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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 new installed surface and borehole stations have recently improved the monitoring capabilities in the region. The station network design and number of station varied significantly during the last years and only a few seismic stations were operational over the entire period. This variability was not taken into account for the assessment of the seismicity like the b-value and completeness.
For some of the areas it is still difficult to detect and analyze events with magnitude below 2 due to bad noise conditions invoked by the thick sediments as well as to the relatively large area to be covered. Up to now, it is not clear whether the small number of fore- and aftershocks is an inherent characteristic of the induced events and thereby different from tectonic earthquake sequences or only the effect of the non appropriate seismic surveillance during the last decades.
Seismicity in a low magnitude range could not be detected in some of the areas but should exist if the Gutenberg-Richter relation is valid. The detection capability can be one of the reasons and is now estimated for the main active areas as a function of time. The applied method bases on the special distribution of the seismic stations and the mean noise level within the dominant frequency range of the detected seismic events. The specific amplitude decay relation is taken into account. Results of the detection threshold investigation are compared with the measured seismicity and the calculated b-value. The outcome of these analyses is also used to develop modifications in the general network design with a larger contribution of more distant seismic stations under significant better site conditions.