



NAM

# AARDBEVINGEN IN GRONINGEN

KIVI avondseminar  
3 maart 2014



**BRON VAN ONZE ENERGIE**



# NAM en Groningen Gasveld

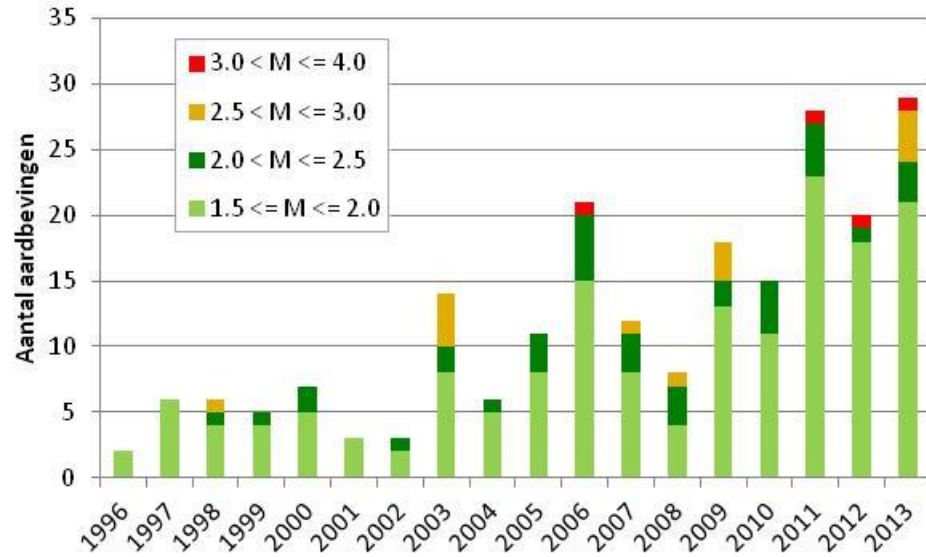


Veld Contour



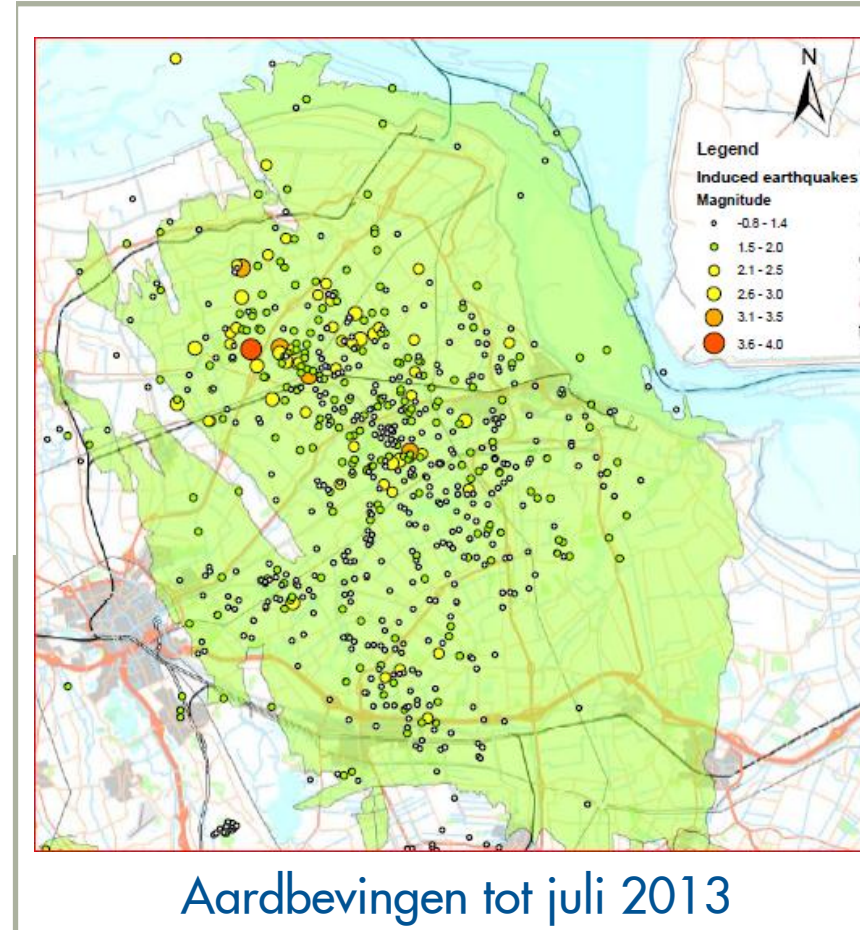
Bierum Cluster





## HUIZINGE, 16 AUGUST 2012

- 3.6 Richter schaal; 3.9 maximum?
- onveiligheid....schade...woningwaarde!



## Bovengronds

Gebouwen  
Schade

Gebouwen  
Beweging

Grond  
Beweging

Studie 1: Seismisch risico

## Ondergronds

Gas  
Productie

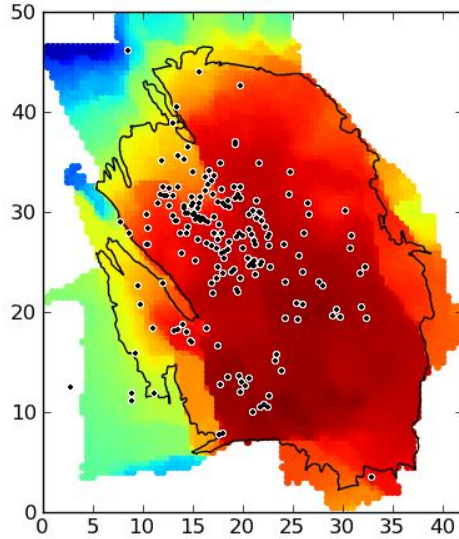
Drukdaling

Compactie /  
Bodemdaling

Aardbeving

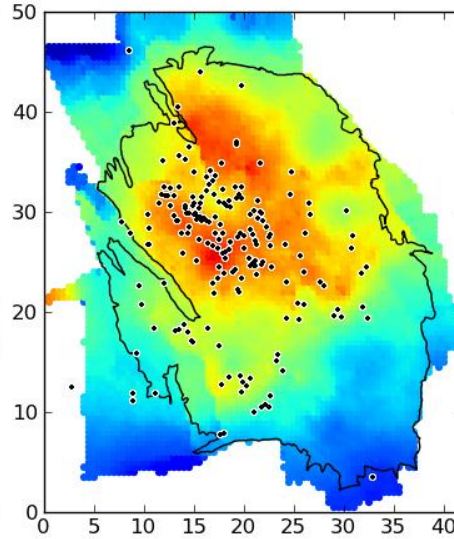
Studies 5 & 6: Seismisch gevaar en alternatieve depletie

## Druk Daling



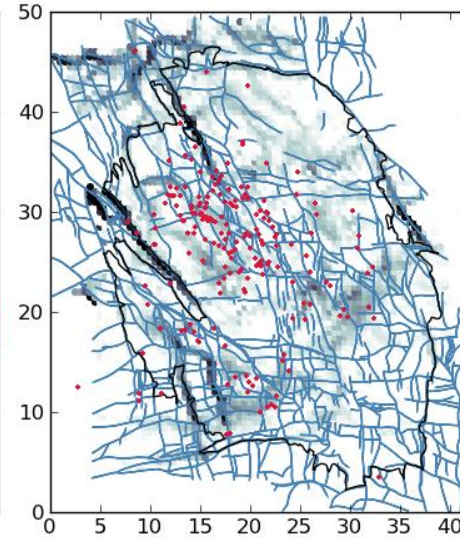
0 12 25  
Pressure depletion,  $\Delta P$  [MPa]

## Compactie

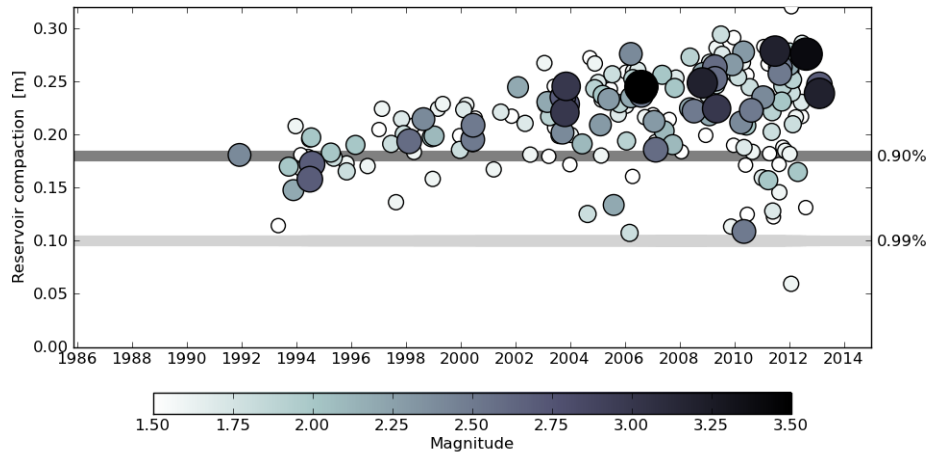


0 0.17 0.35  
Compaction,  $\Delta V$  [m]

## Breuken



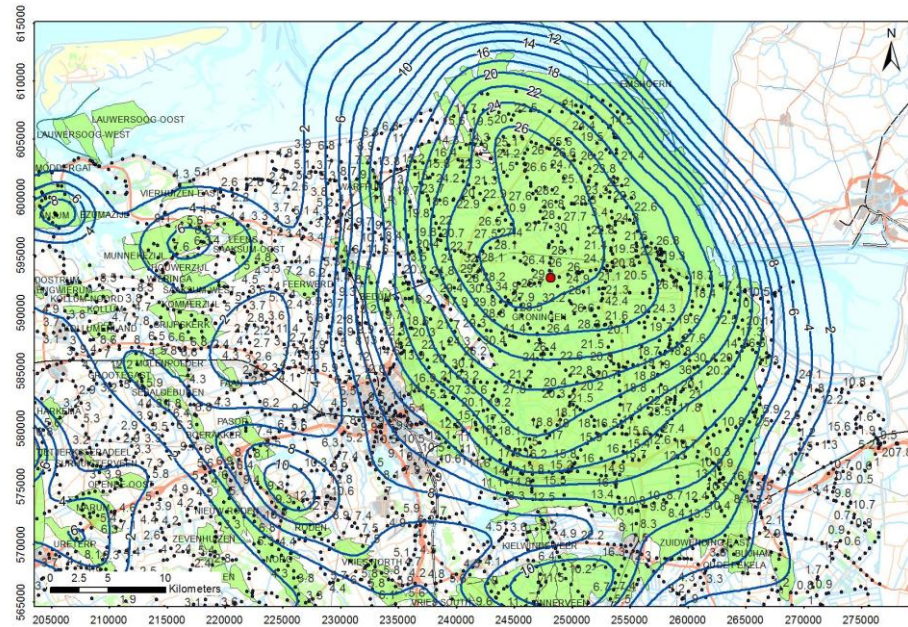
10 40 70  
Compaction gradient,  $|\nabla(\Delta V)|$  [ $\times 10^{-6}$ ]



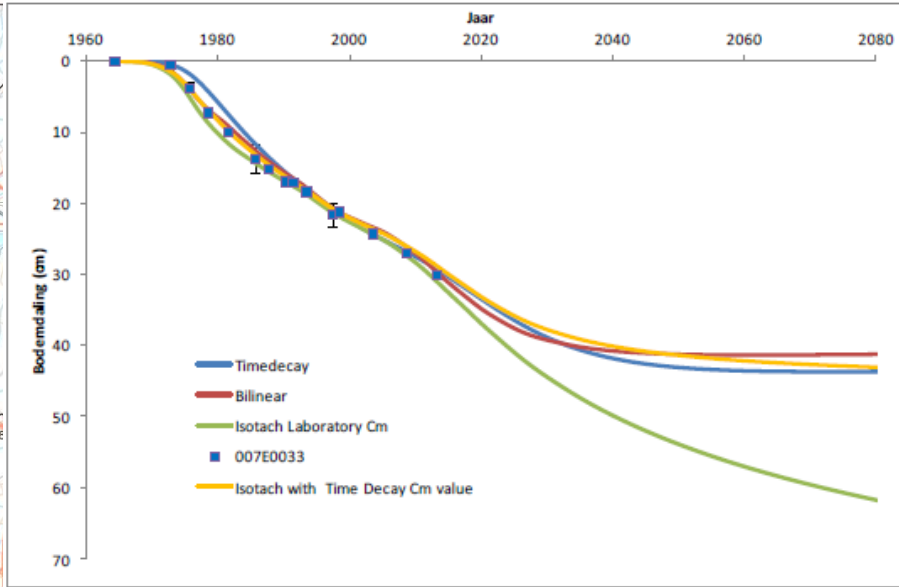
## Seismiciteit en compactie



# Compactie en Bodemdaling



Bodemdaling in 2008

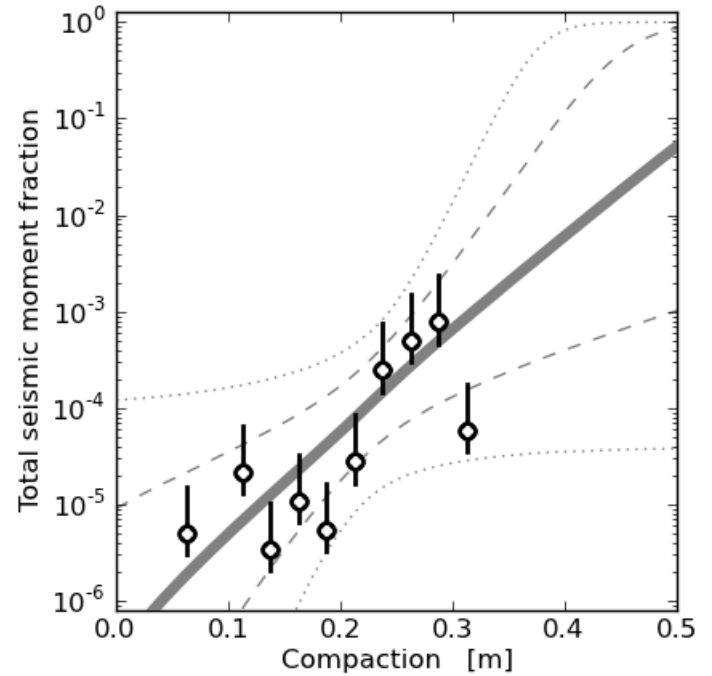
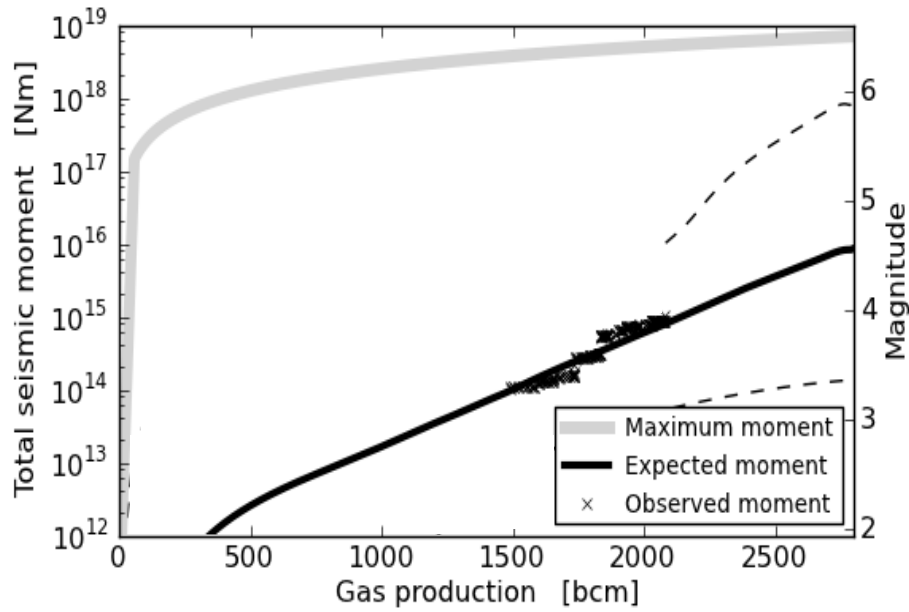


Compactie Modellen



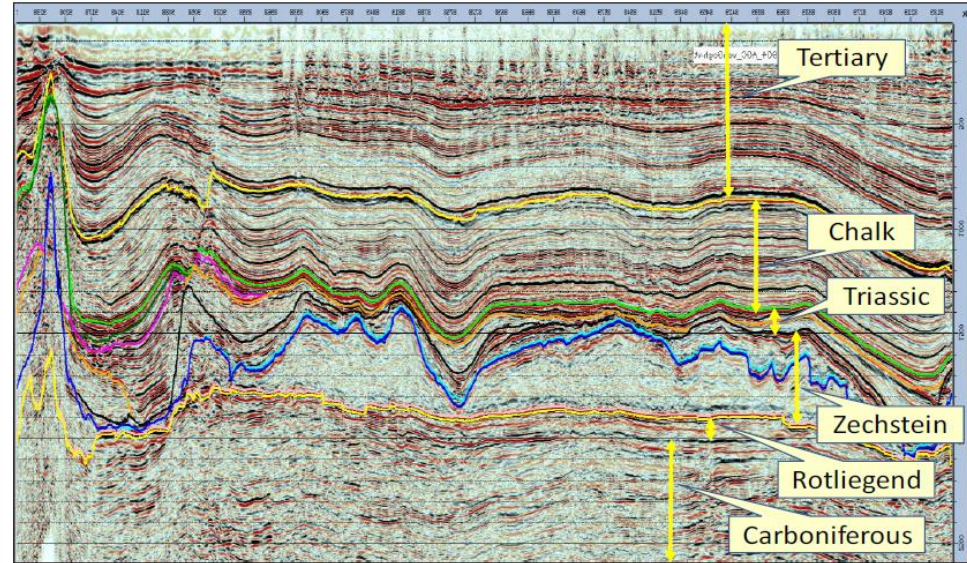
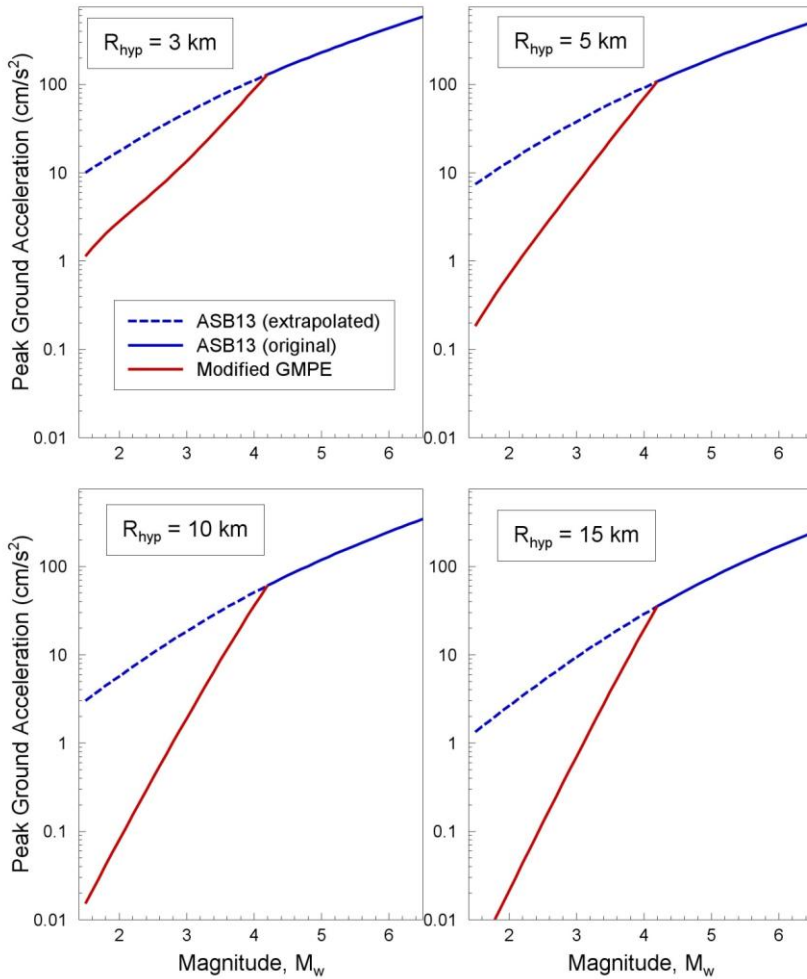


# Seismisch Moment





# Grond Beweging

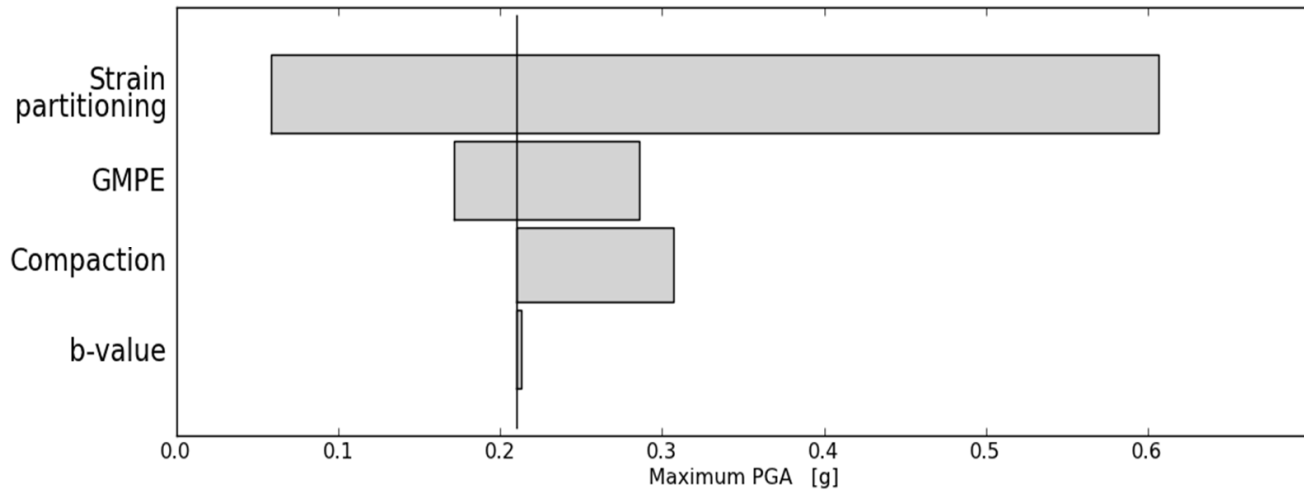
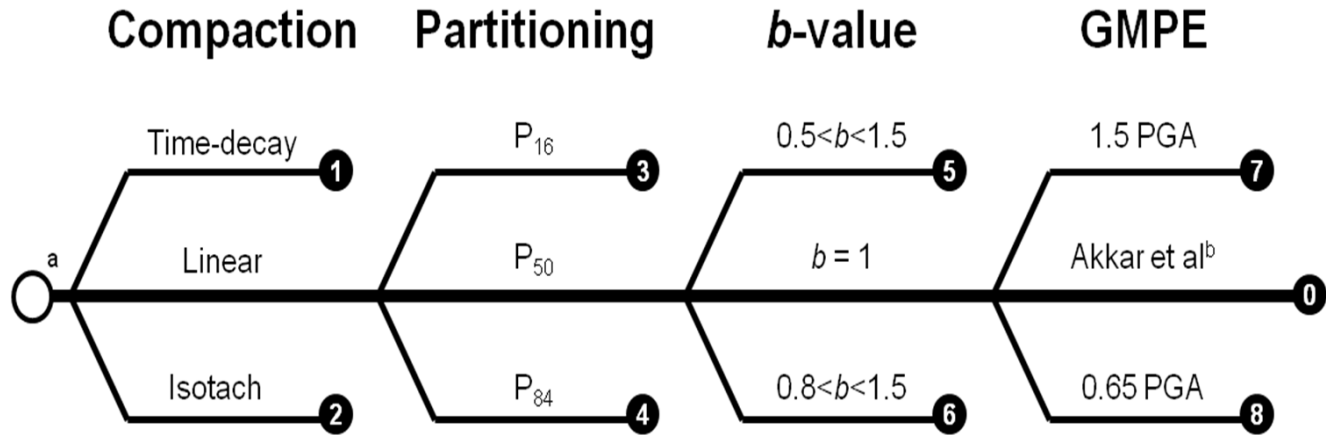


Veld doorsnede

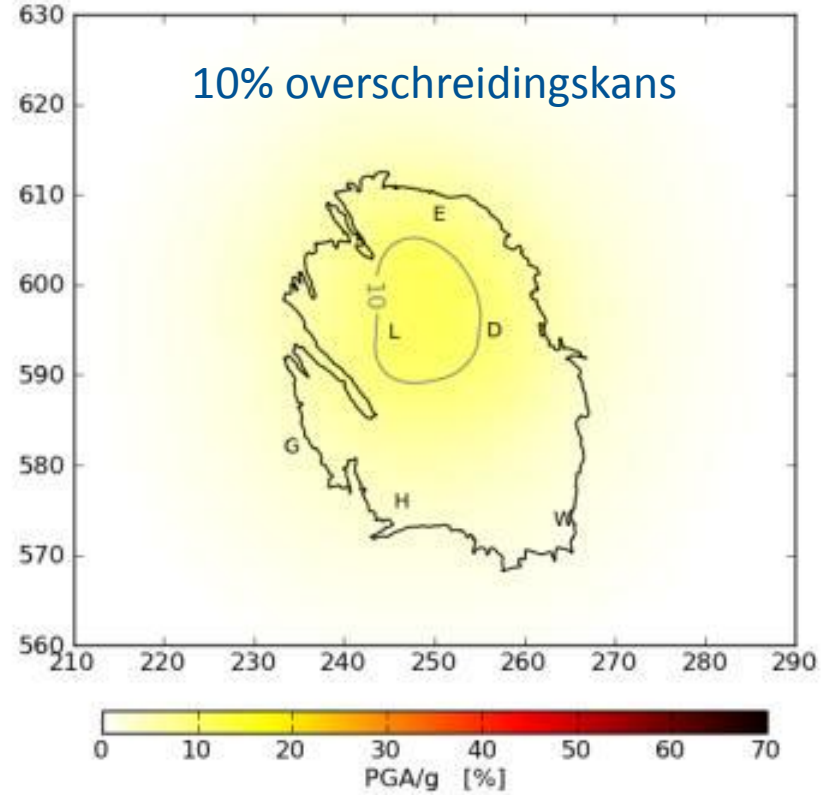
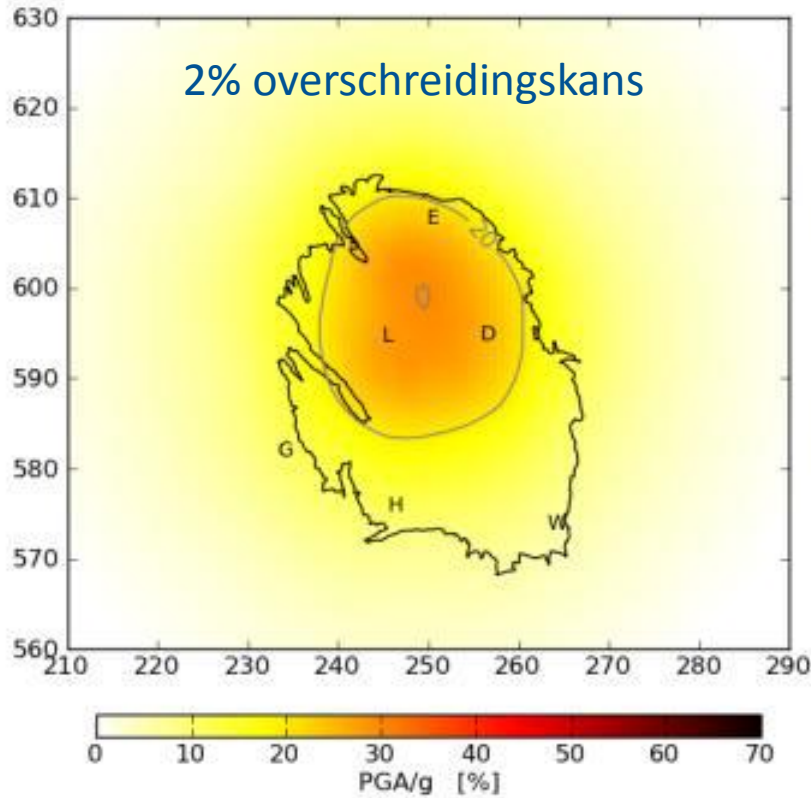
Ground Motion Prediction Equation



# Onzekerheids Analyse



# Seismisch Gevaar (2013-2016)

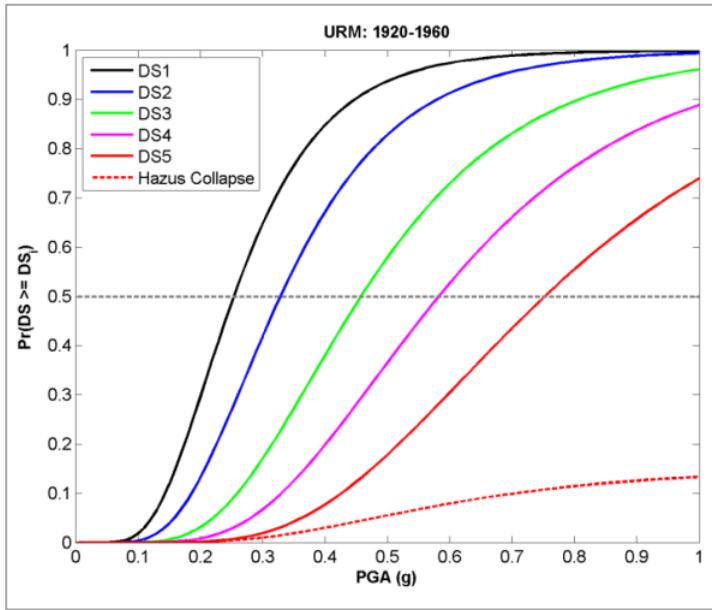


Peak Ground Acceleration (PGA)

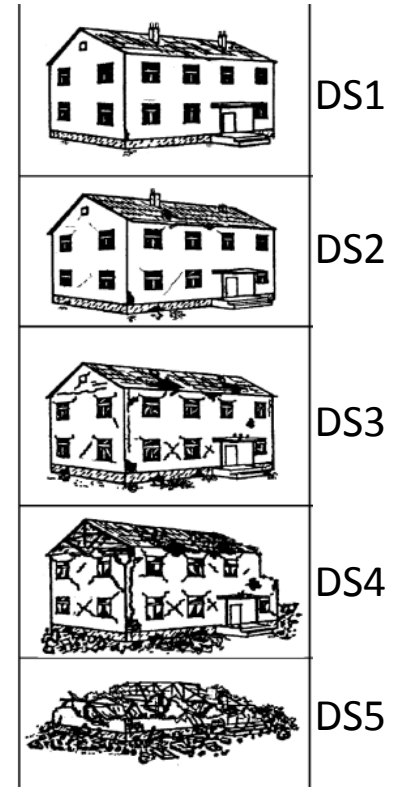


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# Gebouwen Schade



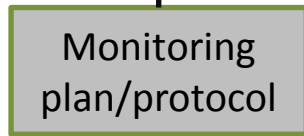
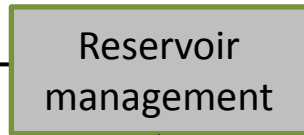
## Fragility Curve



## Schade Classificatie EMS98

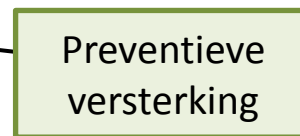
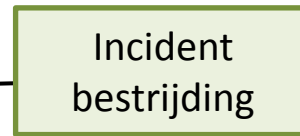
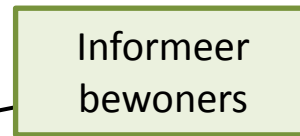
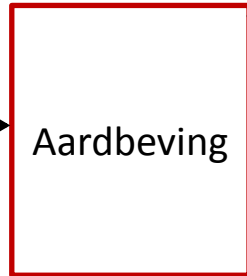


## Gevaar



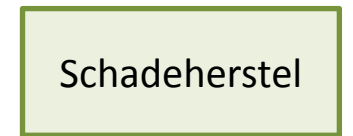
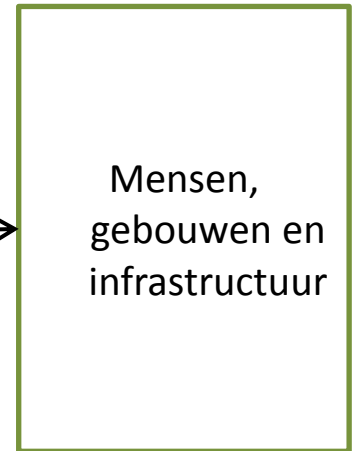
**Reduceer kans**

## Gebeurtenis



**Mitigeer consequentie**

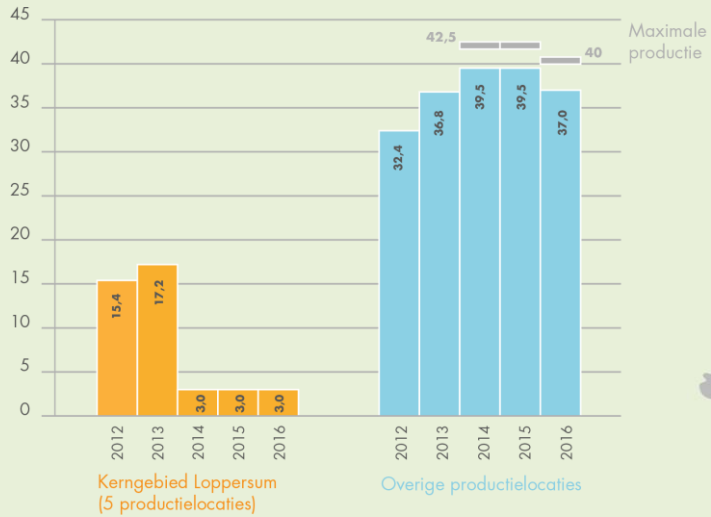
## Consequentie



# Productiebeperking

## NAM PRODUCTIELOCATIES GRONINGEN-GASVELD

Productie uit Groningen-gasveld (per jaar in miljard m<sup>3</sup>)



- 80% vermindering Loppersum
- Bovengrens totale productie



- Groningen-gasveld
- Productielocaties met verminderde gaswinning
- Overige productielocaties
- Satelliet van productielocatie
- Gasleidingen

# Preventief Verstevenigen van Gebouwen



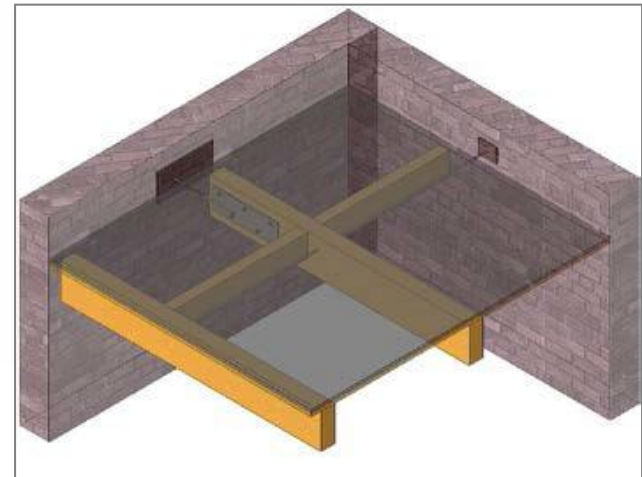
Inspecties



Tijdelijke maatregelen

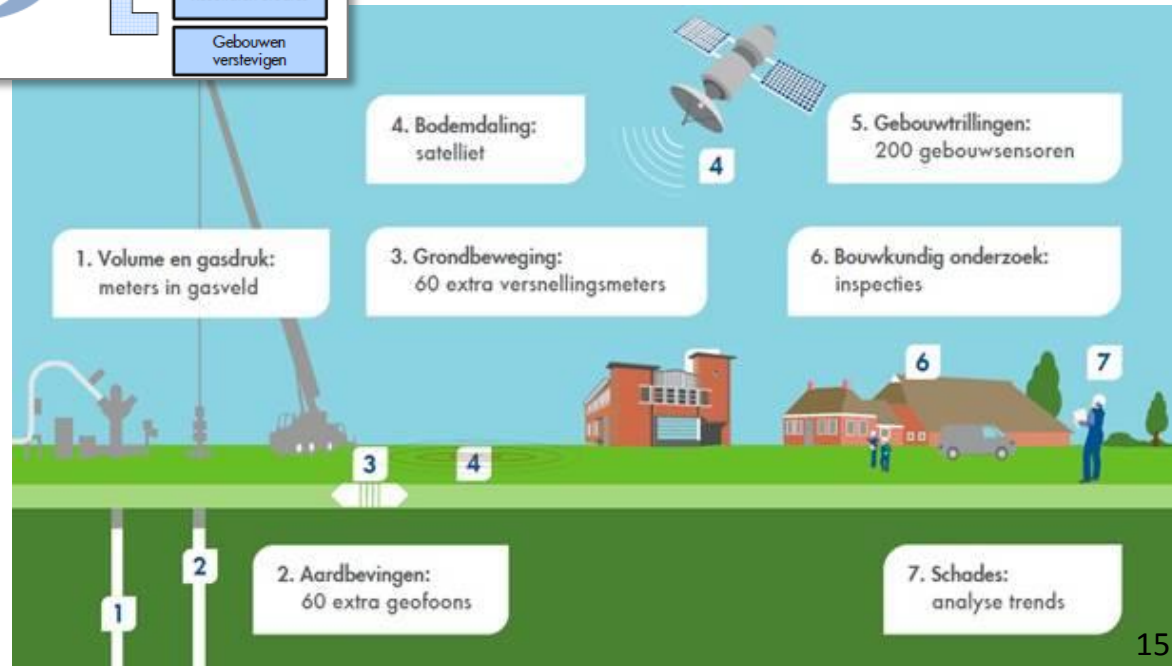
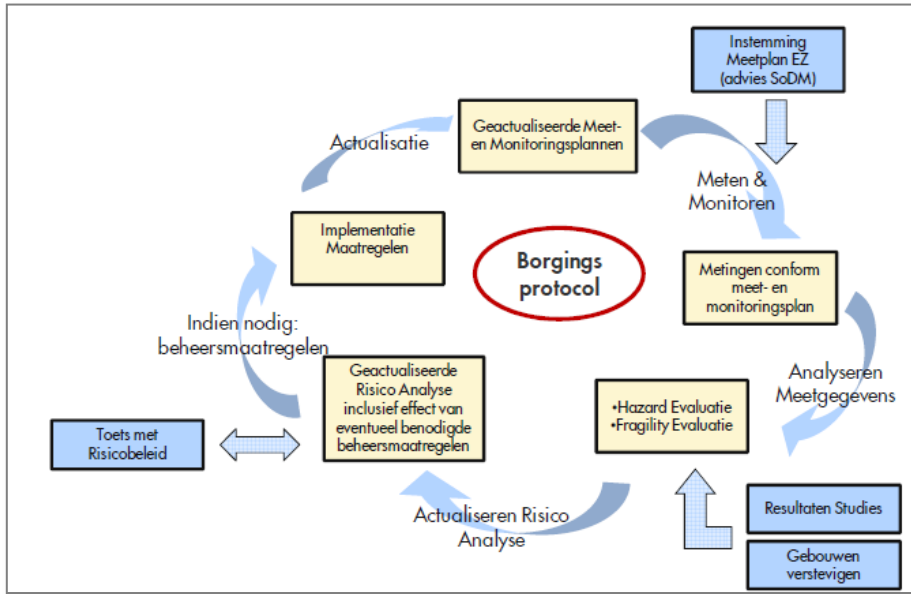


Gevaar van vallende objecten



Verstevenigen







# Breder Pakket Maatregelen





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