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The puzzling Hälsingland intraplate earthquake cluster in central Sweden

Gunnar Eggertsson, Björn Lund, Ólafur Guðmundsson, and Michael Roth
Uppsala University, Department of Earth Sciences, Uppsala, Sweden (gunnar.eggertsson@geo.uu.se)

The Hälsingland earthquake cluster, on the east coast of central Sweden, represents a puzzling case of intraplate seismicity in a tectonically stable continental region. The cluster measures approximately 100 km in length and extends in a near-linear trend from inland in the southwest into the Baltic Sea in the northeast, oriented approximately 35 degrees to the coastline. Unlike many of the earthquake clusters that occur in Sweden, the cause of the Hälsingland seismicity is not well understood, as it has not been possible to associate the cluster with any distinct geological feature, such as old deformation zones or a younger glacially triggered fault. Between September 2021 and September 2025, a temporary network consisting of thirteen broadband seismic stations was deployed in the Hälsingland region in an effort to establish better understanding of the drivers behind the Hälsingland seismicity. During this period, 873 earthquakes were detected and manually analyzed in the region, with local magnitudes ranging from -1.0 to 2.3. Using travel-time data from local quarry blasting, we derived a new, regional seismic velocity model and relocated all the earthquakes in the new model. The earthquake depths range from near-surface down to 39 km, with approximately 80% occurring at depths between 5 and 20 km. As part of this project, a previously unknown glacially triggered fault (GTF) system, the Mörtsjö fault system, was identified in the Hälsingland region, approximately 25 km north of the Bollnäs fault, the southernmost confirmed GTF in Sweden. Both the Mörtsjö and Bollnäs GTFs are small and located outside the most seismically active part of the Hälsingland region. However, relative earthquake relocations reveal multiple events which may be generated by movement on the faults. Waveform cross-correlation analysis shows moderate correlation between most earthquake pairs in the Hälsingland cluster but also identifies multiple families of closely spaced, highly correlating earthquakes, including a single family consisting of more than 30 events. The spread of the earthquake focal mechanisms does not clearly indicate a dominant fault orientation. While strike-slip motion dominates, multiple examples of both reverse and normal motion also occur, often in close proximity to each other. Inverting the focal mechanisms for the earthquake-generating stress field indicates a strike-slip stress state with a NW-SE direction of maximum horizontal stress. The inversion also suggests mostly E-W striking fault planes, suggesting that the faults rupturing in the Hälsingland earthquakes are not oriented in agreement with the general lineament of the cluster. We find that most of the Hälsingland seismicity does not occur on a well defined fault but rather in an active zone which extends to large depth but is only vaguely associated with changes in large scale geological features such as magnetic properties and Moho thickness.