



**State Supervision of Mines**  
*Ministry of Economic Affairs*

# The challenge of managing extraction induced seismicity in Groningen, The Netherlands

Annemarie G. Muntendam-Bos

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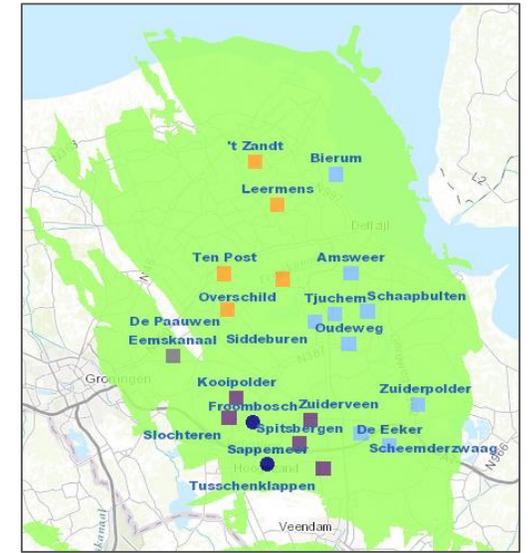
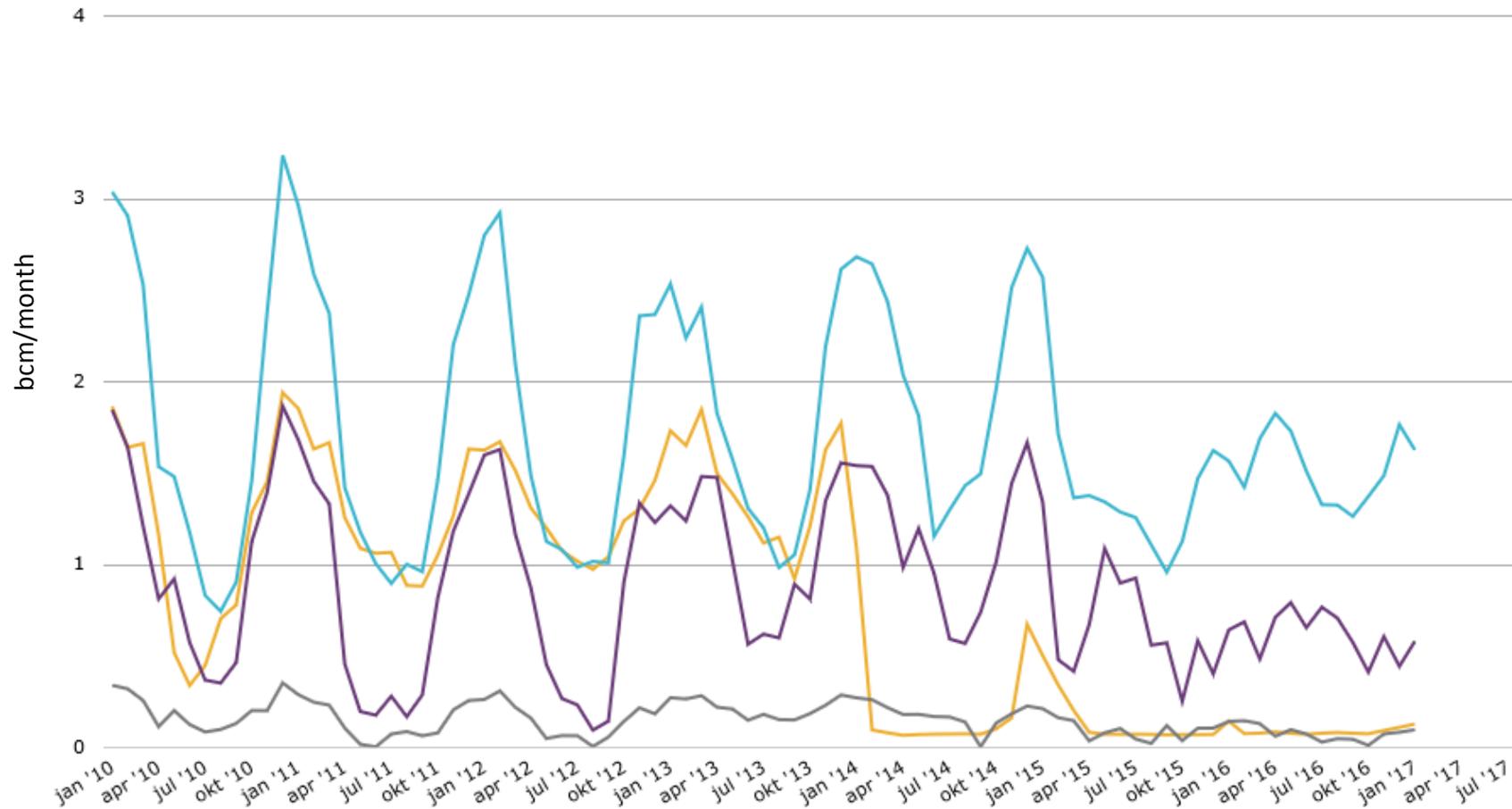
# The Groningen gas field

- Located in the NE of the Netherlands
- Discovered in 1958
- Production started in 1968
- Volume of 2800 bcm of gas on discovery





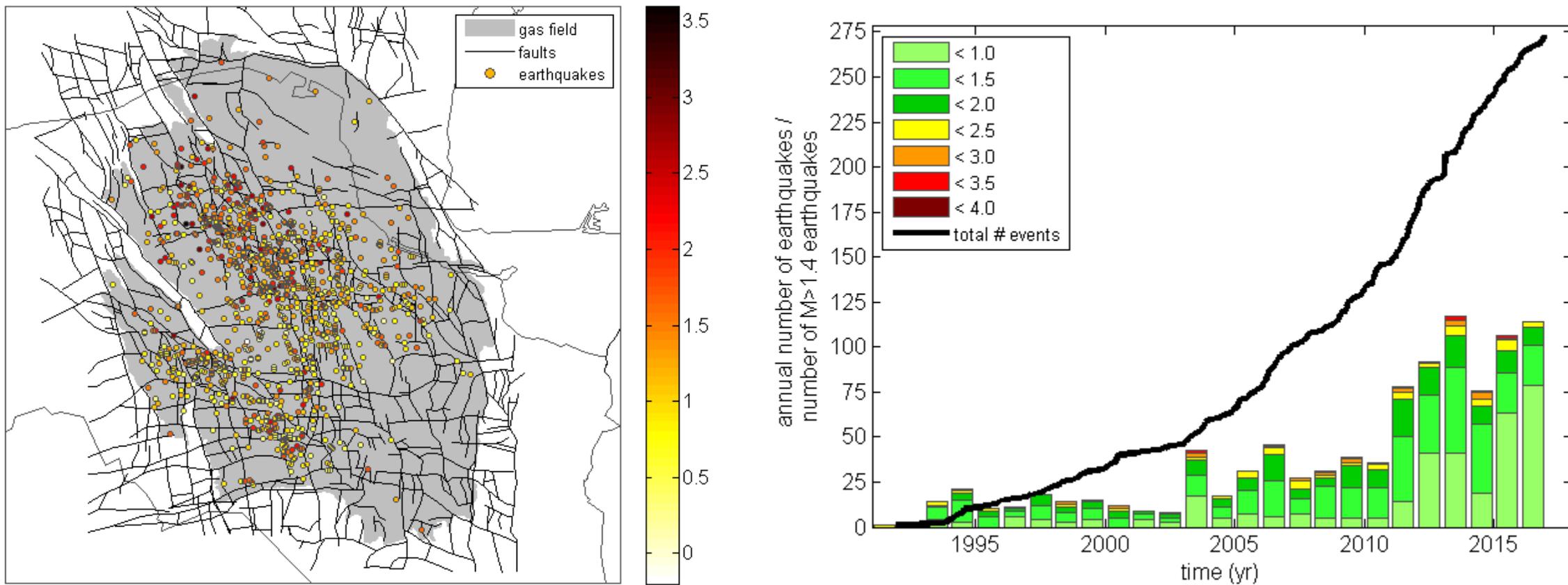
# Production history



Source: nam.nl



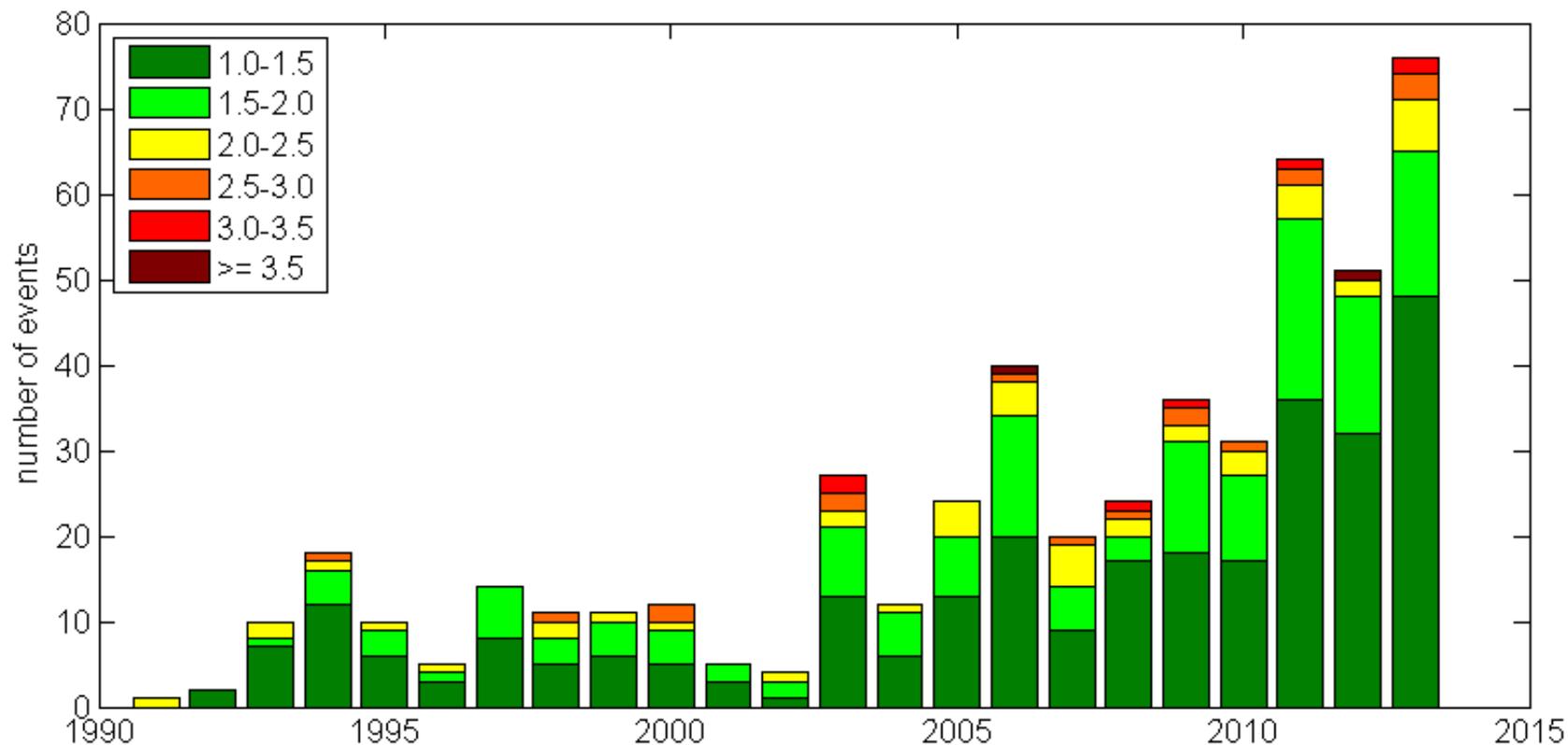
# Development of Groningen seismicity





# Development of Groningen seismicity

1991-2013



Year	Mmax
1993	3.3
1997	3.7
2003	3.9
2012	??

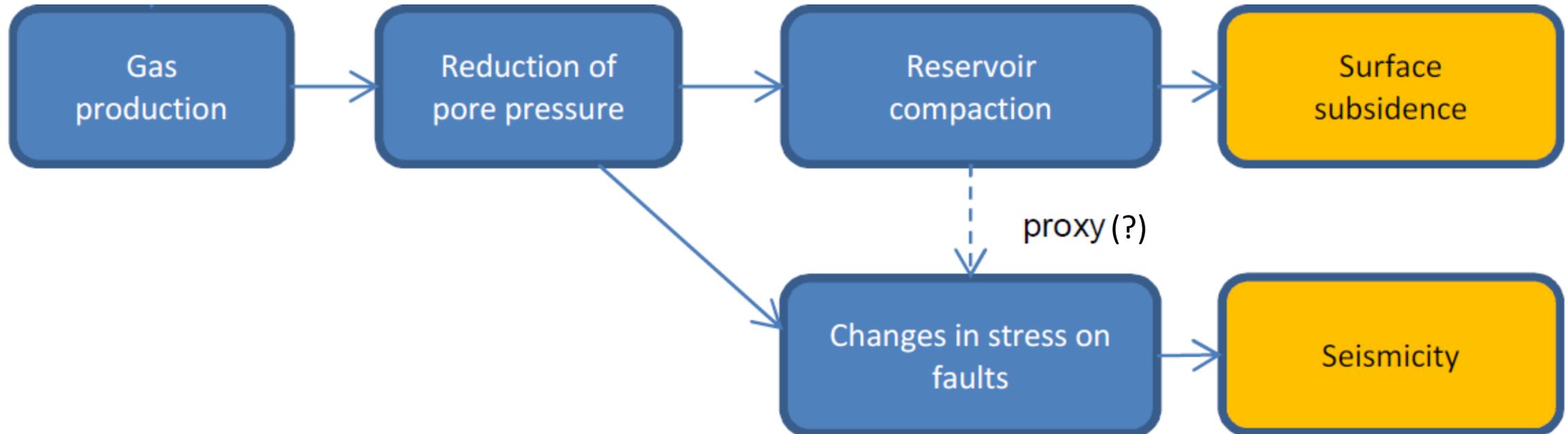


# Seismic Risk?





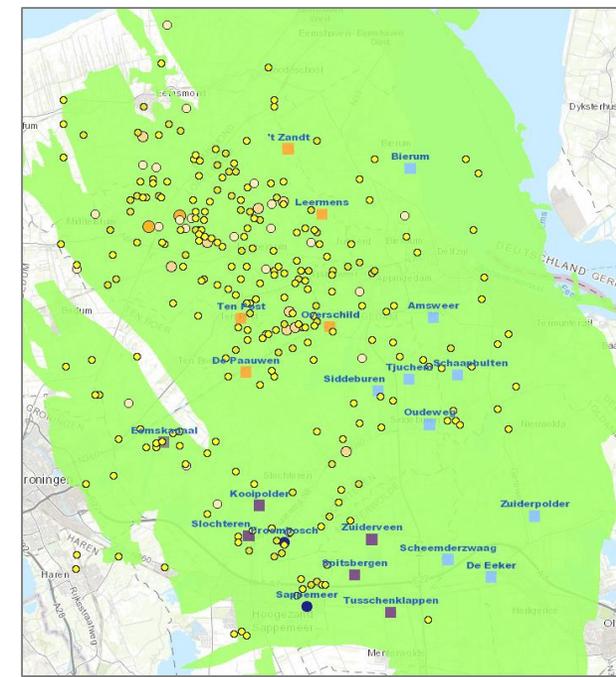
# Gas extraction induced seismicity





# Production measures taken

- January 2014: Reduce production center field by 80%  
54 bcm 2013 -> 49,5 bcm/yr 2014
- January 2015: Reduce production SW to level 2012  
-> 37 bcm/yr 2015
- June 2015: Reduce production evenly to 33 bcm/yr; diminish seasonal fluctuations if possible
- November 2015: Council of State ruling: 27 bcm/yr; diminish seasonal fluctuations if possible
- Oktober 2016: Reduce production evenly to 24 bcm/yr; minimize fluctuations in production





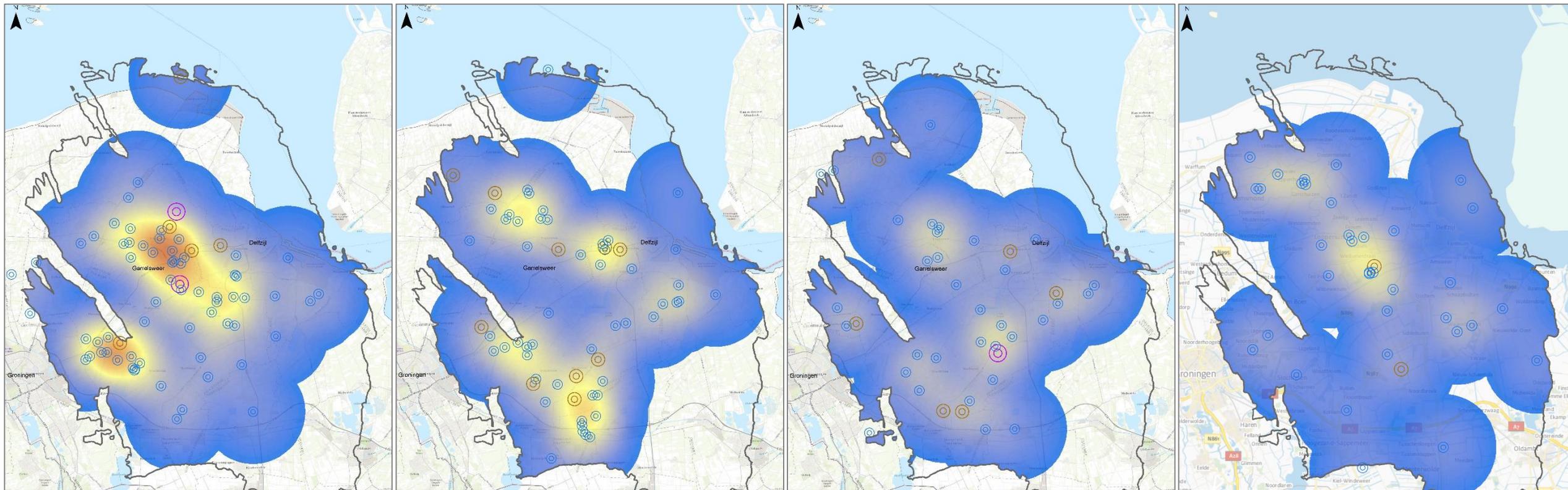
# Impact production measures on seismicity

March 2013-March 2014

March 2014-March 2015

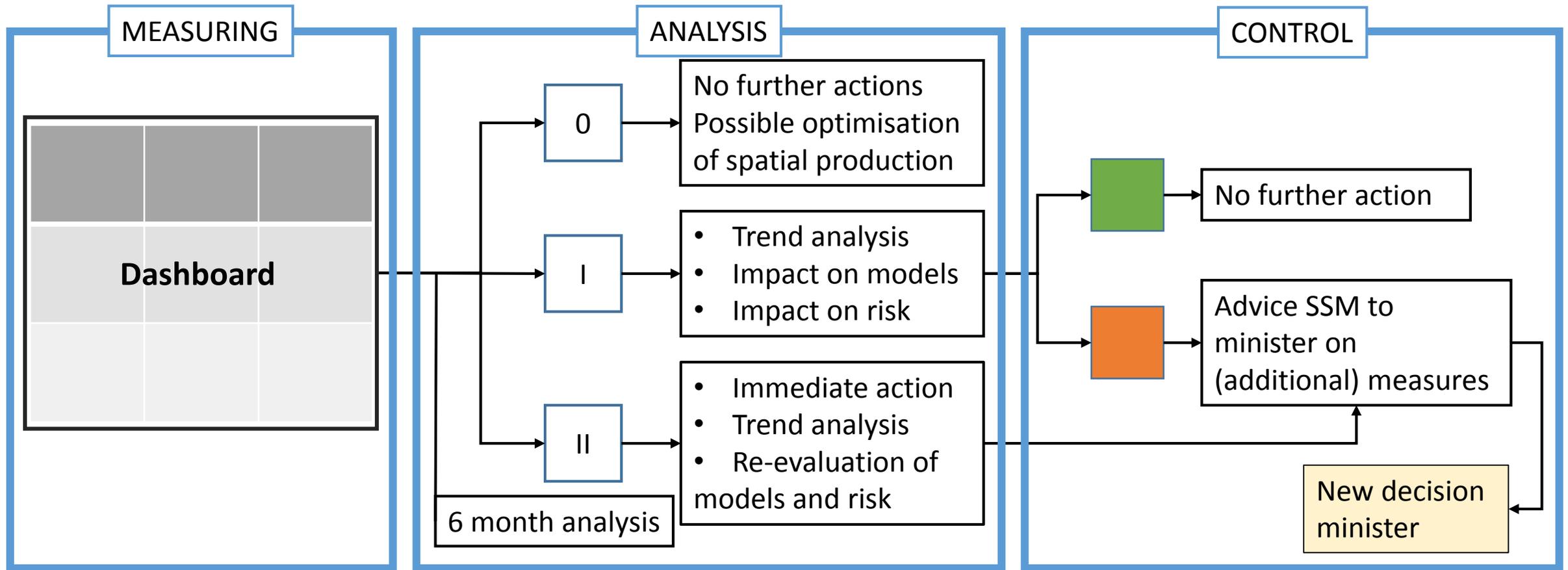
March 2015-March 2016

March 2016-March 2017





# Flow diagram of Measurement & Control loop





# Conclusions

- Induced seismicity has been increasing exponentially up to 2013
- The decreases in production have been effective in interrupting this trend throughout the field.
- Also less larger magnitude events ( $M > 2.5$ ) are observed and none since September 30, 2015.
- Some clustering of small magnitude events is still observed → only very small stress perturbations are necessary to trigger seismic slip.
- Towards the future seismicity will be managed further through the Measurement and Control protocol.



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Thank you for your attention

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