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12 November 2017 Mw 7.3 Sarpol-e Zahab, Iran, earthquake: Results from combining radar and optical remote sensing measurements with geophysical modeling and field mapping

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On November 12, 2017, a large earthquake (Mw = 7.3) hit Kermanshah province of Iran near the border of Iran and Iraq. At least 600 people were killed, 9000 injured and thousands left homeless.

In this study we integrated observations from radar and optical remote sensing, seismology and field mapping to investigate source parameters, coseismically triggered slope failures and secondary faulting related to the Mw 7.3, Sarpol-e Zahab earthquake in Iran. Coseismic surface deformation was constrained by interferometric synthetic aperture radar (InSAR) analysis from SAR images obtained by L-band ALOS-2 and C-band Sentinel-1 satellites. ALOS-2 wide-swath (WS) interferograms were derived from ascending and descending orbits covering 09.08.2016-14.11.2017 and 04.10.2017-15.11.2017 time periods, respectively. Sentinel-1 TOPS coseismic interferograms were derived from ascending and descending orbits covering 11.11.2017-17.11.2017 and 12.11.2017-18.11.2017, respectively. Source parameters and slip models of the earthquake were then obtained by the Bayesian inversion of interferometric results using elastic dislocation modeling, considering the seismic parameters as a priori information. Preliminary results of geodetic source modeling suggests that the 12 November 2017 Sarpol-e Zahab earthquake was generated by blind ENE oblique thrust faulting with an average slip of approximately 4 m at a depth between 17 and 22 km.

The 2017 Sarpol-e Zahab event also triggered a lot of coseismic slope failures including landslides and rock falls, and secondary faulting. Their potential locations were initially assessed by identifying local phase changes and areas affected by loss of coherence in the interferograms. Moreover, large-scale analysis of horizontal surface displacements was performed by pixel-offset tracking using Sentinel-1 SAR images. The results were evaluated by expert interpretation based on optical Sentinel-2 data in combination with geological information and field investigations. Largest horizontal deformation was observed for a co-seismically triggered landslide which was further analyzed using optical PlanetScope data acquired one day apart right before and after the earthquake (12th and 13th of November). Pixel-based change detection allowed exact spatial delineation of the displaced block covering an area of about 4 km2. Cross-correlation analysis resulted in a spatially detailed derivation of horizontal movement vectors indicating displacements in the range from about 5 to 30 m.

The results of this study have shown that a combination of various remote sensing methods with modelling and field investigations is required for gaining an improved understanding of surface processes caused by the Mw 7.3, Sarpol-e Zahab earthquake. Complementary analysis of radar and optical remote sensing has led to a more comprehensive assessment of various types of co-seismically induced surface changes occurring at different spatial scales. Such information can contribute to an improved spatial characterization of co-seismically activated geological structures. This is especially important in the context of seismic hazard assessment for scarcely investigated areas like the one affected by the Sarpol-e Zahab earthquake in the border region between Iran and Iraq.