The 2017 November 12 Mw 7.3 Sarpol-Zahab (Iran-Iraq border region) earthquake: source model, aftershock sequence and earthquakes triggering

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The Mw 7.3 Sarpol-Zahab earthquake occurred on 12 November 2017 in the Lurestan arc of the Zagros Simply Folded Belt (ZSFB). It is estimated that 600 people were killed and 8000 were injured in this earthquake. This earthquake has been the largest instrumentally recorded earthquake in the ZSFB and its moment, as well as its mechanism, were unexpected. We present an earthquake source study on the Mw 7.3 Sarpol-Zahab earthquake, two large following earthquakes in the region in 2018 and their corresponding aftershock sequences to gain insight of seismotectonic of the Lurestan arc fold-thrust belt.

In this study, we complement previous studies on this earthquake, by non-linear probabilistic optimization of joined geodetic and seismic data using a new, efficient Bayesian bootstrap-based optimization scheme to infer the finite fault geometry and fault slip together with meaningful uncertainty estimates of the model parameters. Our optimization is based on the modeling of ascending and descending Sentinel-1 satellite data, seismological waveform from global seismic networks and the strong motion network of Iran. The posterior mean model of the Sarpol-Zahab earthquake shows that the causative fault plane is centered at is 14±2 km depth and has a low dip angle of 17°±2° and a strike of 350°±10°. The rake angle of 144°±4° points to an oblique thrust mechanism. The rupture area of the uniform-slip, rectangular model is 40±2 km long and 16±2 km width and shows 4.0±0.5 m fault slip, which results in a magnitude estimate of Mw 7.3±0.1.

Later, in August and November 2018, two large earthquakes with Mw 6.0 and Mw 6.4 occurred about 40 km east and 60 km south of the Sarpol-Zahab epicenter, respectively. These earthquakes could have been triggered by the 2017 Sarpol-Zahab earthquake. We apply the same joint inversion modeling to derive the corresponding fault plane solutions. We found strike-slip mechanisms for both events but centroid depths at 10±2 km and 16±2 km for Mw 6.0 and Mw 6.4, respectively.

The 2017 Sarpol-Zahab earthquake and the following studied 2018 earthquakes were followed by
a sustained aftershock sequence, with more than 133 aftershocks exceeding ML 4.0 until December 30, 2019. We rely on the local and regional seismic broad-band stations of Iran and Iraq permanent networks to estimate full-waveform moment tensor solutions of 70 aftershocks down to ML 4. Most of these aftershocks have shallow centroid depths between 5 and 12 km, so that they occurred in the uppermost part of the basement and/or in the lower sedimentary cover, which is ~8 km thick in this area.

Our results suggest that the Sarpol-Zahab earthquakes activated low-angle thrust faults and shallower strike-slip structures, highlighting that both thin- and thick-skin deformation take place in the fold-thrust belts in the Lurestan arc of the Zagros. Such information on the deformation characteristics is important for the hazard and risk assessment of future large earthquakes in this region.

Additionally, we demonstrate how the joint inversion of different geophysical data can help to better resolve the fault geometry and the earthquake source parameters.