Complex triggering and rupture dynamics of the 2023 Turkey M_w7.8-7.7 earthquake doublet from space geodetic and seismic imaging

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Abstract. The destructive 2023 Kahramanmaras Mw 7.8 and 7.7 earthquake doublet in southwest Turkey occurred as a complex rupture sequence that involved slip on multiple fault segments. Here, we use both seismic and geodetic data to resolve the fault slip distribution for these events and their time evolution. We used Synthetic Aperture Radar (SAR) data collected by Sentinel-1 and ALOS-2 satellite missions to map the rupture traces and coseismic displacements. SAR measurements were complemented by vector displacements from a local network of continuous GNSS sites. The initial Mw 7.8 earthquake ultimately ruptured about 300 km of the East Anatolian Fault (EAF) but nucleated on a subsidiary fault, the Nurdağı-Pazarcık Fault (NPF). Most of the EAF rupture was to the northeast at sub-shear-wave speeds but rupture to the southwest also occurred following about a 10 s delay. The Mw 7.7 event occurred 9 hours later on the Surgu-Cardak Fault (SCF), about 30 km northwest of the EAF, and ruptured bilaterally with super-shear rupture velocities occurring only on its westward branch. Most of the Mw 7.7 moment was released close to the hypocenter, indicating a relatively high-stress-drop event. The eastward rupture branch veered to the northeast, avoiding an intersection with the EAF rupture from the Mw 7.8 earthquake. The Mw 7.7 hypocenter occurred where static and dynamic Coulomb stresses were increased by the earlier earthquake rupture, but delayed triggering from the much stronger dynamic stresses may also have been a factor. We use numerical rupture modeling to explore the dynamics of these complicated earthquakes and what may have caused their slip evolution, time delays, and branching behavior. The Kahramanmaras sequence highlights the importance of physics-based understanding of fault interactions for evaluation of future seismic potential and associated hazards.