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Reactivation of giant paleo-rockslides during the Sarpol-Zahab Mw7.3 earthquake, Iran

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Zagros Mountains form a seismically active fold and thrust belt in western Iran. In addition to the high levels of seismicity, slope failures are common throughout the region, where historical records of very large landslides (> 30 km^3) are documented. On the November 12th 2017, the largest earthquake (Mw 7.3) ever recorded in the Zagros occurred near the town of Sarpol-Zahab (NW Zagros/Iraq border). Following the earthquake, only one large co-seismic rockslide and some small rockfalls were documented near the epicenter. This rather small landslide activity for such a large earthquake raises the question of both the observation completeness and the controlling factors of the landslide triggering in this arid mountainous environment.

We conducted an original inventory mapping of the landslides induced by this event along 200 km of the Iran-Iraq border. The landslides were detected by different methods: the scars of rapid co-seismic landslides were mapped using a comparison of pre- and post-seismic Planetlab images (3 m resolution), whereas slow-moving landslides (cm/yr-m/yr) were detected by deriving time-series of ground deformation from radar and optical satellite images. Interferometric measurements were constructed for 3 ascending and descending Sentinel-1 SAR tracks, over a time period of 15 months (spanning 6 months before and 9 months after the main shock), allowing the detection and monitoring of very-slow-moving landslides (cm/yr), while slow-moving landslides of higher velocities (m/yr) were detected from correlation of pre and post-earthquake optical satellite images (Planet and SPOT67 imagery; 3 m and 1.5 m resolution, respectively), orthorectified over precise DEMs.

We detected 8 giant rotational rockslides (3.10^6 to 3.10^7 m^2) and 360 small rockfalls (2.10^2 to 2.10^4 m^2) in our study area. The small slope-failures were concentrated in the steepest areas around the epicenter (within a radius of 45 km) while the giant ones were situated in far fields (150 km far from the epicenter). Geomorphological analysis of the giant landslides revealed the reactivation of huge masses with several hundreds meters scarps at their top and runout distance of several hundreds meters, advancing over a river at their toe. The geodetical analysis of these giant landslides, show their co-seismic acceleration by few cm. Furthermore, the analysis of the displacement time-series of these giant rockslides shows that four of them are destabilized over

the longer term. This observation raises question both of the risk posed by these rockslides and the controlling factors of their initiation. A geological and seismological analysis suggests that the triggering of these giant rockslides can be controlled by the geological structure (stratigraphy and folding) and the resulting topography, as well as by the fault mechanism of major earthquakes. Finally, the landslide reactivation mechanism during the Sarpol-Zahab earthquake is discussed.