Earthquake Ruptures and Stress Changes in the Mexican Earthquake Sequence of 2017–2018

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Abstract

Southern Mexico was struck by four earthquakes with Mw > 6 and numerous smaller earthquakes in September 2017 and another Mw > 7 in February 2018, starting with the 8 September Mw 8.2 Tehuantepec Earthquake beneath the Gulf of Tehuantepec offshore Chiapas and Oaxaca. We study the ruptures of these earthquakes with geodetic and seismic methods to examine the rupture extents and locations. We also look at whether this M8.2 earthquake triggered the four subsequent large M> 6 quakes in southern Mexico to improve understanding of earthquake interactions and time-dependent risk. All four large earthquakes in September 2017 were extensional despite the subduction of the Cocos plate at the convergent plate boundary. In contrast, the 16 February 2018 Mw 7.2 Pinotepa earthquake near Pinotepa Nacional in Oaxaca was a thrust event on the subduction interface. The traditional definition of aftershocks: likely an aftershock if it occurs within two rupture lengths of the main shock soon afterwards. Two Mw 6.1 earthquakes, half an hour after the M8.2 beneath the Tehuantepec gulf and on 23 September near Ixtepec in Oaxaca, both fit as traditional aftershocks, within 200 km of the main rupture. The 19 September Mw 7.1 Puebla earthquake was _˜600 km away from the M8.2 shock, outside the standard aftershock zone. The Pinotepa earthquake was about 350 km away from the Tehuantepec rupture but was in an area of Coulomb stress decrease from the M8.2 quake, so it seems unlikely to be a regular aftershock. Geodetic measurements from interferometric analysis of synthetic aperture radar (InSAR) and time-series analysis of GPS station data constrain finite fault static slip models for the M8.2, M7.2, and M6.1 Ixtepec earthquakes. We include open-ocean tsunami waveforms for the M8.2 inversions. We analyzed InSAR data from Copernicus Sentinel-1A and -1B satellites and JAXA ALOS-2 satellite. Our Bayesian (AlTar) static slip model for the M8.2 quake shows significant slip extended > 150 km and possible 220 km NW from the hypocenter. There is a high probability that the slip extended to depths of at least 70 km indicating slab pull stress state. Our AlTar slip model for the M7.2 Pinotepa thrust earthquake is similar to the USGS NEIC FFM with all of the slip confined to a very small (10-20 km diameter) rupture. The Pinotepa earthquake ruptured a portion of the Cocos megathrust that has been previously mapped as partially coupled and shows that at least small asperities in that zone of the subduction interface are fully coupled and fail in high-stress drop earthquakes. The previous 2012 Mw 7.4 Ometepec earthquake

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is another example of asperity in the partially coupled zone but was not imaged by InSAR so the rupture extent is not so well constrained. Inversions for the M6.1 Ixtepec normal quake confirm shallow depth in the upper-plate crust and show centroid is about 30 km SW of the preliminary NEIC epicenter but consistent with cluster relocations. Similarly, the preliminary NEIC epicenter for the Pinotepa earthquake was about 40 km away (NE) from the rupture imaged by InSAR. The NEIC updated epicenters and Mexican SSN locations are closer to the InSAR-constrained location for both earthquakes, because they use regional seismic data.