Geophysical Research Abstracts
Vol. 20, EGU2018-16036-1, 2018
EGU General Assembly 2018

Earthquake swarm in non-volcanic areas of western Saudi Arabia: comparison of observations and imaging

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Western Saudi Arabia is surrounded by several regional and local active seismic zones such as the Red Sea, the Gulf of Aqaba, and Najd fault system in addition to many others that potentially can accommodate different magnitudes of earthquakes such as the destructive 1995 Mw 7.3 event in the Gulf of Aqaba.
Over the last few years, the Saudi Geological Survey (SGS) has deployed a dense network to reliably monitor seismicity in the Kingdom. This network has recently detected seismic swarms within the Arabian Shield that appear unrelated to the existing regions of Cenocoic volcanism (so called “harrats”). One of the seismic swarms occurs north of Harrat Lunyyir near the coastal town Umm-Lujj, reaching magnitude Ml 3.7. Another swarm is located at the southern town of Al-Namas, reaching magnitude Ml 4.0. For both locations, the seismicity is shallow, and located within the uppermost crust. The goal of this study is to compare both earthquake swarms and to assess their properties and tectonic implications.
The data used in this study are differential travel times from a combination of high-precision cross-correlation measurements, and from ordinary travel time picks for every possible pairs of earthquakes recorded at common stations. Residuals between observed and theoretical traveltime differences (or double-differences) are minimised for pairs of earthquakes at each station, while linking all observed event-station pairs.
We process a total of 600 earthquakes of Ml 0.5 - 4.0, recorded on 60 stations of the SGS network, to create local velocity models and to update the locations of earthquake hypocenters. We also investigate the possible causes of this swarm sequences, that is, whether the activities are, for instance, of tectonic- or hydro-thermal origin.
Our results for the UmmLujj area indicate three earthquake clusters that are revealed by event relocation; the cluster seems to migrate in time from depth to shallow levels. The results provide an image of what could potentially be a fault plane (NW-SE Najd system). The focal mechanism solutions of the largest earthquakes indicate normal faulting, which agree with the regional stress field. Initial analysis of the dataset of Al-Namas area provides a more diffuse picture that requires in particular a refined Earth model for more accurate earthquake locations.