Determination of the dipping direction of a blind reverse fault from InSAR: Case study on the 2017 Sefid Sang earthquake, Northeastern Iran

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Determining the fault parameters of an earthquake is fundamental for studying the earthquake physics, understanding the seismotectonics of the region, and forecasting future earthquake activities in the surrounding area. Dense crustal deformation data such as InSAR are useful for fault parameter determination, but determining the dipping direction of a blind fault is often challenging. The 5 April 2017, Mw 6.1 earthquake occurred near the city of Sefid Sang, northeast of Iran, provides an excellent case for exploring the potential of Interferometric Synthetic Aperture Radar (InSAR) data for determining the dipping direction of a blind reverse fault. Using Advanced Land Observing Satellite-2 (ALOS-2) and Sentinel-1A interferograms of four different observation directions and a fault slip inversion method that allows thorough exploration of the fault geometry led to two candidates of reverse fault models, dipping either to the northeast or the south. The results show that the fault models of both dipping directions explain the data well, with a slight advantage in the northeast-dipping fault model in terms of the misfit when the atmospheric corrections were applied. The northeast-dipping fault model was, in addition, more consistent with the strike of the mapped active faults in the region and with the aftershock distribution, from which we infer that the 2017 Sefid Sang earthquake occurred on a northeast-dipping dextral reverse fault. The preferred fault model has a strike angle of 314.6˚, dip angle of 43.9˚ and rake angle of 128.3˚, and a slip distribution of maximum 1.11 m at depth of 5 km equivalent to Mw 6.0.
This study illuminates the difficulty of determining the dipping direction of blind faults even with InSAR measurements from multiple directions, but also that correcting for the atmospheric noise and comparing with other kinds of data can help infer the fault dipping direction.

Keywords: Northeastern Iran, Sefid Sang earthquake, InSAR, Coseismic crustal deformation, blind fault