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Seismic network detection capability within the natural gas fields in Northern Germany

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The Northern German Basin is a tectonic region of relatively low seismic activity with only singular and weak tectonic events. However, during the last decades seismicity raised in the vicinity of the natural gas fields. Due to the spatial vicinity of the epicenters to the operated gas fields and their appearance starting after the beginning of extraction they are ranked as induced events. The epicenters of these events extend 50 km NS and 400 km EW from the border to the Netherlands in the West to Altmark region in the East.
Altogether, 63 events with ML 0.5 to 4.5 were detected between 1977 and 2015. Many of them were felt by parts of the inhabitants up to 15 km from the epicenter whereas the strongest one, the magnitude 4.5 event close to the village of Rotenburg on 20th October 2004, was even felt in Hamburg as far as 65 km from the epicenter.
Several newly installed surface and borehole stations have recently improved the monitoring capabilities in the region. The network design and number of station varied significantly during the last years and only a few seismic stations were operational over the entire period discussed here. This variability was so far not taken into account in the assessment of the seismicity - including b-value and completeness estimation – in this region.
In some parts of the study areas it is still difficult to detect and analyze events with magnitude below ML 2. This is due to bad noise conditions invoked by the thick sediments as well as to the small number of stations covering a relatively large study area. Up to now, it is not clear whether the observed deficit in detected fore and aftershocks for the induced earthquakes in the study area is an inherent characteristic of the seismicity or an artifact of non appropriate seismic surveillance during the last decades.
Here we investigate the spatio-temporal variation of the completeness Mc in the study area between 1977 and today. We take into account the noise levels and geometry of the changing seismic network as well as a seismic attenuation model derived for the study area. We discuss the observed seismicity and previously derived b-values and fore and aftershock rates in the light of our results. We use the network optimization approach of Kraft et al. (2013) to investigate possible network modifications to improve the performance of seismic monitoring in the study area. We discuss the expected 3D completeness and location precision for the proposed modified network geometries by numerical modeling.