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Fault healing model for the seismic cycle: Example of the 1999 Mw 7.6/7.2 Izmit-Duzce earthquake sequence

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Previous geodetic studies have shown that earthquake co-seismic displacements are usually greatest at intermediate depths (i.e. 2-8 km). At shallow depths (i.e. 0-2 km), coseismic displacements tend to range between 0 and 100% of the maximum displacement, depending on the magnitude of the earthquake and the nearfield fault geology. From intermediate depths to the brittle-ductile transition (i.e 8-20 km), coseismic displacements again decrease. We use this characteristic coseismic displacement profile to constrain a 3-layer, elastic model for the seismic cycle. Assuming that the intermediate layer with the highest displacement relocks soon after the earthquake, we use GPS velocities obtained after the 1999 Mw 7.6/7.2 Izmit-Duzce earthquake pair to constrain time-dependent postseismic slip-rates on the shallow and deep layers of the fault. The models suggest that shallower postseismic slip decays rapidly, although after slip on the order of a few mm/yr may last for several decades; a result that is supported by InSAR and cross-fault creep meter observations that indicate ongoing afterslip along both the 1999 Izmit-Duzce earthquake segment and the 1944 Mw 7.3 Izmetpasa earthquake segment. Postseismic-slip at deeper depths decreases more slowly, accounting for the majority of the postseismic deformation signal.
We suggest that this model reflects the post-earthquake healing processes on the fault plane. Relocking of the fault in preparation for the next earthquake very soon after the event implies a shorter earthquake repeat time.