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Are recent seismic swarms around Harrat Lunayyir (Saudi Arabia) associated with magmatic intrusions?

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In volcanic fields, magmatic intrusions are usually preceded and accompanied by seismic swarm. Even if the intrusions do not culminate in an eruption, these events typically produce ground deformation that can be observed using geodetic techniques such as InSAR. It is therefore important to combine seismic and geodetic data to better understand these magmatic processes and to find out whether a seismic swarm is associated with a magmatic intrusion or not. One example occurred in Harrat Lunayyir volcanic field, in Saudi Arabia, where a seismic swarm of ∼30000 earthquakes hit between April and July 2009 with the largest earthquake of Mw 5.7. Extensive surface fractures formed over 10km in length at the height of the activity. The ground displacements measured with InSAR showed that the swarm was accompanied by a dyke intrusion, estimated to be ∼7km in length and with an opening of up to 4m. During the past two years, the Harrat Lunayyir region has been hit by two new seismic swarms. The first one, located about 60km to the North, started in February 2017 and lasted until August 2018. The second swarm, located about 30km to the West, started in late September 2018 and is still ongoing. These swarms are characterized by frequent earthquakes of Ml<4. To assess if significant ground deformation was associated with the swarms, we used InSAR technique again. We processed Sentinel-1 SAR images acquired from both ascending and descending orbits between January 2017 and December 2018. Due to the general high coherence, the interferograms could easily be unwrapped and used to calculate deformation rate maps in the line of sight (LOS) of the satellites with the SBAS technique. The resulting rate maps showed signals correlated to topography, indicating that significant elevation-related atmospheric delays were affecting the results. We reduced this signal by estimating linear correlation coefficients between elevation and the LOS signal and subtracted the results from the rate maps. The corrected deformation rate maps mostly show spatially smooth LOS-rate variations of [U+F0B1] 0.5cm/year, which are due to strong atmospheric delays in some of the interferograms that could not be fully removed in the processing. No detectable deformation is seen at the locations of the relocated seismic swarms. Using the relocated hypocenters of the first seismic swarm, we estimated the fault geometry and the likely total fault slip and roughly quantify the expected ground deformation. The maximum surface displacement associated to slip on a 4km x 8km normal fault dipping 30° at 5km depth is less than 0.5mm and thus not detectable with InSAR. In contrast, a sub-vertical 4km x 8km dyke with 0.5m opening at the same depth would produce more than 1cm of ground deformation. Since no clear ground deformation was detected in the two areas affected by the seismic swarms, we conclude that they were not accompanied by shallow magmatic intrusions. However, the SGS will continue to monitor the area with their permanent seismic network and the InSAR deformation maps will be updated to detect any anomalous ground deformation.