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JOINT ANALYSIS OF THE ALOS-2 AND SENTINEL-1A DATA ON THE 2017 SEFID SANG EARTHQUAKE, NORTHEASTERN IRAN

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The Iranian plateau is deformed between the converging Arabian and Eurasian plates. Their convergence is principally taken up by the active Makran subduction zone to the South, in addition to shortening and strike-slip faulting accommodated by crustal structures, which are non-uniformly distributed in several continental deformation domains such as the Zagros, Alborz and Kopeh Dagh mountain ranges.

Indeed, despite all the efforts made by previous workers to shed light on active tectonics in northeast Iran, this region still suffers from a lack of detailed structural and kinematics data and should be considered as a concealed segment in the geodynamic puzzle of the Arabia-Eurasia collision. This matter is made worse by the facts that northeast Iran is the second populated region and one of the most seismically active deformation domains in the country that has experienced at least nine large earthquakes (M ≥ 7) during the last six centuries. On 5 April 2017, an Mw 6.1 earthquake occurred in the northeastern region of Iran, about 90 km southeast of the city of Mashhad, the second most populous city in Iran with a population of over 3 million people. The epicenter (35.776 N, 60.436 E, USGS) was at a remote mountainous area, about 30 km northeast of the Sefid Sang district where approximately 5000 people live, and the depth was about 13 km. This earthquake raised an opportunity to study the deformation pattern in the SE of the Kopeh Dagh Mountains. Space geodetic observations of ground deformation provide important data to investigate the seismogenic fault and the subsurface deformation mechanics. Here we used ALOS-2 and Sentinel-1A Synthetic Aperture Radar data (Table 1) to produce SAR interferograms using the GMTSAR software (Sandwell et al., 2016) to investigate coseismic and postseismic deformation associated with the 2017 Sefid Sang earthquake.

Table 1. Details of satellite Synthetic Aperture Radar (SAR) images used in this study.

Satellite	Path	Master YYYYMMDD	Slave YYYYMMDD	Incidence Angle (degree)	Look Direction
ALOS-2	171 A	20170121	20170624	36.2	Right looking
ALOS-2	64 D	20170315	20170524	32.5	Right looking
Sentinel-1A	13 A	20170324	20170405	33.8	Right looking
Sentinel-1A	93 D	20170330	20170411	33.8	Right looking

The ascending and descending interferograms for the two satellite radar were produced and all indicate thrust-dominated slip that is consistent with seismic data sets, the maximum ascending and descending line-of-sight coseismic displacement of ALOS-2 SAR data were 9.9 (Figure 1) and 13 cm, respectively, and for Sentinel-1A SAR data were 9.7 and 12.9 cm, respectively, which have good consistency together. We transformed the interferograms into local kilometric coordinates with the center of the deformed area set as the origin and data points subsampled in concentric grids. We inverted the unwrapped interferograms using a method to simultaneously solve for nonlinear and linear fault parameters. The nonlinear parameters were location, size and orientation of the fault plane and the rake angle, whereas the linear parameters were the slip on the fault patches and the offsets in the interferograms (Fukushima et al., 2018). In one of our preliminary models using ALOS-2 datasets, the optimal resultant parameters indicate a reverse fault with dip of 47.8°, strike of 103° and rake of 73.7° (Table 2).

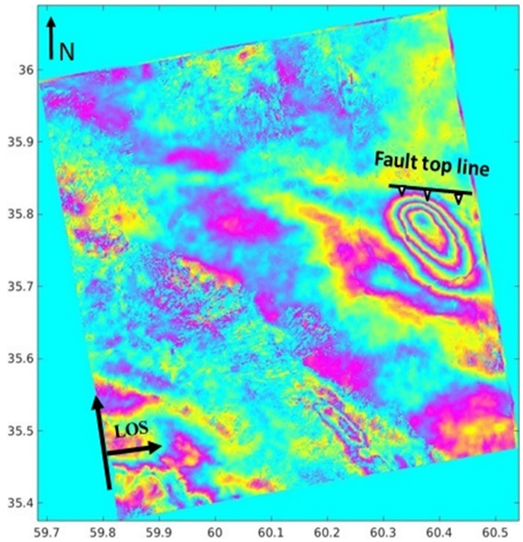

Figure 1. The ascending interferogram of ALOS-2 SAR data. The interferometric fringes were rewrapped with interval of 3 cm.

Table 2. Estimated nonlinear parameters of the Sefid Sang earthquake causative fault by this study and other datasets.

Source	Strike (°)	Dip (°)	Rake (°)
USGS	316/105	20/73	120/80
GCMT	312/91	53/44	117/59
IRSC	329/101	45/56	127/58
Xu et al., 2018	120	40	61
This study	103	47.8	73.7

The optimal slip distribution map (Figure 2) shows the main slip area is located at depths of about 5-14 km with a maximum slip of about 1 m at 9 km, which is consistent with the results of Xu et al. (2018). We also used ascending SAR data acquired on 2017/06/24 to 2018/12/22 for evaluating the postseismic deformation caused by this earthquake. The produced interferogram does not show any displacement more than noise level (~1 cm).

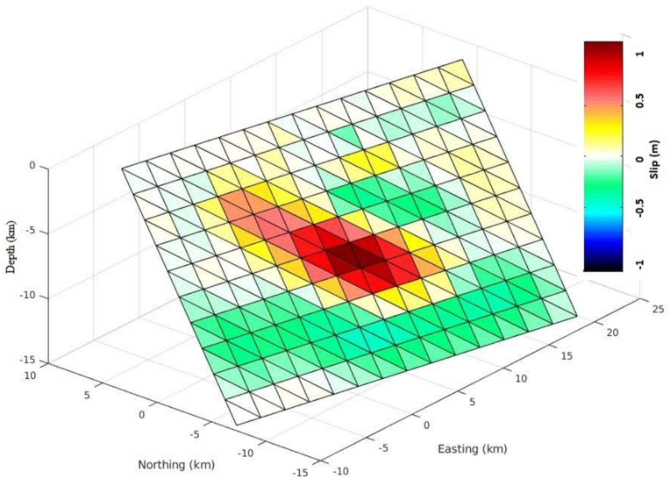

Figure 2. Slip distribution on the fault plane.

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