KEM Innovation/Research Question (max. 4 pages + annex)
Improving seismological data used for in GMPE's and earthquake catalogue in the Groningen region

Objective

This research question is a follow up of KEM-11 project finished (Phase 1).

The two objectives of this additional research question are to:

- re-evaluate, correct and partially reprocess seismological data recorded in the area of the Groningen gas field used for calibrating GMPE's (KEM-11b),
- improving the existing seismological data records induced earthquake catalogue at KNMI using the recommendations in the previous study (KEM-11c).

KEM11b (Phase 2a and 2b)

The main objective is to obtain a more complete understanding of what a state-of-the-art system comprises with respect to building reliable and consistent GMPEs. Based on these findings, such a comparison has to be made between an ideal to the current network of seismometers and accelerometers installed at the Groningen field and identify methods and means where changes are feasible and necessary to improve on the current setup.

KEM-11c (Phase 3)

The objective is to build upon the current KNMI induced seismicity catalogue, such that its value for understanding the induced seismicity at Groningen is enhanced. In particular, the improvements will target: the consistency of the methodologies and results; the adding to data/metadata completeness; earthquake characteristics and their uncertainties.

State of the art, background

The seismological data of KNMI and the induced earthquake record in the Groningen area is a primary input for assessing the earthquake hazard and risk and for deciding on production levels. The KNMI is the official seismological service in the Netherlands and has been operating the seismological network and processing the data to obtain earthquake source parameters. Over the course of the past 30 years the network over the Groningen gas field has developed in steps from virtually non-existent to a state-of-the-art network of dozens of borehole sensors, today resulting in a detection threshold of M_L~0.5 and a 500m location accuracy. In addition, processing techniques and computer power have developed tremendously.

KEM11b (Phase 2a and 2b)
In 2019 studies were carried out to understand the flaws in the Groningen seismological data recordings. These have been reported in various studies, coordinated by the State supervision of Mines. See references. KEM-11 and KEM-07 studies also indicated that quality and coverage outside the Groningen area (completeness) need to be improved. Recommendations have been made to improve.

KEM-11c (Phase 3)
The past five years have seen a number of efforts towards improving the seismological baseline information in the Groningen area. Recently, the KNMI has been reprocessing data between 2014 and 2016 using a new 3D velocity model. In addition, NAM/Shell have been reprocessing selected data since 2015 using full waveform inversion, in order to derive more accurate locations to improve correlation with faults analysis. Both analyses have improved the location accuracy substantially, especially in depth. In addition, many earthquakes have been relocated using double difference approaches and now better match the known fault patterns in the field. In addition, full waveform analysis of selected earthquakes has allowed for the derivation of focal mechanisms of the events, which provides important additional information. Finally, in 2016 KNMI analysed in detail the relation between M_L and M_w for the Groningen dataset of M≥1.5 as well as the completeness of recording through space and time.

KEM-11a study showed that a higher quality, more consistent and more complete earthquake catalogue sould be realised. Recommendations were given in the KEM-11 project reports and its evaluation.

Such improvement is crucial for using the catalogue in further research and for defining the path forward.

Research Question

KEM-11b (Phase 2a and 2b)

1. How van the network design and detection capability of the Groningen seismological network be improved? How should these changes be evaluated?
2. What are the best configurations, instruments and recording settings to capture the seismological data recording required for event detection and HRA-tool calibration?
3. What procedures will effectively ensure data quality in all circumstances? Can this be demonstrated?

KEM-11c (Phase 3)

1. Design and demonstrate the reprocessing of a selected subset of data associated with the KNMI induced seismicity catalogue and contribution to KRB?
2. Which extra methods should be applied, based on performing new analyses using different methodologies that will provide added value? How to ensure that state of the art processing is being performed with new methodologies?
3. Evaluate the effectiveness derivation process of additional source parameters (stress drops/focal mechanism) using the KNMI data.

Deliverables expected

Deliverables of KEM-11b:

- Synthesis report answering the research questions, including recommendations for a high-quality seismological data recording and event catalogue operations and management in The Netherlands

Deliverables of KEM-11c:

- Well-tested processing procedure and derivation of additional event parameters for the KNMI seismological event catalogue, to be delivered in a few steps/phases (to be defined).

Timeline

KEM-11b approximately 3-6 months

KEM-11c approximately 12-18 months

Expected use

The results are relevant for current and future seismic event detection, seismic activity monitoring on mining activities and the calibration of HRA-tools.

Expertise and tools preferred for the team

Academic and practical experience in seismological data acquisition. Preferably knowledge of the Groningen seismological network.

Quality assurance, Organisational and communication requirements

Professional team
Communication with stakeholders
High quality review in place

Remarks and Suggestions

None

References

SodM reports on seismic data quality Groningen evaluation 2019: see website

KEM-11a reports: see www.kemprogramma.nl for reports.

KNMI Reports (https://cdn.knmi.nl/system/readmore_links/files/000/000/408/original/20170615_Technisch_rapport_hazardkaart_Groningen_2017.pdf?1497511525) and (ftp://ftp.ingv.it/pub/mario.anselmi/MARTA/sdarticle.pdf)

NAM Reports (https://nam-feitenencijfers.data-app.nl/download/rapport/a283a0ed-39b0-409f-a5cf-5ec5dda6299f?open=true) and (https://nam-feitenencijfers.data-app.nl/download/rapport/62253e3b-4843-4e65-aa8b-6d5186cc00df?open=true)