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Thermo-mechanical coupling of faults and mantle shear zones

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Paleo-seismological records suggest non-steady and potentially periodic trends in slip rates over time scales of the order of millennia. It is unclear whether the variability of recurrence times is due to fault processes alone or if they are modulated by off-fault deformation. Theoretical and numerical modeling of fault kinematics from geodetic data have enabled an explosion of new findings about the mechanics of the earthquake cycle. However, these models have been mostly confined to processes along the interface of a fault. Therefore many sources of off-fault deformation, such as thermoelasticity and viscoelasticity, cannot yet be accounted for in the earthquake cycle. Here, we couple fault kinematics and viscoelastic deformation within shear zones using the integral method to simulate unified earthquake cycles that combine fault and off-fault processes. We consider the modulation of slip rates along a fault within the brittle layer due to strain in a viscoelastic substrate beneath the brittle-ductile transition. By implementing a thermally-activated rheology accounting for thermal diffusion, we investigate the thermo-mechanical coupling of faults and mantle shear zones and its implications for earthquake recurrence.