Supplement to the Technical Addendum for Winningsplan Groningen 2016

Subsidence
Development of Seismicity
Maatschappelijk Veiligheidsrisico
Epistemic Uncertainties

Contents

1 Management Summary

1.1 Background to this Report

On the 1st April 2016, NAM submitted the Groningen Winningsplan 2016 to the Minister of Economic Affairs and SodM. This Winningsplan is accompanied with a Technical Addendum providing further background to the technical assessments used in the Winningsplan. In January 2016, the planned date for the submission was brought forward from 1st July 2016 to 1st April 2016. As a consequence some topics could not be included into the original submission and are included in this supplement to the Technical Addendum. Some queries that were raised after the submission date are also addressed in this supplement.

1.2 Summary

The topics included in this Supplement are:

- Additional subsidence maps are presented.
- Additional annual seismic event count assessments have been added. Where in the Technical Addendum annual events count for earthquakes with magnitudes above M ≥ 1.5 is shown, the assessment is now also shown for M ≥ 2 and M ≥ 2.5. The differences in annual event count between different production scenarios are also shown.
- The assessment of Maatschappelijk Veiligheidsrisico for seven requested communities.
- The sensitivity to epistemic uncertainty created some confusion. A section is included explaining this better and an alternative representation of the sensitivity to epistemic uncertainty is included.

1.3 Achtergrond bij dit Rapport

Op 1 april 2016, heeft NAM het Groningen Winningsplan 2016 aangeboden aan de minister van Economische Zaken en SodM. Dit Winningsplan wordt vergezeld door een Technische bijlage met aanvullende achtergrond voor de technische evaluaties die worden gebruikt in de Winningsplan. In januari 2016 werd de geplande datum voor de indiening vervroegd van 1 juli 2016 tot 1 april 2016. Als gevolg daarvan konden een aantal onderwerpen niet worden opgenomen in het oorspronkelijk aangeboden document. Deze zijn opgenomen in deze aanvulling op de Technische Bijlage. Ook enkele vragen die na de datum van indiening zijn gerezen, zijn opgenomen in deze aanvulling.

1.4 Samenvatting

De onderwerpen die aan de orde komen in deze aanvulling zijn:

- Extra verduidelijking van bodemdaling door meer bodemdalingskaarten te presenteren.
- Extra analyse van het jaarlijks aantal aardbevingen; waar in de Technische Bijlage jaarlijkse aardbevingsaantallen voor aardbevingen met een magnitude boven M ≥ 1,5 wordt getoond, worden deze nu ook getoond voor M ≥ 2 en M ≥ 2,5. De verschillen in aantallen tussen de verschillende productiescenario's worden ook getoond.
- De beoordeling van Maatschappelijk Veiligheidsrisico in zeven gevraagde gemeenschappen.
- De gevoeligheid voor epistemische onzekerheid leidde tot enige verwarring. Een hoofdstuk is toegevoegd waarin deze wordt uitgelegd en een alternatieve weergave van de gevoeligheid voor epistemische onzekerheid is tevens opgenomen.

2 Subsidence forecasts

2.1 Supplement to Winningsplan

In section 5.2 of the Winningsplan Groningen 2016 contour plots are presented of the total subsidence as a result of gas production from the Groningen field and neighbouring fields forecasted for the years 2025, 2050 and at the end of gas production (cf. Figures 5.4 to 5.6 in the Winningsplan). Subsidence was modelled using the RTCiM compaction model and assuming an alternative (optimized) spatial/regional offtake (as described in section 4 of the technical addendum). For completeness similar contour plots (Figure 2.1 to Figure 2.3) are also presented in this supplement to the Winningsplan Groningen 2016 using the regional offtake according to the (non-optimized) HRA Nov 2015 production profile.

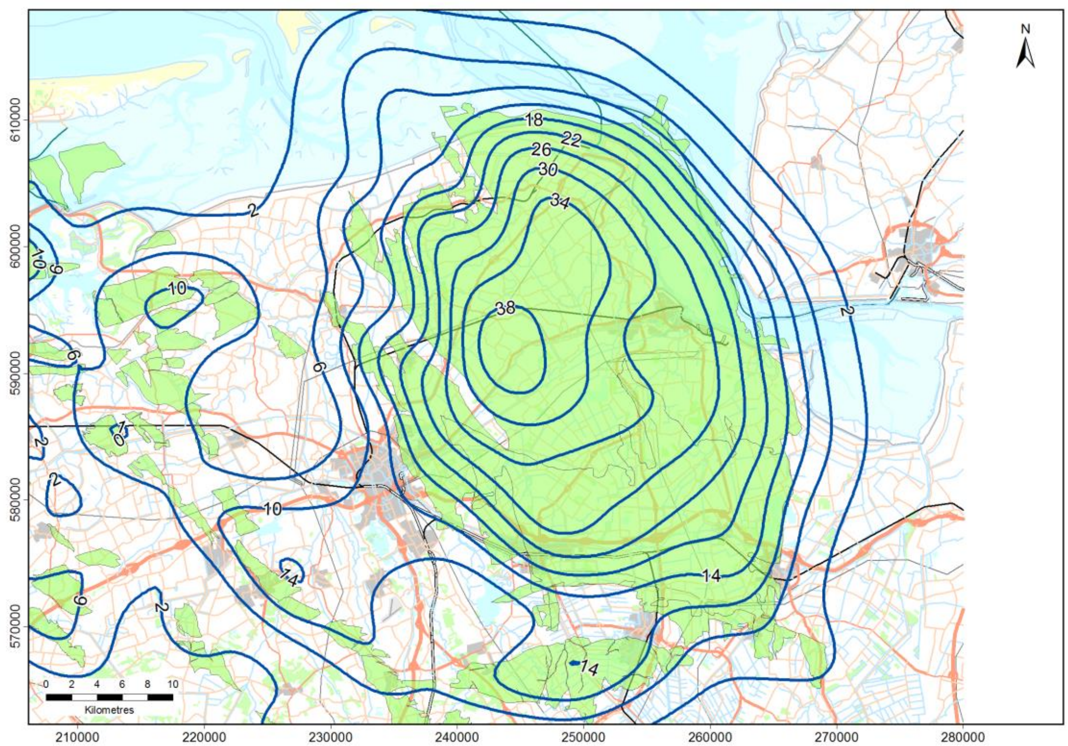


Figure 2.1 Subsidence prognosis for 2025 (approximately 38 cm in deepest point)

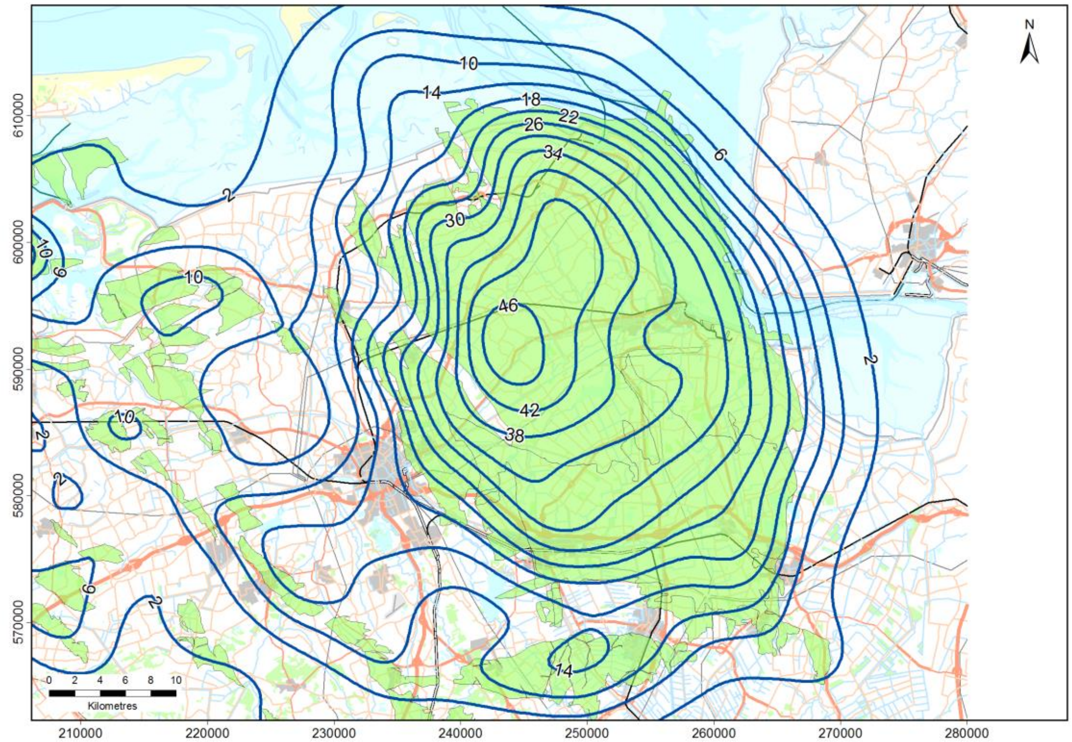


Figure 2.2 Subsidence prognosis for 2050 (approximately 46 cm in deepest point)

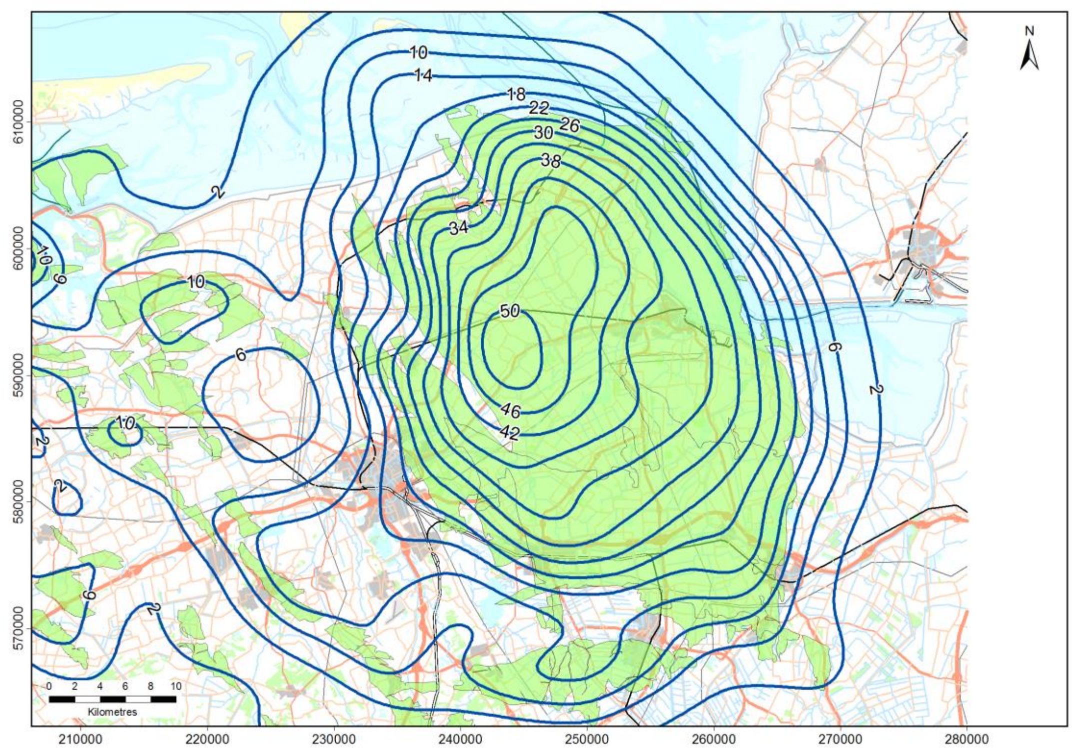


Figure 2.3 Subsidence prognosis for total subsidence after end of gas production (approximately 50 cm in deepest point)

In section 5.3.2 of the Winningsplan Groningen 2016 Figure 5.7 shows the subsidence that is still to be expected. A similar contour plot based on the (non-optimized) HRA Nov 2015 production profile is presented below (Figure 2.4).

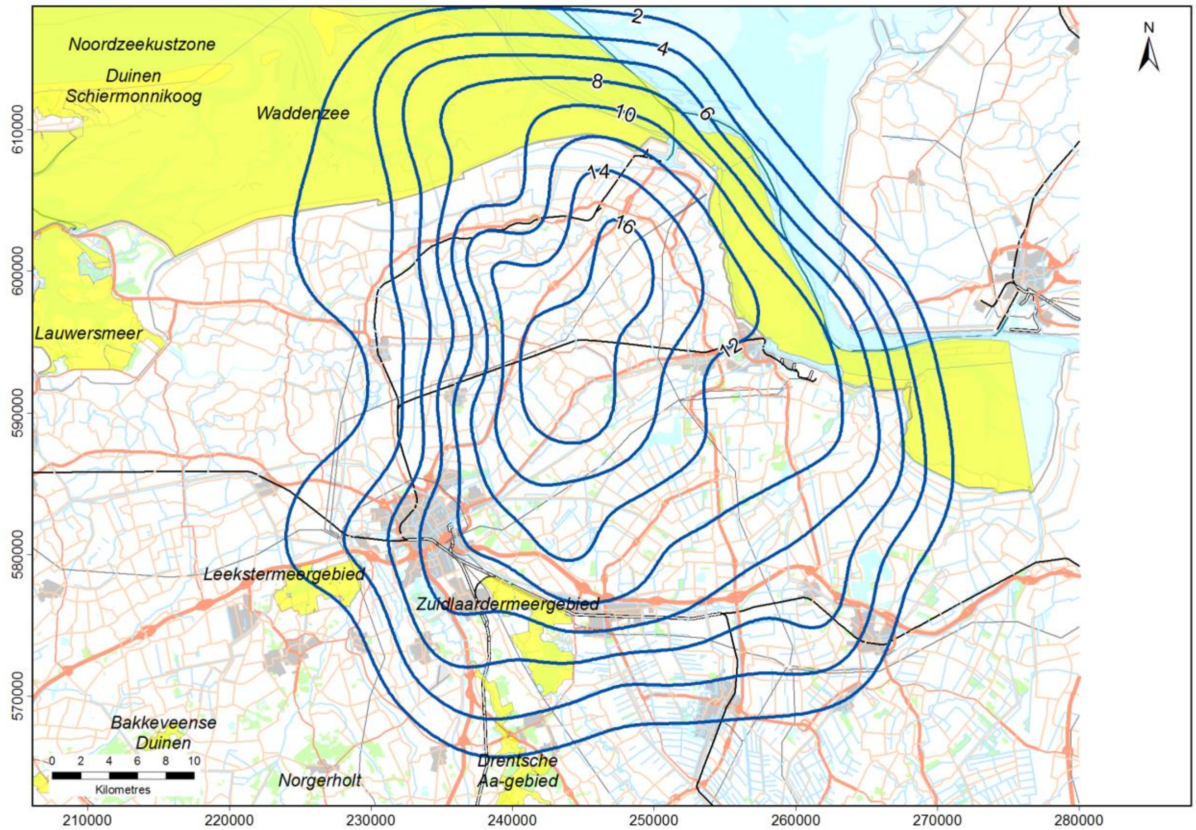


Figure 2.4 Expected additional subsidence in cm (2016-2100) and Natura 2000 areas

2.2 Supplement to Technical Addendum

In section 6.7 of the technical addendum to the Winningsplan Groningen 2016 contour plots of the forecasted development in time of subsidence are shown for various gas production scenarios, assuming an alternative (optimized) spatial/regional offtake (as described in section 4 of the same technical addendum). For completeness in this supplement to the Winningsplan Groningen 2016 similar contour plots are also presented using the regional offtake pattern according to the (non-optimized) HRA Nov 2015 production profile.

Figure 2.5 shows the forecast of the ultimate subsidence (status in 2100, approximately 30 years after the end of production) using the RTCiM compaction model.

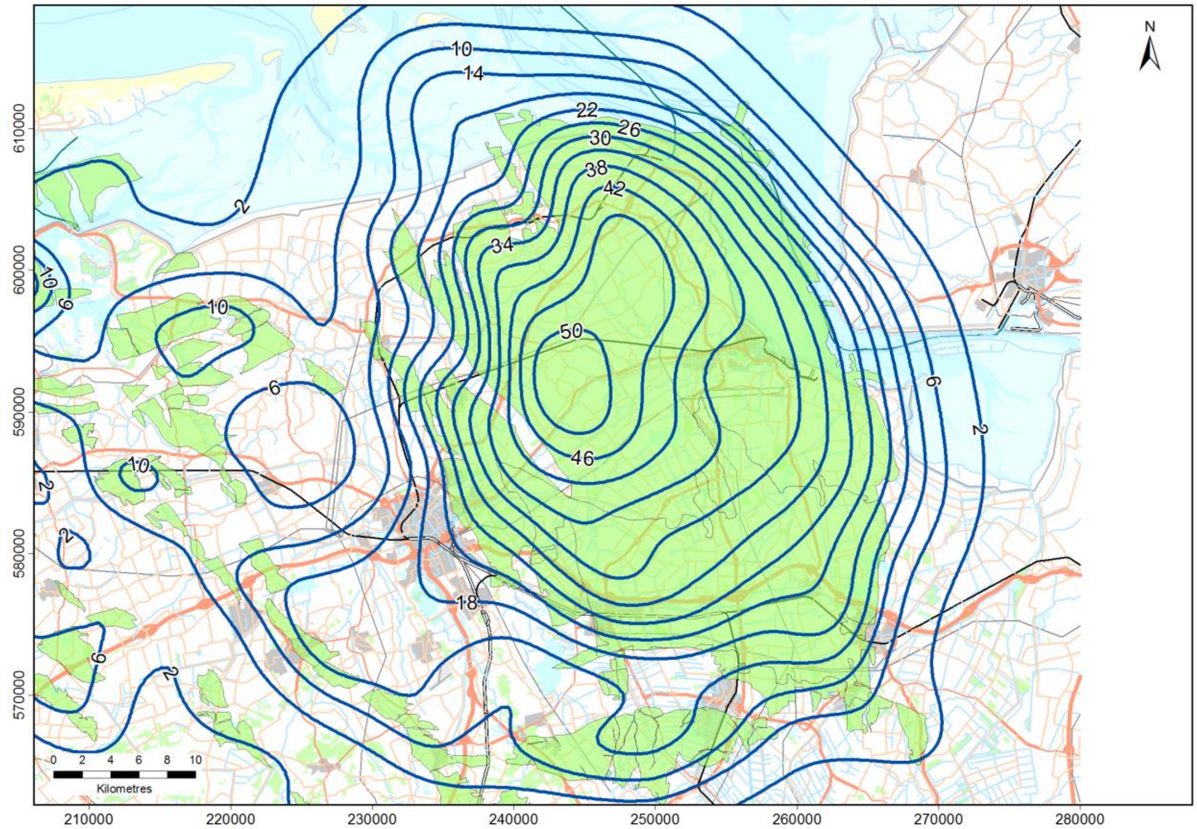


Figure 2.5 *Subsidence prognosis based on the RTCiM model in 2100, approximately 30 years after the end of gas production. This figure shows the subsidence due to gas production for the Groningen field using the 'HRA Nov 2015' offtake pattern in combination with the subsidence predicted for other fields (subsidence in cm).*

The subsidence forecast in this contour plot is almost identical to the subsidence expected for the optimized regional offtake scenario as shown in Figure 2.6, which is a corrected version of Figure 6.24 in the addendum document, where an erroneous pressure distribution in the underground gas storages Norg and Grijpskerk (to the west of the Groningen field) was used.

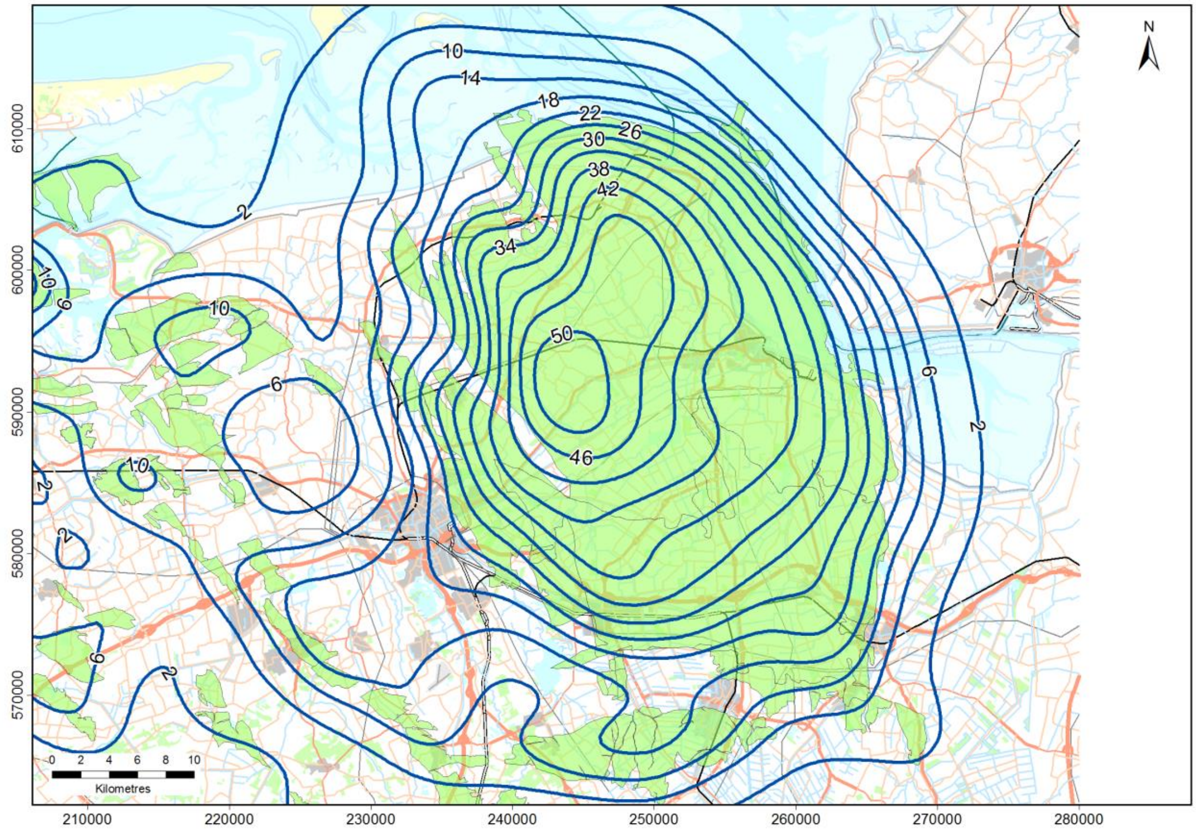
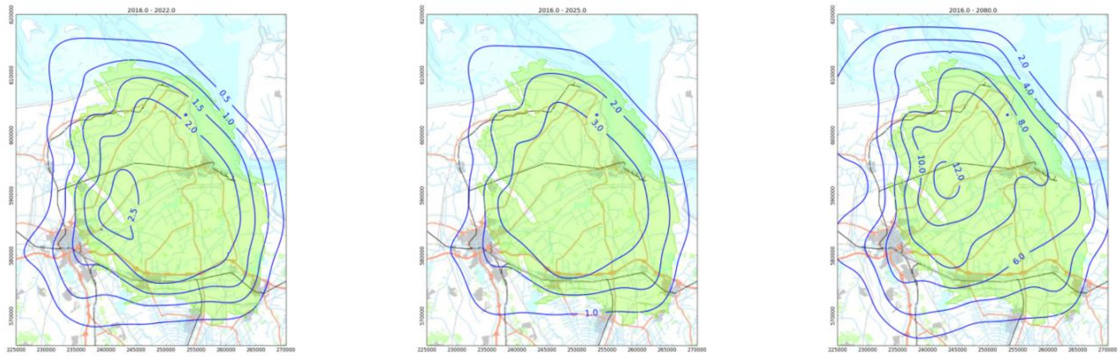


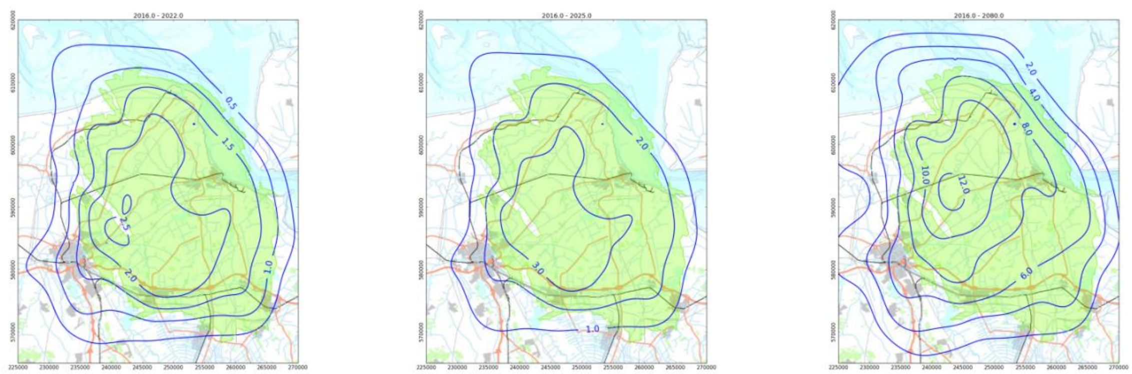
Figure 2.6 *Subsidence prognosis based on the RTCiM model in 2100, approximately 30 years after the end of gas production. This figure shows the subsidence due to gas production for the Groningen field using the 'optimized' regional offtake pattern in combination with the subsidence predicted for other fields (subsidence in cm).*

The development of the future subsidence through time for the different compaction models and different (HRA Nov 2015) gas production scenarios is shown in Figure 2.7 to Figure 2.12.



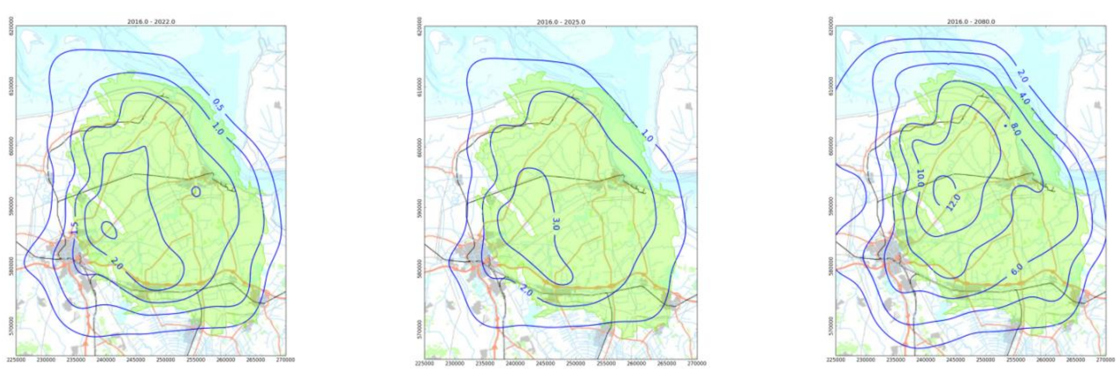
2016-2022 2016-2025 2016-2080

Figure 2.7 Development of future subsidence according to the time decay compaction model with 33 BCM annual production



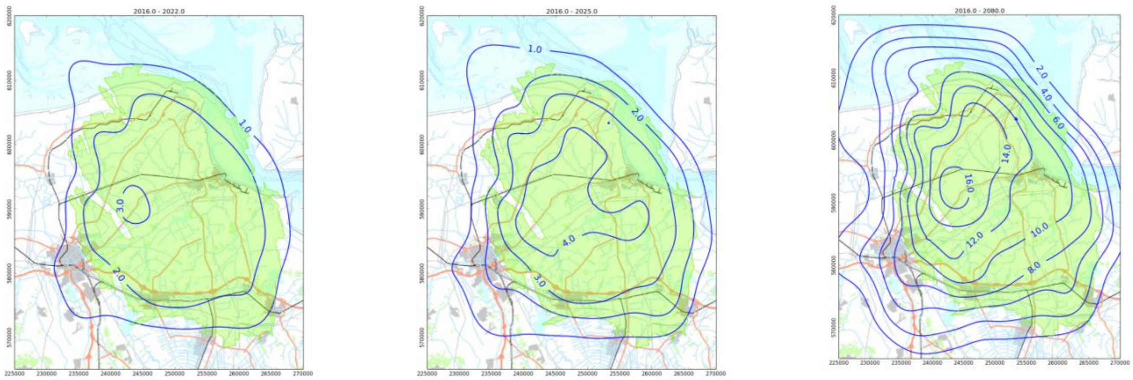
2016-2022 2016-2025 2016-2080

Figure 2.8 Development of future subsidence according to the time decay compaction model with 27 BCM annual production



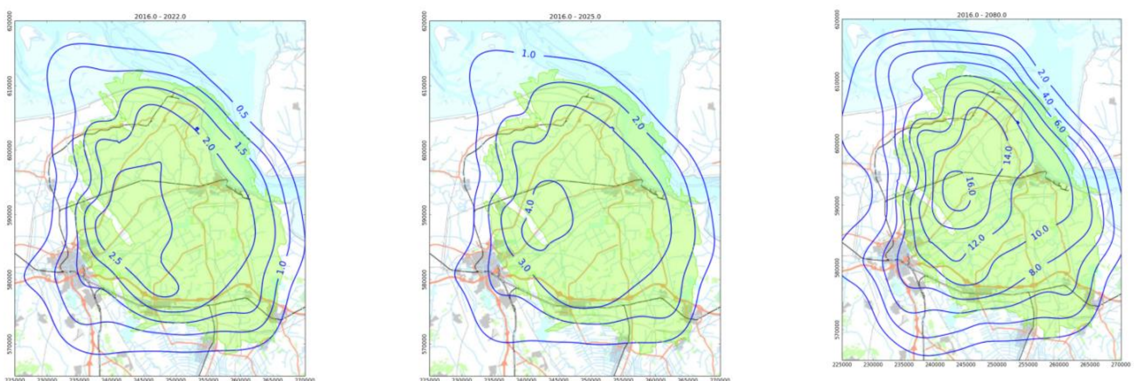
2016-2022 2016-2025 2016-2080

Figure 2.9 Development of future subsidence according to the time decay compaction model with 21 BCM annual production



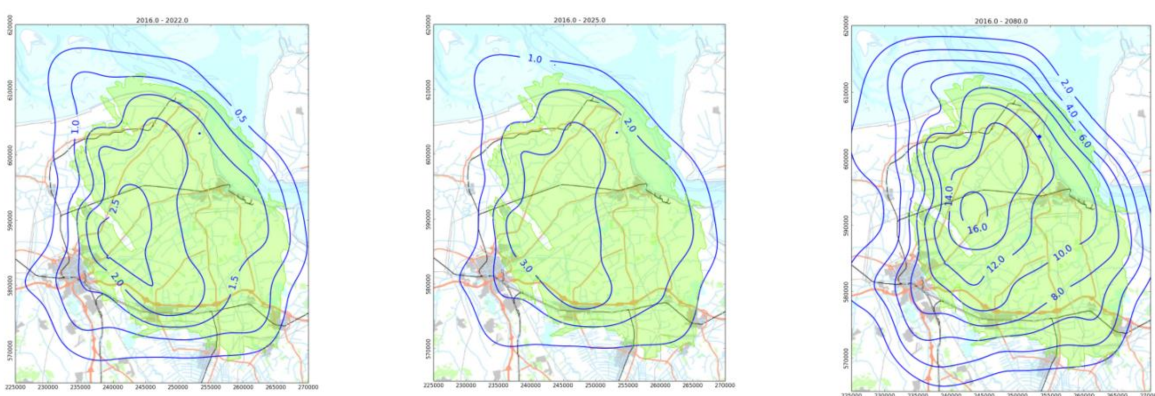
2016-2022 2016-2025 2016-2080

Figure 2.10 Development of future subsidence according to the RTCiM model with 33 BCM annual production.



2016-2022 2016-2025 2016-2080

Figure 2.11 Development of future subsidence according to the RTCiM model with 27 BCM annual production.



2016-2022 2016-2025 2016-2080

Figure 2.12 Development of future subsidence according to the RTCiM model with 21 BCM annual production.

Figure 2.13 shows the results of subsidence models in comparison with the measured subsidence at benchmark 007E0033 near the deepest point of the subsidence bowl (cf. Figure 6.29 in the addendum document).

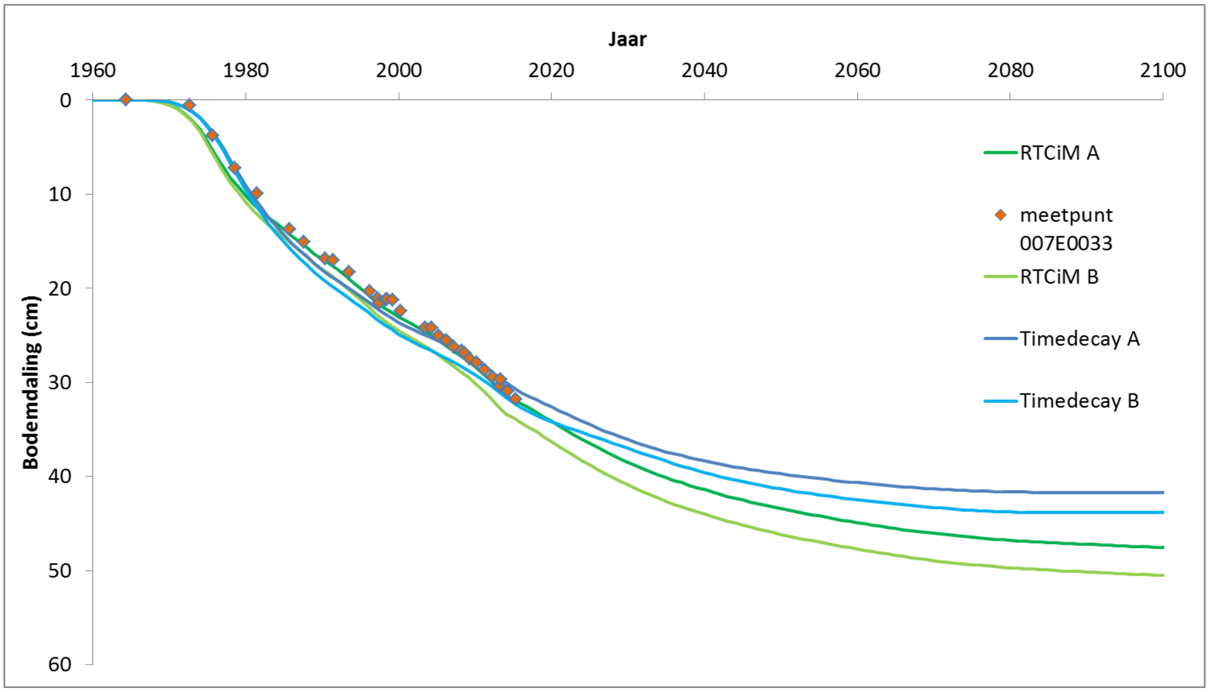


Figure 2.13 Development of subsidence (bodemdaling) by year (jaar) at benchmark 007E0033 near the centre of the subsidence bowl. Meetpunt is Dutch for benchmark.

3 Development of Seismicity

3.1 Annual Seismic Event Counts

In the Technical Addendum in section 7, annual event counts were discussed. This section in the supplement provides additional assessments of the annual event counts and also shows differences in event rates between production scenarios. Figure 3.1 (also shown in the Technical Addendum) shows the annual event count for M≥1.5 for 6 scenarios.

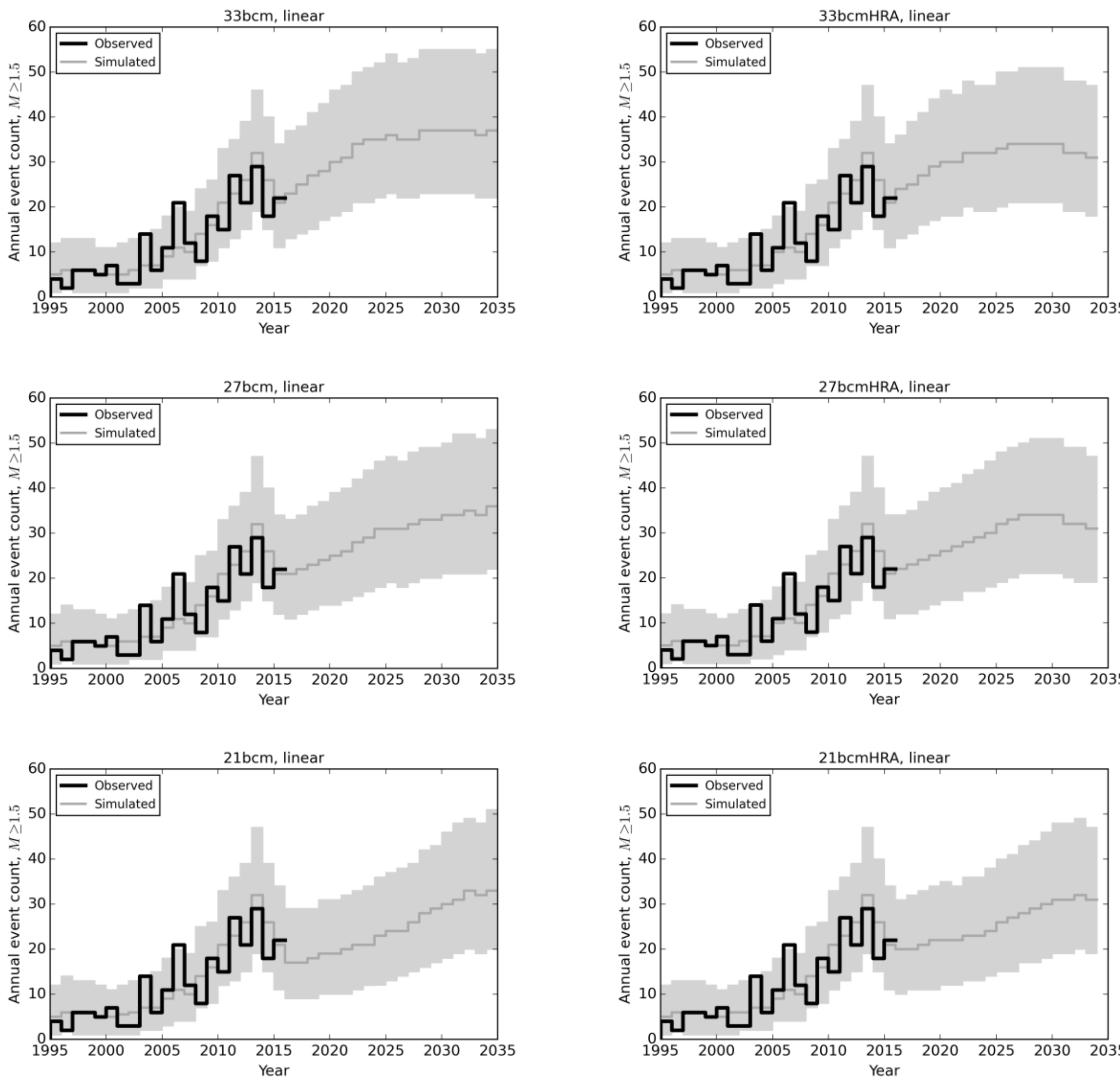
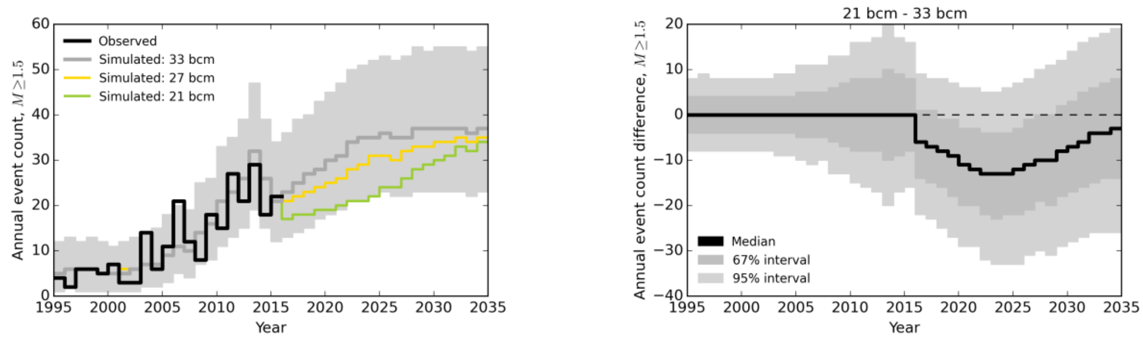


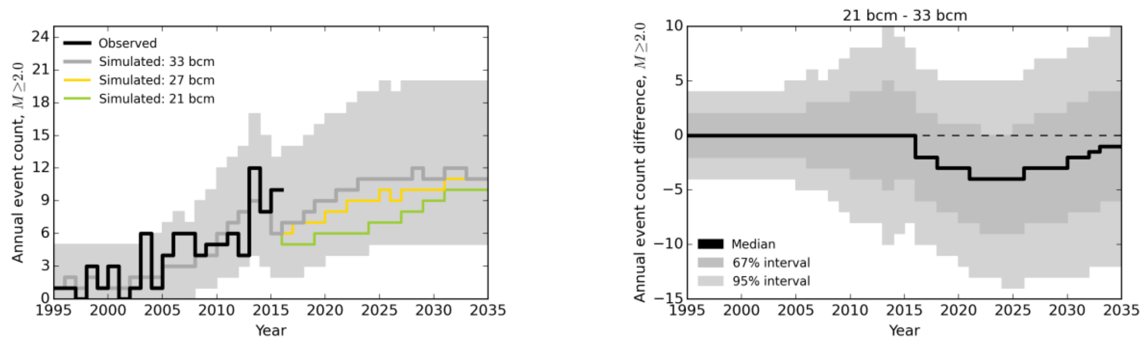
Figure 3.1 *The annual number of M ≥ 1.5 according to the seismological model with aftershocks for the different production scenarios for the period up to 2035. Simulated results are based on 10,000 independent simulations; grey lines and regions denote the expected annual event count and its 95% confidence interval respectively. These simulations are based on a Monte Carlo sampling of the distribution of estimated parameter values and includes aftershocks. A linear compaction model is used. Note that uncertainty in the compaction forecast increases with time, this uncertainty is not included in these seismological forecasts. On the left-hand side of the chart the optimised production offtake distribution is used, while on the right-hand side the distribution imposed early in 2015 is used (also basis for interim update HRA Nov. 2015).*

The annual event rates for three production level scenarios are shown in figure 3.2 for three different minimum magnitudes; M≥1.5, M≥2.0 and M≥2.5. On the right hand side of this figure the difference in annual event count is shown between the 21 Bcm/year and the 33 Bcm/year scenarios. The right hand side of figure 3.3 shows the difference between the 27 Bcm/year and the 33 Bcm/year scenarios. The differences in forecast annual event rates increase until about 2025 and thereafter decrease again so that by 2035 differences are almost zero. Lower production scenarios lower the expected seismic activity rate prior to 2035. However, given the seismic variability some years may still experience a higher actual rate.

(a)



(b)



(c)

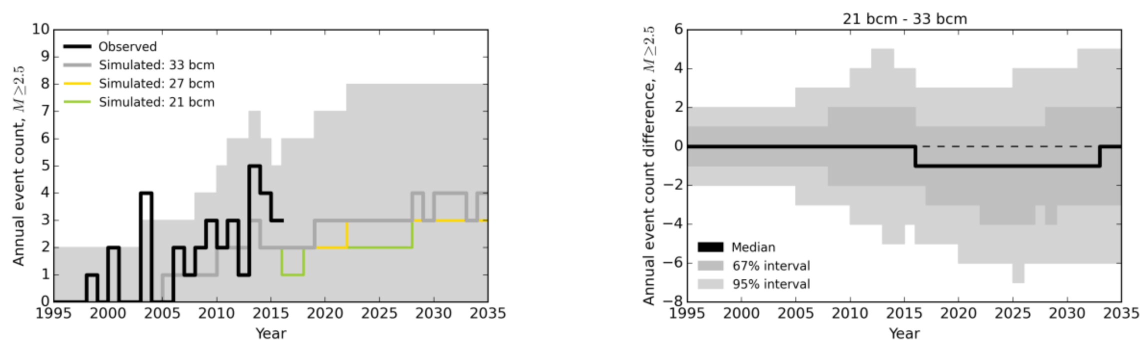


Figure 3.2 *Comparison of the forecast annual number of (a) M ≥ 1.5, (b) M ≥ 2.0, and (c) M ≥ 2.5 events for each production scenario and the differences between these forecasts for the 33 bcm and 21 bcm production scenarios. Uncertainty in the forecast annual event counts (left) is denoted as the 95% prediction interval by the light grey-filled region for the 33 bcm production scenario. Uncertainty in the differences between the 21 bcm and 33 bcm forecasts (right) is denoted by the 67% (dark grey) and the 95% (light grey) prediction intervals. For reference, the dashed black line denotes a difference of zero.*

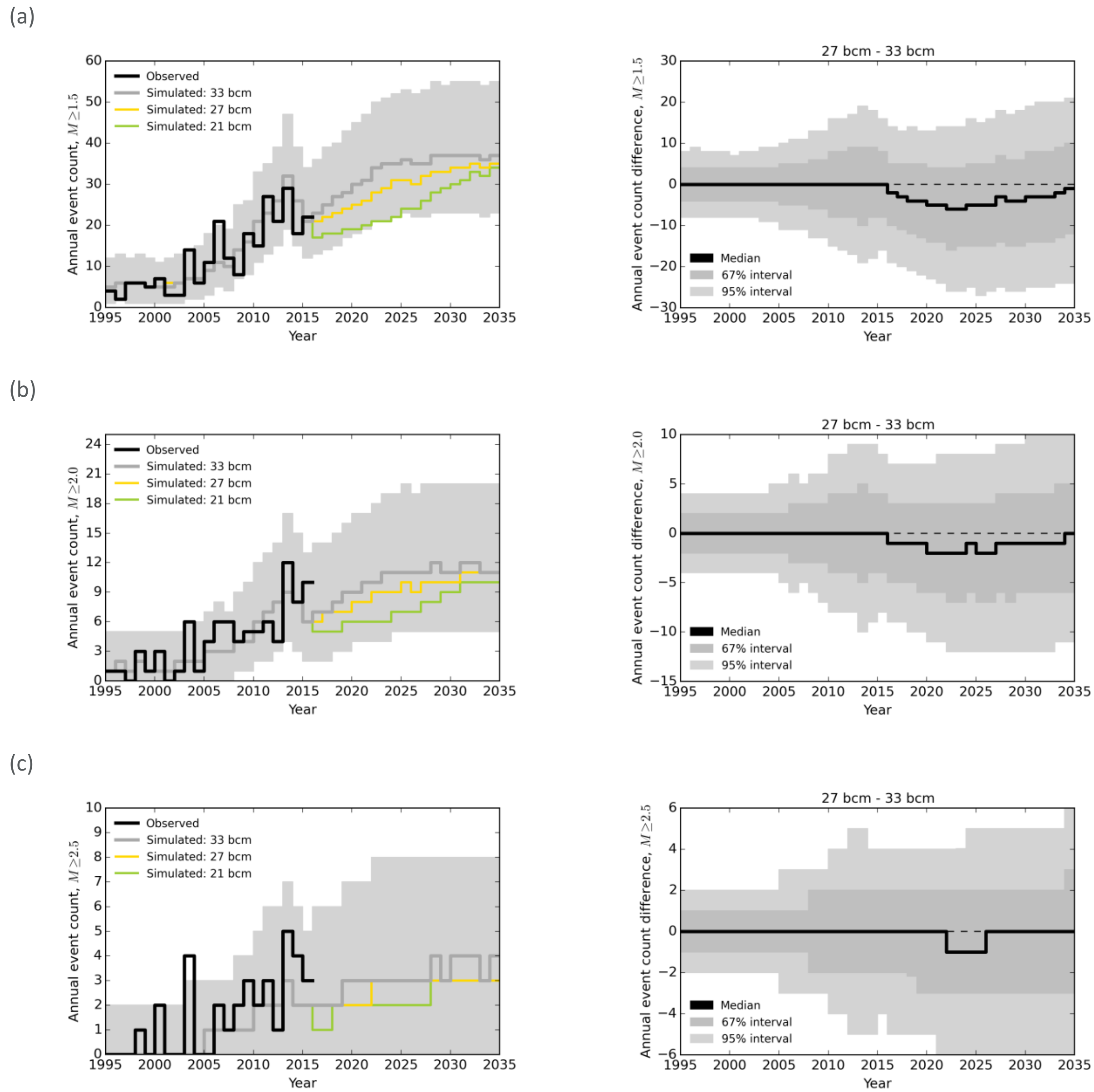


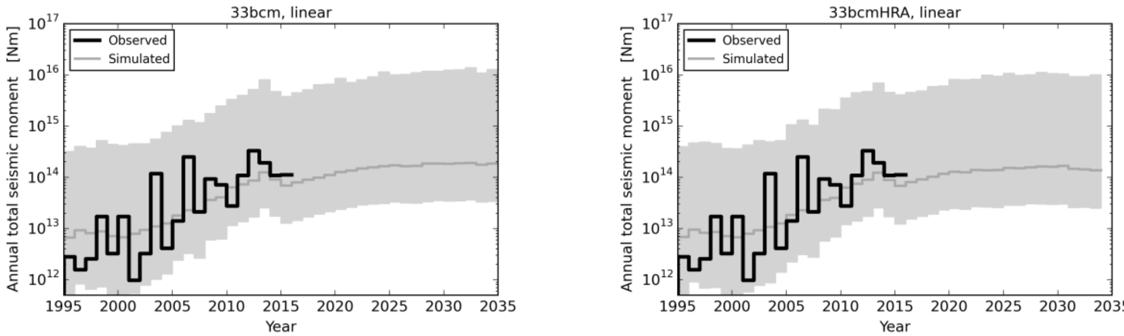
Figure 3.3 As Figure 3.2, except for annual event rate differences between the 27 bcm and 33 bcm production scenarios.

The mean annual event count for the 27 Bcm/year scenario shows one less earthquake larger than M≥2.5 for both 2024 and 2025 compared to the 33 Bcm/year scenario.

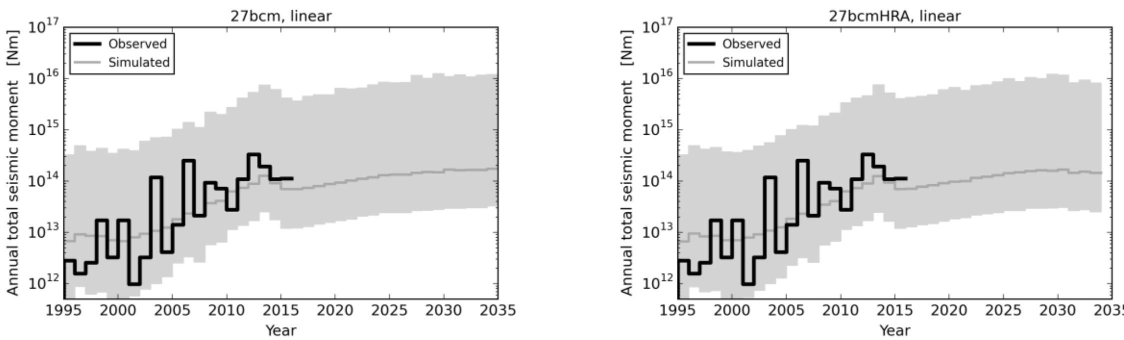
3.2 Annual Total Seismic Moments

In this section, figures showing the forecasted development of the annual total seismic moment are shown.

(a)



(b)



(c)

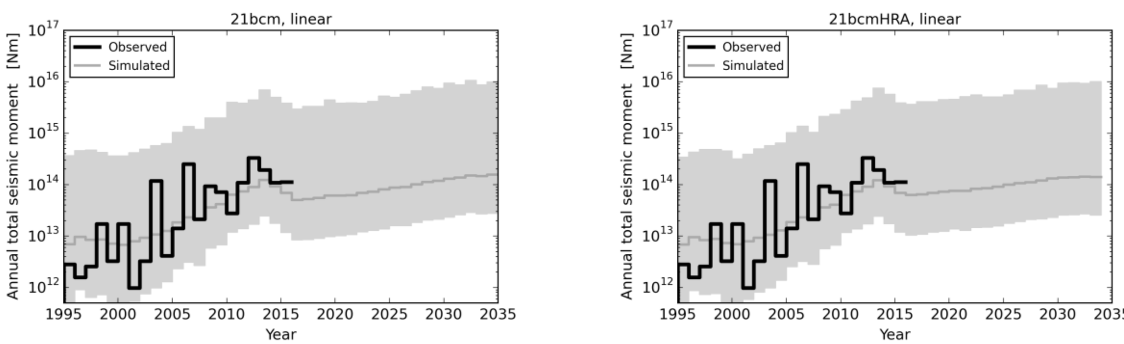


Figure 3.4 As Figure 3.1, except for the annual total seismic moments.

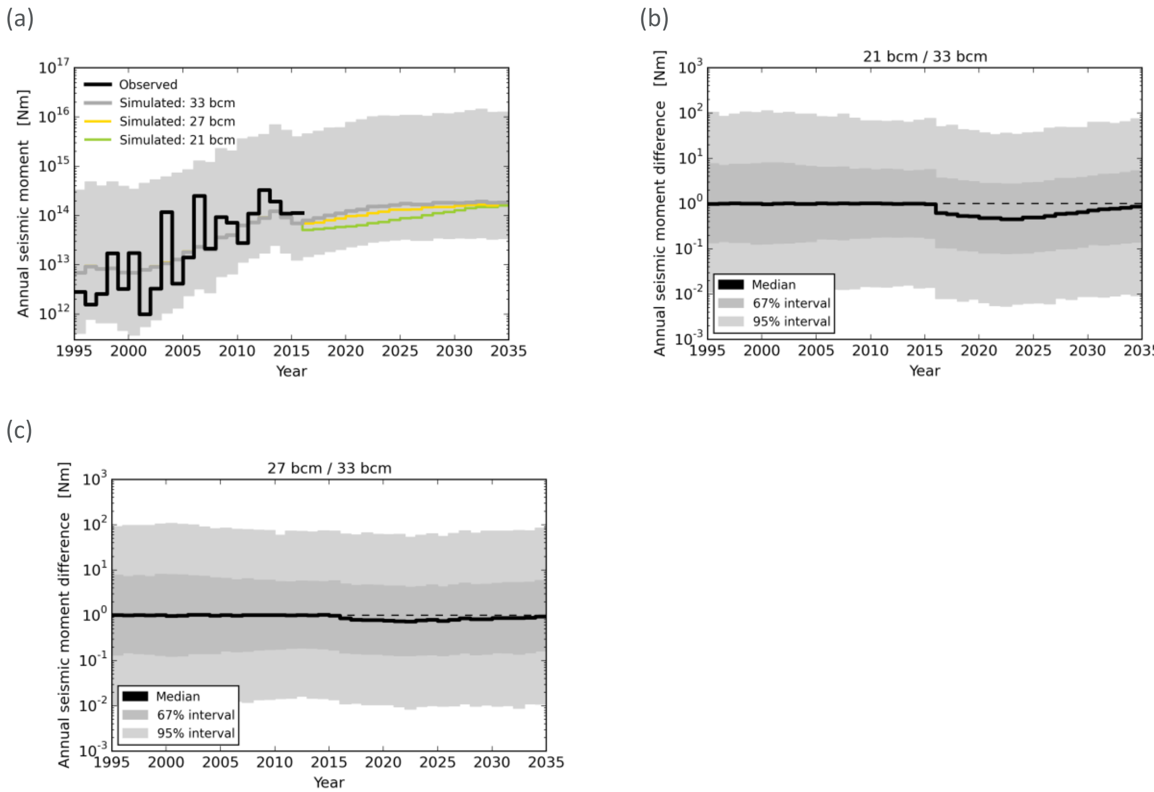


Figure 3.5 *(a) Comparison of annual total seismic moment forecasts for each production scenario. (b) Ratio of the forecasts for the 21 bcm and 33 bcm production scenarios. (c) Ratio of the forecasts for the 27 bcm and 33 bcm production scenarios.*

4 Maatschappelijk Veiligheidsrisico

4.1 Origin of this new Risk Metric

Aggregated risk metrics are available and are commonly applied for the evaluation and management of technical risks (e.g. chemical plant explosions) and natural risks (e.g. flooding) (Ref. 1). The group risk[1] (GR) metric was developed based on the concept that society has lower tolerance to accidents involving multiple fatalities in a single event than to multiple events involving single fatalities. However, there is no wide acceptance to use aggregate risk metrics. In its first advisory report, the committee Meijdam (Commissie-Meijdam) concluded: “The committee advises against the use of group risk on the grounds that this metric has not been given legal status in any safety domain, due to problems with the computability and the absence of any clear norms.“[2] (Ref. 2). The assessment of an aggregated risk metric also received attention in July 2015 from policy makers and politicians (Ref. 5, 6 and 7). In November 2015, NAM published an assessment of group risk (Ref. 8 and 9).

The third and final advisory report from Commissie-Meijdam (Eindadvies Handelingsperspectief voor Groningen Adviescommissie ‘Omgaan met risico’s van geïnduceerde aardbevingen’) (Ref. 4) introduced the new aggregated risk metric of Maatschappelijk Risico (MVR).

Eindadvies

Handelingsperspectief voor Groningen

Adviescommissie ‘Omgaan met risico’s
van geïnduceerde aardbevingen’
(Commissie-Meijdam)

Figure 4.1 Title page of final advice from Commissie-Meijdam (Eindadvies Handelingsperspectief voor Groningen Adviescommissie ‘Omgaan met risico’s van geïnduceerde aardbevingen’)

On the 27th of January 2016, a clarification meeting between SodM and NAM was held in Rijswijk. The purpose of this meeting was to ensure SodM and NAM had the same understanding of the definition of Maatschappelijk Veiligheidsrisico and to discuss any potential issues with its implementation. The outcome of this meeting was that Maatschappelijk Veiligheidsrisico would be calculated for a selection of communities. The Ministry of Economic Affairs in consultation with the National Coordinator Groningen sent an advice on 15th March 2016, in which seven communities were identified for which NAM was asked to calculate the Maatschappelijk Veiligheidsrisico. The definition of the communities was based on the wijk- en buurten definition by CBS (Ref. 11). Due to the complexity of the calculations and the requirement of thorough quality assurance, the Maatschappelijk Veiligheidsrisico calculations were not part of the submission of the Winningsplan Groningen 2016 on the 1st of

1 Both the terms “societal risk” and “group risk” have been used as translations of the Dutch term “groepsrisico”. In this document, we have therefore not translated the newly introduced term “Maatschappelijk Veiligheidsrisico” as this could lead to confusion.

2 Original text in Dutch: “Ook het gebruik van groepsrisico’s raadt de commissie af, omdat deze norm nergens een wettelijke status heeft gekregen, onder andere vanwege problemen met de berekenbaarheid.” (Ref. 2).

April. The results are being presented in this supplement. On the 14th April 2016, preliminary results were discussed with SodM, NCG and EZ, while technical assurance was still in progress.

4.2 Definition of Maatschappelijk Veiligheidsrisico

A new risk metric, “Maatschappelijk Veiligheidsrisico” (in Dutch) was introduced in the final Commissie Meijdam advice as an alternative to Group Risk. Maatschappelijk Veiligheidsrisico is an assessment of the annual frequency (F) with which a given number of fatalities (N) due to single earthquakes is exceeded. This frequency is then adjusted by subtracting the equivalent frequency for a Reference Group Risk defined as an independent individual probability of fatality of 10^{-5} per year. The calculation procedure for Maatschappelijk Veiligheidsrisico is described in the final Commissie Meijdam advice (Ref. 4).

The definition of Maatschappelijk Veiligheidsrisico, therefore is:

$$\mathrm{MVR}(N) = \mathrm{GR}(N) - \mathrm{RGR}(N)$$

where:

GR(N) = Group Risk: Annual exceedance rate for N fatalities due to single earthquakes within a given community

RGR(N) = Reference Group Risk: Annual exceedance probability for N fatalities in a single year within the community for an independent and uncorrelated individual annual fatality rate of 10^{-5}

Note: RGR is the survival function of the binomial distribution where the probability of an event is $p = 10^{-5}$ and the number of trials is the community population, n. In the limit of large populations, e.g. $n > 100$, the binomial distribution converges to the Poisson distribution with an expected value of $\lambda = np$.

For N=1 (a single fatality), we expect GR(1) < RGR(1) because most individual risks due to earthquakes are less than 10^{-5}/year. So, for N=1 Maatschappelijk Veiligheidsrisico will be negative. As the Reference Group Risk applies to a population exposed to an independent uncorrelated reference risk, for increasing N the Reference Group Risk will rapidly decrease. As a result, for larger N, e.g. N>10, Maatschappelijk Veiligheidsrisico will be essentially equal to Group Risk.

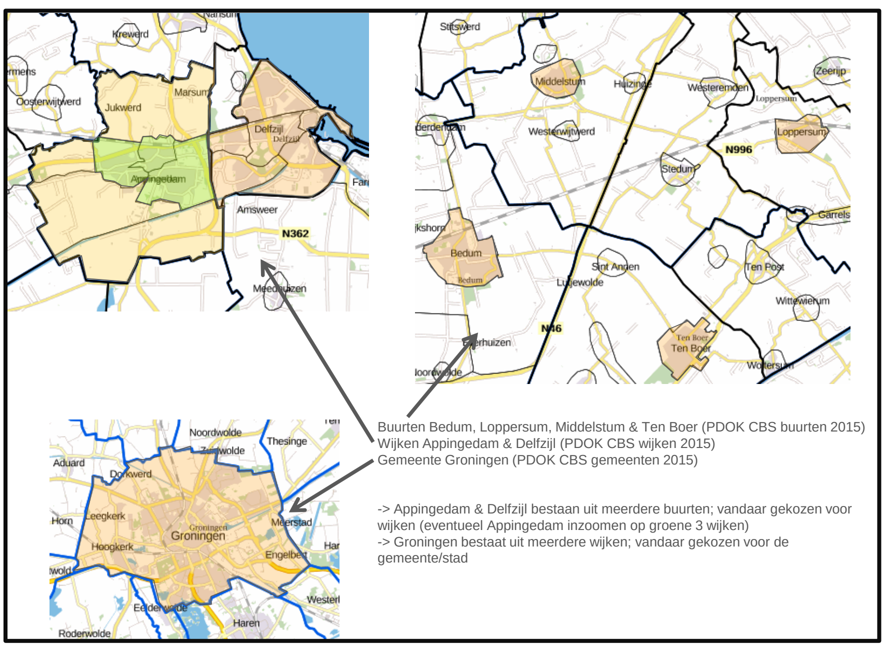


Figure 4.2 Extract from the advice by Ministry of Economic Affairs in consultation with NCG received on 15th March 2016, total seven communities were selected for calculation of Maatschappelijk Veiligheidsrisico.

Maatschappelijk Veiligheidsrisico is calculated for seven identified communities consisting of one or more neighbourhoods as defined in the wijk- en buurten register by CBS (Ref. 11). For instance the community “gemeente Groningen” consists of 10 neighbourhoods. Table 1 shows the neighbourhoods included in the seven communities. The calculation of the Maatschappelijk Veiligheidsrisico for the city of Groningen was limited by the areal extent of the database that is used in the hazard and risk assessment, known as the exposure database. The two neighbourhoods at the very western part of the city (Hoogkerk and Stadsparkwijk) were only partly included due to the limits of the exposure database, which documents the presence and typology of each building.

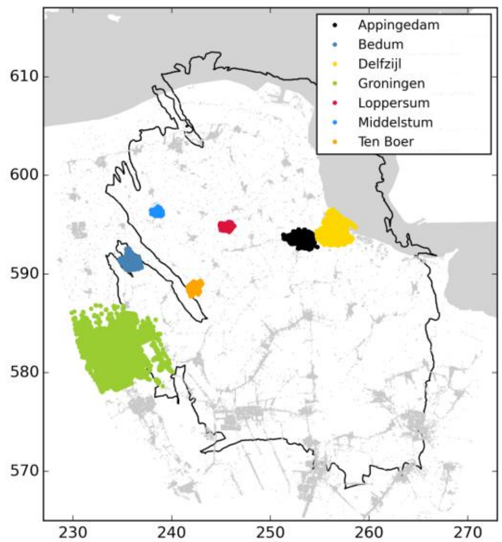


Figure 4.3 Buildings in the exposure database belonging to each of the seven communities.

Community	Attribute Value	CBS Neighborhood/District
Appingedam	Appingedam-Centrum Appingedam-West Appingedam-Oost	Appingedam-Centrum Appingedam-West Appingedam-Oost
Delfzijl	Delfzijl-Centrum Delfzijl-Farmsum Delfzijl-Noord Delfzijl-West Delfzijl-Fivelzigt Delfzijl-Tuikwerd	Delfzijl-Centrum Farmsum Delfzijl-Noord Delfzijl-West Fivelzigt Tuikwerd
Groningen	Groningen-Binnenstad Groningen-Schilders- en Zeeheldenwijk Groningen-Oranjewijk Groningen-Korrewegwijk	Wijk 00 Binnenstad Wijk 01 Schilders- en Zeeheldenwijk Wijk 02 Oranjewijk Wijk 03 Korrewegwijk
	Groningen-Oosterparkwijk Groningen-Oosterpoortwijk Groningen-Herewegwijk en Helpman Groningen-Stadsparkwijk Groningen-Hoogkerk Groningen-Noorddijk	Wijk 04 Oosterparkwijk Wijk 05 Oosterpoortwijk Wijk 06 Herewegwijk en Helpman Wijk 07 Stadsparkwijk Wijk 08 Hoogkerk Wijk 09 Noorddijk
Bedum	Bedum	Bedum
Loppersum	Loppersum	Loppersum
Ten Boer	Ten Boer	Ten Boer
Middelstum	Middelstum	Middelstum

Table 4.1 The seven identified communities consist of one of more neighbourhoods as defines in wijk- en buurten register by CBS. Community “gemeente Groningen” consists of 10 neighbourhoods.

4.3 Assessment of Maatschappelijk Veiligheidsrisico

Generically, both Group Risk and Maatschappelijk Veiligheidsrisico can be thought of as consisting of two separate contributions:

- Collapse of large occupancy buildings; i.e. collapse of a single building in which multiple people are present resulting in multiple fatalities and
- Collapse of multiple smaller buildings in a single community as a result of a single earthquake.

The hazard and risk assessment methodology addresses both contributions to the earthquake risk:

- The larger occupancy buildings at higher risk can be identified using the building community risk, defined as the product of the Local Personal Risk and the average night/day population for that building. In the work scope for structural upgrading these buildings (e.g. schools, hospitals and care homes) are treated with priority.
- The collapse of multiple buildings in a single event in a single community, is captured in the calculation of Local Personal Risk (LPR). The structural upgrading plan also targets buildings in this second contribution to group risk.

Reliable assessment of the multiple collapse (second) contribution requires detailed representation of the spatial correlations in the earthquake ground motions. In the current assessment, spatial correlation is represented as strong within each near-surface amplification zone up to a distance of 3 to 5 km with no correlation beyond this distance. More studies are required to address the modelling of the spatial correlation of ground motion to ensure it is appropriately represented. These studies have been included in the Study and Data Acquisition Plan – Winningsplan 2016 (Ref. 12).

Figure 4.4 shows the calculation of Maatschappelijk Veiligheidsrisico for a community. The Group Risk (in green), the Reference Group Risk (in blue) and the resulting Maatschappelijk Veiligheidsrisico (in red) are all shown.

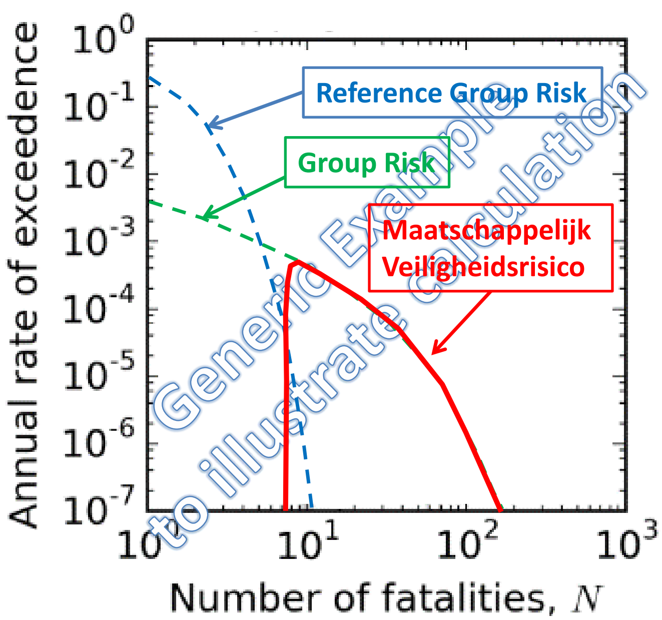


Figure 4.4 Maatschappelijk Veiligheidsrisico (red) resulting from earthquakes is the difference between earthquake group risk (green) and the reference group risk (blue).

For small N, the Reference Group Risk is larger than Group Risk and therefore the Maatschappelijk Veiligheidsrisico is negative. However the Reference Group Risk reduces fast with increasing N, dropping below Group Risk. For larger *N*, the Maatschappelijk Veiligheidsrisico is equivalent to Group Risk.

The Maatschappelijk Veiligheidsrisico assessments for all seven communities are shown in figure 4.5.

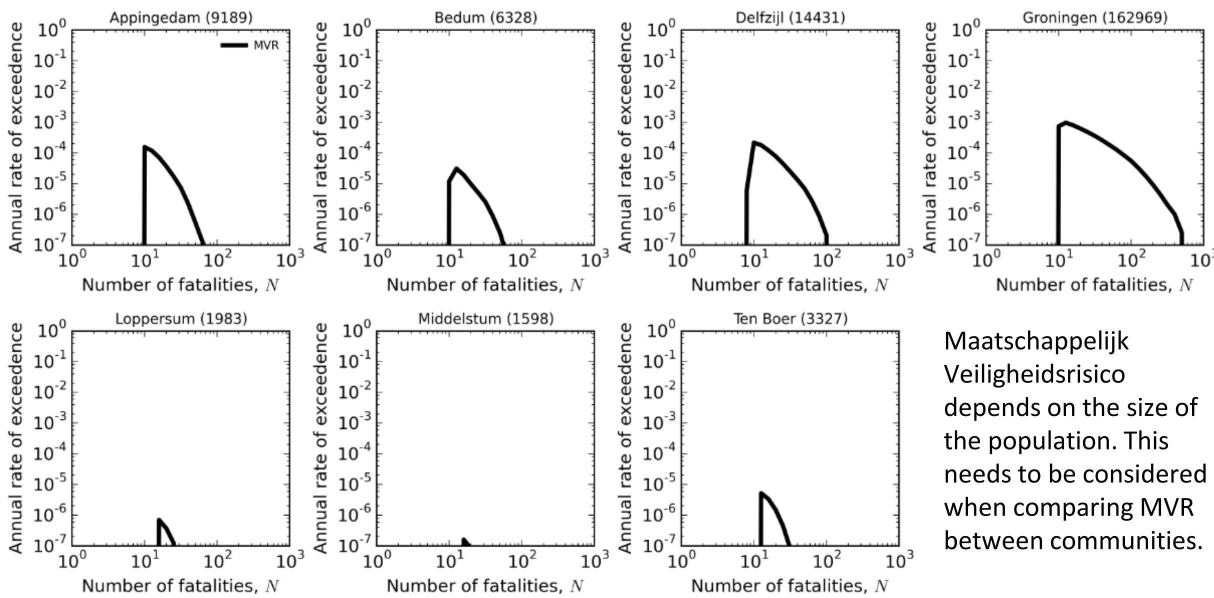


Figure 4.5 *Maatschappelijk Veiligheidsrisico based on the mean off the logic tree, for the seven community (in alphabetical order) for a production scenario of 33 Bcm/year. Numbers after each community name denote the average day-night inside total population for that community.*

For N smaller than about ten, the Reference Group Risk is larger than Group Risk and therefore the Maatschappelijk Veiligheidsrisico is negative. The curves in fig. 4.5 show for the seven selected communities, that for *N* larger than about ten, the Maatschappelijk Veiligheidsrisico is about equivalent to Group Risk.

The population (mean inside day-night population) is shown for each community. The Maatschappelijk Veiligheidsrisico clearly depends on population size. When comparing Maatschappelijk Veiligheidsrisico for different communities the size of these communities needs to be taken into consideration. A normalization for community size needs to be done prior to comparing Maatschappelijk Veiligheidsrisico for different communities.

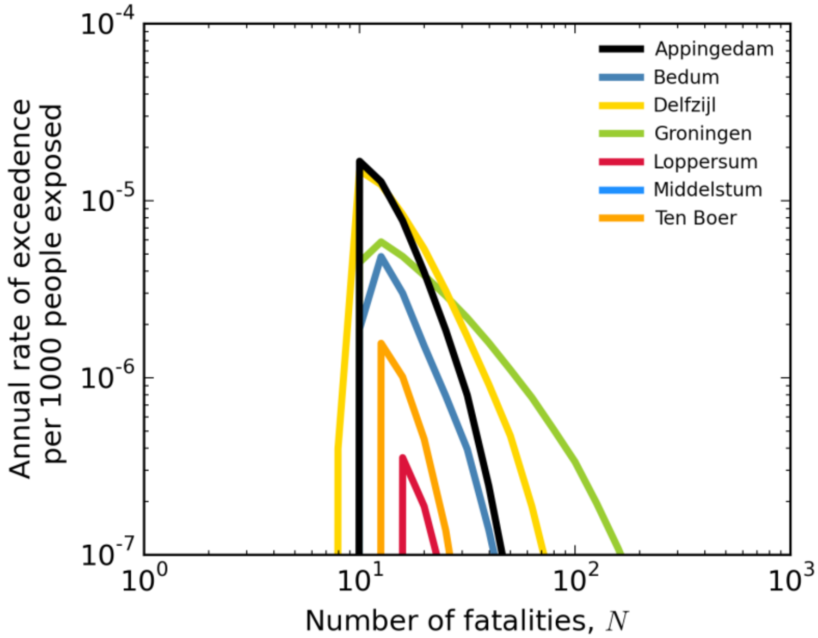


Figure 4.6 *As Figure 4.5, except Maatschappelijk Veiligheidsrisico is normalized by the average day-night total inside population for each community as the annual rate of exceedance per 1000 people exposed. This normalization allows comparison of Maatschappelijk Veiligheidsrisico for communities of different sizes.*

4.4 Conclusion

- The committee Meijdam introduced the aggregated risk metric of Maatschappelijk Veiligheidsrisico in its final advice to the Minister of EZ of November 2015. The communities for which the Maatschappelijk Veiligheidsrisico were to be calculated were defined by EZ in consultation with the NCG.
- The Maatschappelijk Veiligheidsrisico for induced seismicity has been assessed for seven communities in Groningen.
- The Maatschapplijk Veiligheidsrisico depends on population size. When comparing Maatschappelijk Veiligheidsrisico for different communities the size of these communities needs to be taken into consideration.

5 Sensitivity to Epistemic Uncertainties

In the Technical Addendum to the Winningsplan, tornado plots are provided for the epistemic uncertainty (Fig. 5.1). These show the impact of the epistemic uncertainties in the logic tree on the mean local personal risk and buildings with mean local personal risk. This is difficult to reconcile with the building exceedance curves, which show mean exceedance. The reason for this is because they are different measures. The mean local personal risk is the average of all assessed values of local personal risk for a given building from the entire logic tree. This mean value was used for all figures denoting mean local personal risk, including the building exceedance curves, with the exception of a tornado plot. For the tornado plot denoting the number of buildings with mean LPR ≥ 10^{-5}/year, the extent of the grey bars show the mean number of buildings with LPR ≥ 10^{-5}/year computed for sub-sets of the logic tree. This is different because it concerns LPR and mean building counts rather than mean LPR and building counts. Or to state it another way, he exceedance of means is not the same as the mean of exceedances. The original tornado plot axis label did not make this distinction clear.

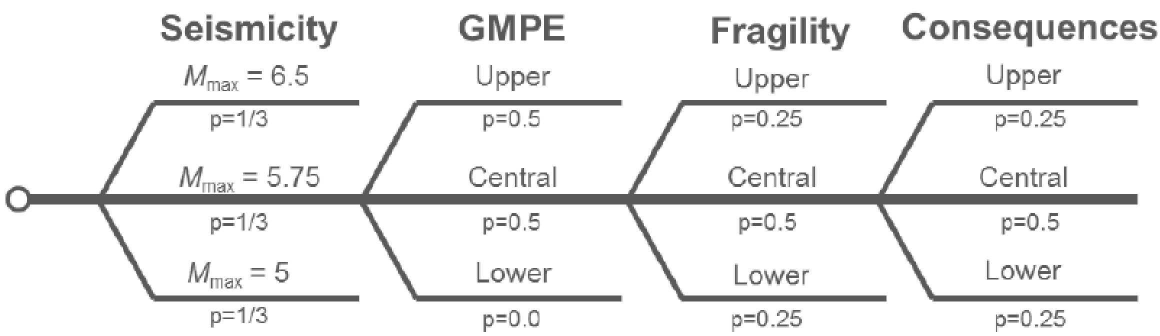


Figure 5.1 *Sensitivity of the assessed seismic risk to the epistemic uncertainties identified on the logic tree for the 4 key factors: the seismicity model, ground motion prediction equation, building fragility model, and the consequence model. The extent of each grey bar denotes the average value of the risk metric for the subset of the logic tree where the given factor is constrained to the lower branch (lower limit) and then the upper branch (upper limit).*

To avoid this confusion, Figure 5.2 plots the fractional variation in local personal risk and buildings with local personal risk to show the relative risk sensitivities to each source of epistemic uncertainty represented by the logic tree (Figure 5.1).

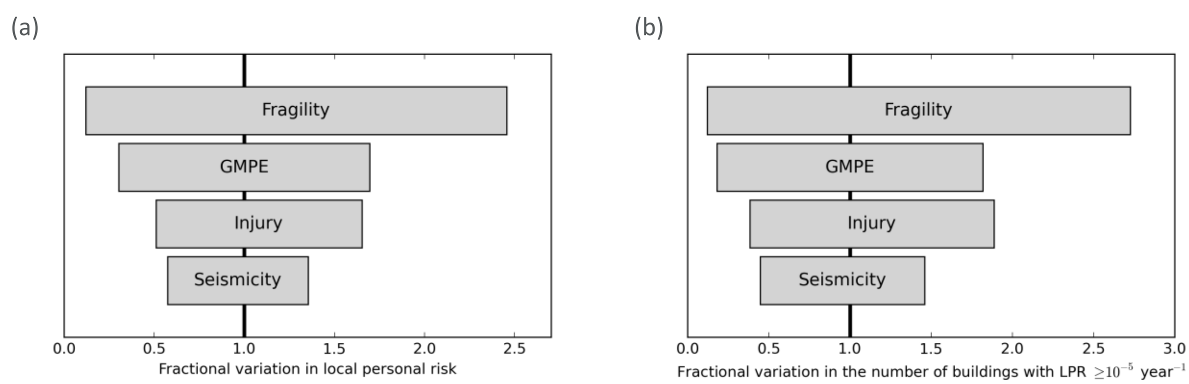


Figure 5.2 *Results for 2016-2021 under the 33 bcm production scenario for two different risk metrics: (a) the mean local personal risk for all populated buildings, (b) the number of populated buildings with a local personal risk exceeding 10^{-5} year^{-1}. Other assessment periods and production scenarios yield similar results.*

6 References

1 Guidelines for Developing Quantitative Safety Risk Criteria, Center for Chemical Process Safety, ISBN 978-0-470-26140-8,

2 Eerste advies Adviescommissie 'Omgaan met risico's van geïnduceerde aardbevingen' 23 juni 2015,

3 Tweede advies Omgaan met hazard- en risicoberekeningen in het belang van handelingsperspectief voor Groningen Adviescommissie 'Omgaan met risico's van geïnduceerde aardbevingen' 29 oktober 2015,

4 Eindadvies Handelingsperspectief voor Groningen Adviescommissie 'Omgaan met risico's van geïnduceerde aardbevingen' (Commissie-Meijdam) 14 december 2015,

5 Antwoorden van de Minister van Economische zaken op de vragen en opmerkingen van de vaste commissie voor Economische Zaken inzake mijn brief 'Gaswinning Groningen en meerjarenprogramma NCG' (Kamerstuk 33 529, nr. 212).

6 Tweede Kamer der Staten-Generaal, MOTIE (33 529 - 189) VAN DE LEDEN JAN VOS EN BOSMAN. Voorgesteld tijdens het Notaoverleg van 1 juli 2015.

7 Tweede Kamer der Staten-Generaal, MOTIE (33 529 - 195) VAN HET LID AGNES MULDER C.S. Voorgesteld tijdens het Notaoverleg van 1 juli 2015

8 Interim Update of the Hazard and Risk Assessment for induced seismicity in Groningen, NAM, 7th November 2015.

9 "Inzichtelijk maken groepsrisico", brief NAM, 30 november 2015. http://www.sodm.nl/documenten/publicaties/2015/12/18/5.7-%E2%80%9Cinzichtelijk-maken-groepsrisico%E2%80%9D-brief-nam-30-november-2015,

10 Antwoorden van de Minister van Economische zaken op de vragen en opmerkingen van de vaste commissie voor Economische Zaken inzake mijn brief 'Gaswinning Groningen en meerjarenprogramma NCG' (Kamerstuk 33 529, nr. 212), 24 februari 2016,

11 Toelichting Wijk- en Buurtkaart 2013, 2014 en 2015 Respectievelijk Versie 3, 2 en 1, CBS, December 2015. https://www.cbs.nl/nl-nl/dossier/nederland-regionaal/geografische%20data/wijk-en-buurtkaart-2015.

12 Study and Data Acquisition Plan for induced seismicity in Groningen, NAM, 1st April 2016.

7 Appendix A – List of Abbreviations

ALARP	As Low As Reasonably Practicable
ARUP	Engineering Company named after founder: Ove Arup
Bcm	N.Bcm refers to a volume of a billion normal cubic meters. Normal means the volume is measured at a standard temperature (0 degree C) and pressure (1 bar)
CBS	Centraal Bureau Statistiek
EZ	Ministerie van Economische Zaken
GR	Group Risk
HRA	Hazard and Risk Assessment
ILPR	Inside Local Personal Risk
I&M	Ministerie van Infrastructuur en Milieu
KNMI	Koninklijk Nederlands Meteorologisch Institute
LPR	Local Personal Risk
M	Earthquake Magnitude
MVR	Maatschappelijk Veiligheidsrisico
NAM	Nederlandse Aardolie Maatschappij B.V.
NCG	Nationaal Coordinator Groningen
OIA	Objectgebonden Individueel Aardbevingsrisico (Object related individual earthquake risk)
OIR	Object-bound individual risk (same as OIA)
RGR	Reference Group Risk
RIVM	Rijksinstituut voor Volksgezondheid en Milieu
RTCiM	Rate-Type Compaction isotach Model
SAC	Scientific Advisory Committee
SodM	Staatstoezicht op de Mijnen (also SSM State Supervision of Mines)
SSHAC	Senior Seismic Hazard Analysis Committee
TK	Tweede Kamer (Dutch equivalent of House of Commons)
TNO	Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek, Netherlands Organisation for Applied Scientific Research
TNO-AGE	Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek – Advies Groep Economische Zaken