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Seismicity in the vicinity of the natural gas fields of Völkersen und Söhlingen (Northern Germany) - looking for imperceptible seismic events

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Northern Germany is a region of relatively low seismic activity with only some rare and singular tectonic events. However, during the last decades seismic events consistently occurred in the vicinity of the natural gas fields in Northern Germany. Due to their spatial vicinity and their temporal appearance just starting after the beginning of extraction they are ranked as induced events.
Altogether, 35 events in the magnitude range 1.9 to 4.5 could have been detected in the time span between 1976 and 2013. Most of them were felt by parts of the inhabitants whereas the strongest one, the magnitude 4.5 event close to the village of Rotenburg on 20th October 2004, has even been felt in Hamburg 65 km away from the epicenter near Rotenburg.
During the last years the majority of events took place in the vicinity of the two natural gas fields Völkersen and Söhlingen. Several new installed surface and borehole stations have recently improved the monitoring capabilities in the region. However, 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.
Here, we present several approaches to retrieve weak events for the region of the Völkersen natural gas field and discuss their implications. Thereto, detection algorithms are applied on the basis of cross-correlation techniques and similarities of already recorded and identified waveforms of stronger events. Moreover array techniques are applied to the recordings of a small cluster of temporary stations that are installed in the middle of 2012 to improve the signal-to-noise ratio. In the same way the Gorleben seismic network situated more to the east of the gas fields is considered as an array. In a third approach recordings of a more distant hard rock station with a low detection threshold are analyzed in order to retrieve potential small events.