the kinetic energy, the dissipated energy and the radiated energy to define how energy is consumed within crustal systems during seismic events.