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Interactions between fault geometry, crustal damage and slip before, during and after the 2023 Kahramanmaraş earthquakes (Turkey)

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Large continental strike-slip earthquakes usually present a complex rupture trace composed of several segments separated by discontinuities. Fault geometry may interact with stress concentration and rupture propagation and have an influence on the distribution of coseismic slip and the termination of ruptures. However, other factors can influence slip distribution and rupture propagation, such as the rheology of the fault and the bulk, which can be affected by crustal damage from earthquakes, and the initial stress state, which notably depends on slip history. Here we characterize these complex interactions in the case of the 2023 Mw 7.8 Pazarcık and Mw 7.5 Elbistan earthquakes that ruptured several segments of the East Anatolian Fault Zone (EAFZ) in south-central Turkey. We use a Bayesian framework to model coseismic slip in a layered elastic medium with geodetic data. In our model, most of the slip occurs above 15 km depth, with a shallow slip deficit. Shallow slip decreases at geometrical complexities supposedly due to off-fault deformation in these highly damaged areas. The termination of both ruptures also correspond to geometrical complexities. Aftershocks spread in wide fan-shaped damage zones around the southwestern tip of both ruptures, whereas they are more focused on the main fault or on subparallel planar structures to the northeast. We also build 2-year postseismic Sentinel-1 InSAR displacement time series and find that the segments with relatively strong shallow afterslip are located at the northeastern end of the rupture trace for both earthquakes. Preseismic InSAR time series computed by the FLATSIM service also show shallow creep on the Pütürge segment northeast of the Pazarcık rupture and more distributed deformation in the rest of the EAFZ. These observations suggest that deformation in the EAFZ is more localized to the northeast and more distributed to the southwest before, during and after the 2023 earthquakes. Our postseismic displacement time series also shows shallow creep on several secondary faults. Comparing these deformations to the stress changes caused by the 2023 earthquakes can give interesting rheological insights and help refine our understanding of the complex interactions between fault geometry, crustal damage and slip.

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