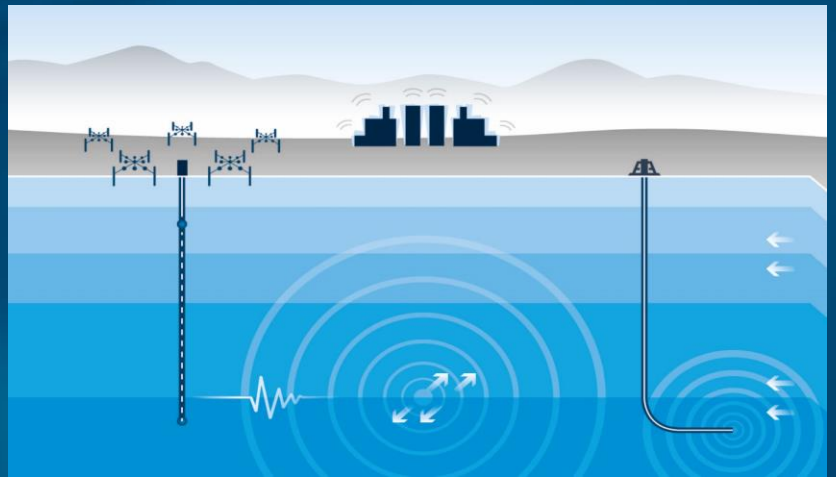
NORSAR
Exploring the Earth

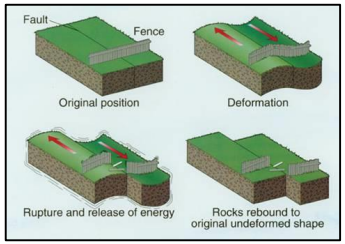
Handling microseismic background
-
Monitoring offshore seismicity



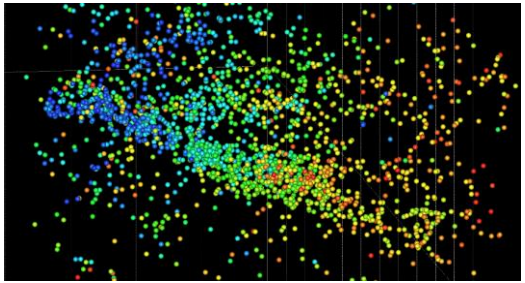
Volker Oye
volker@norsar.no

What is microseismicity? When does it happen?

Tectonic earthquake, M7

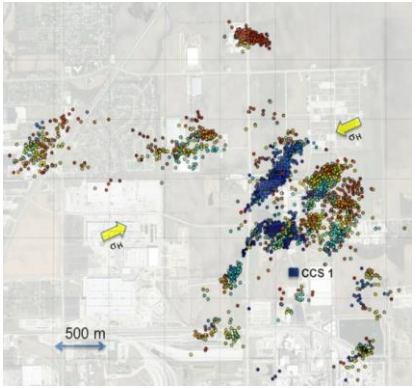


Hydraulic fracturing

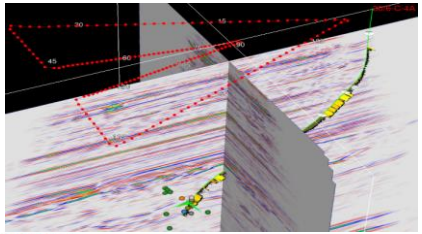


Gas production in the Netherlands

CO_2 storage, Illinois Decatur



North Sea waste water injection



What do magnitudes mean ???

magnitude

size of fault

slip on fault

M ~ 2

~ 4 mm

M ~ 4

~ 4 cm

Avoid !

M ~ 6

~ 40 cm

M ~ 8

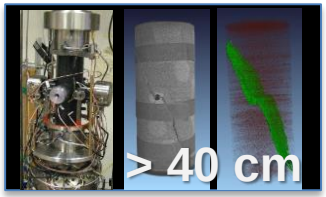
~ 4 m

magnitude

size of fault

slip on fault

M < -3



> 10 μm

M ~ -2

~ 40 μm

Benefit!

M ~ 0

~ 0.4 mm

M ~ 1

~ 1 mm

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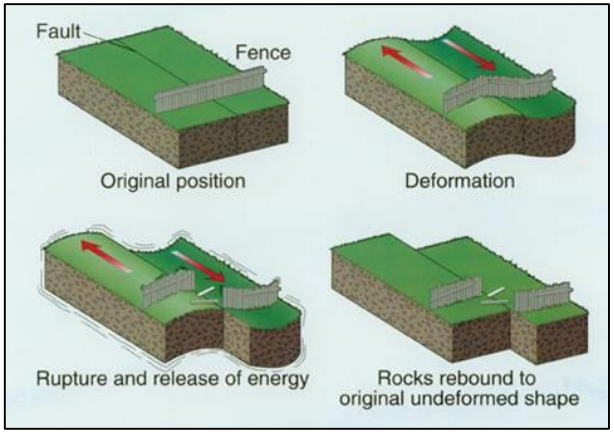
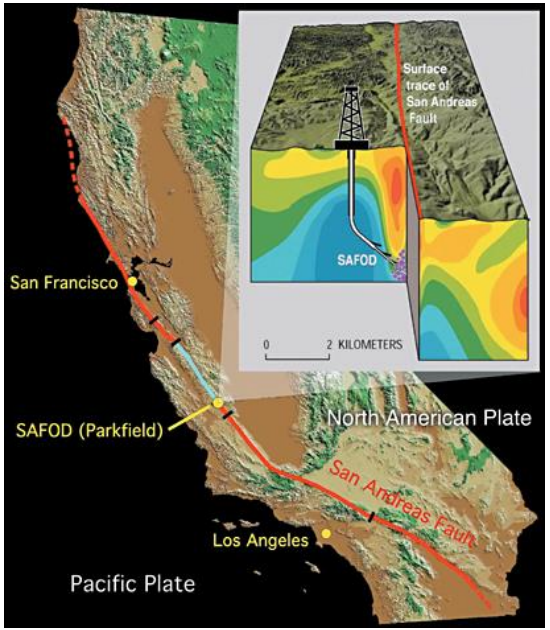
Background seismicity and return periods

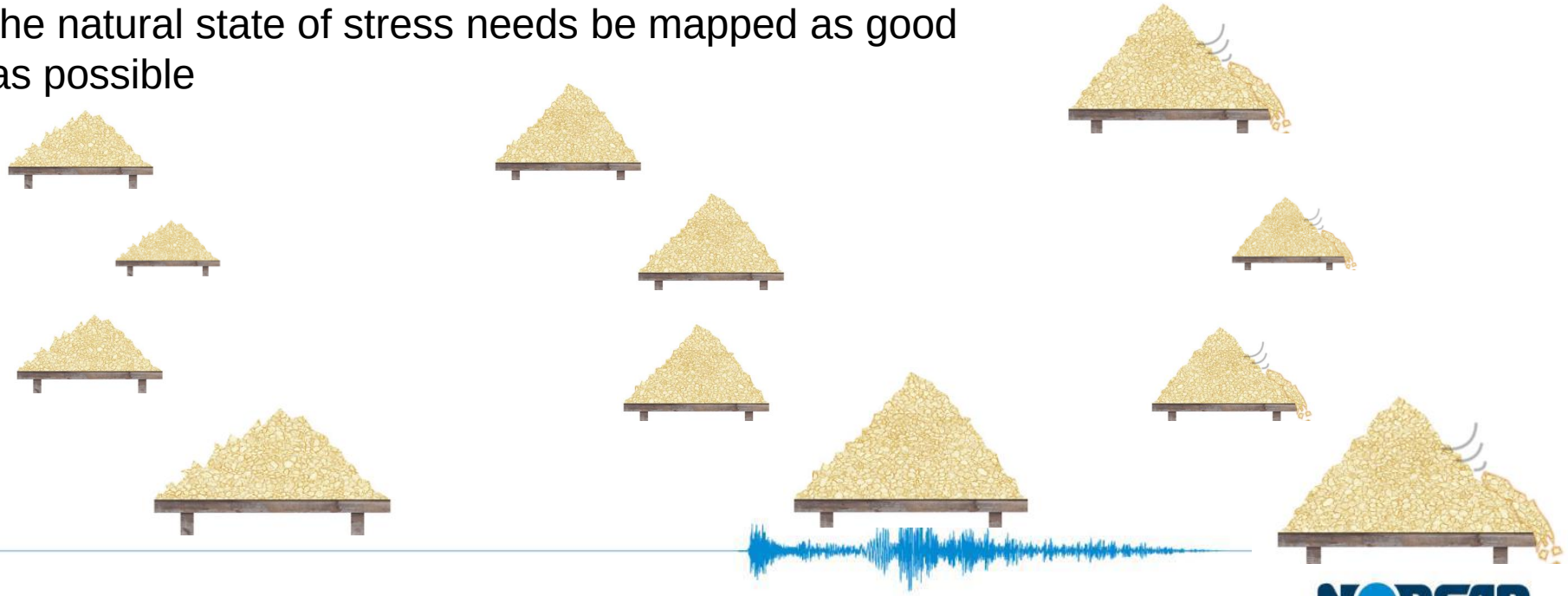
Nature puts «sandkorns» on the pile, tectonic loading

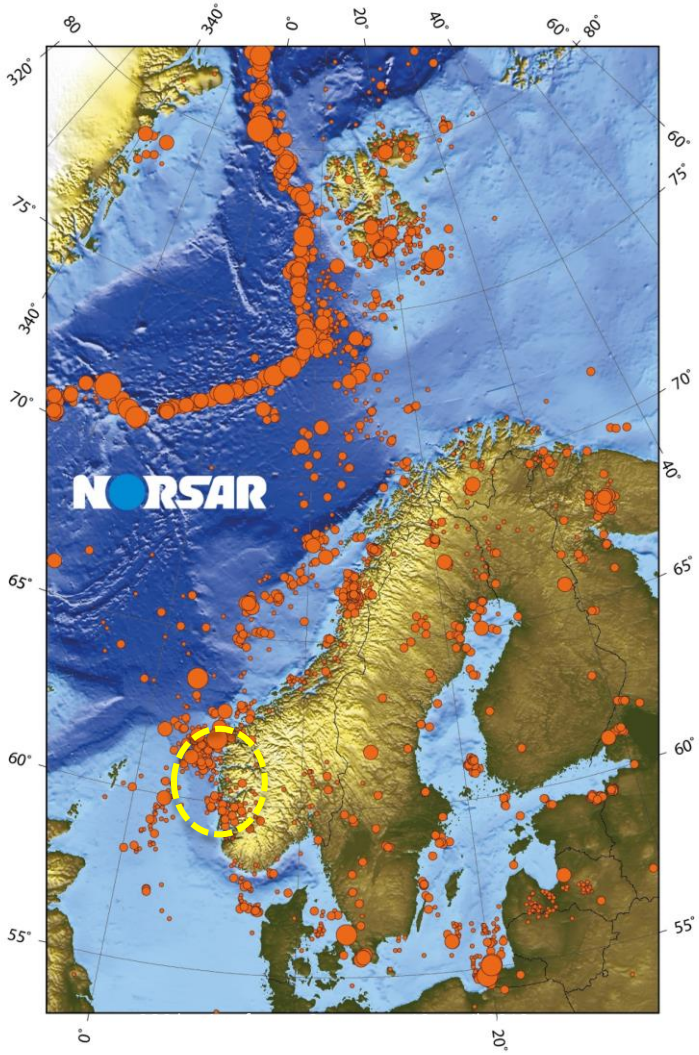




What happens if we add, or remove sandkorns in addition?

To have a chance of understanding a complex system, the natural state of stress needs be mapped as good as possible



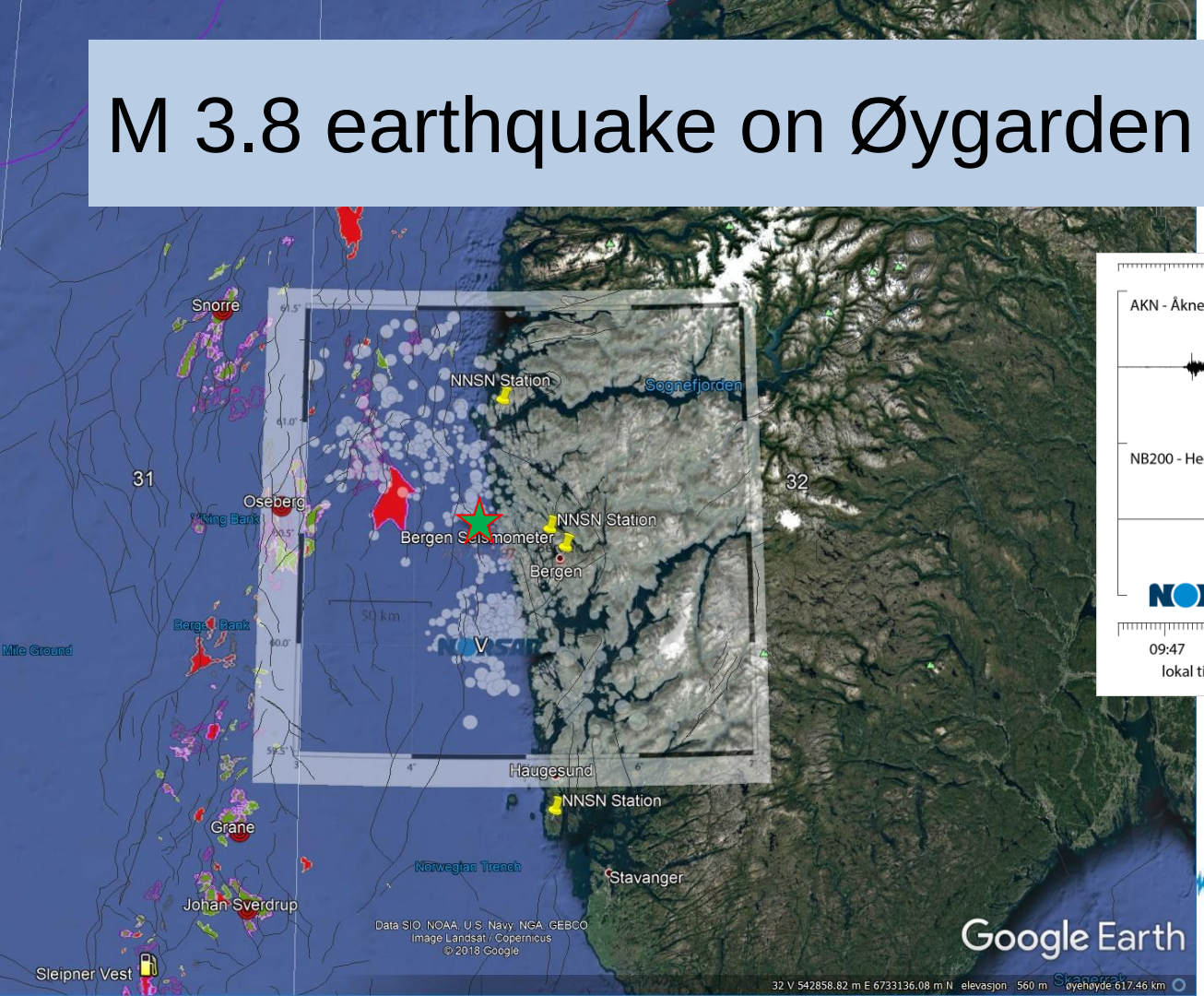


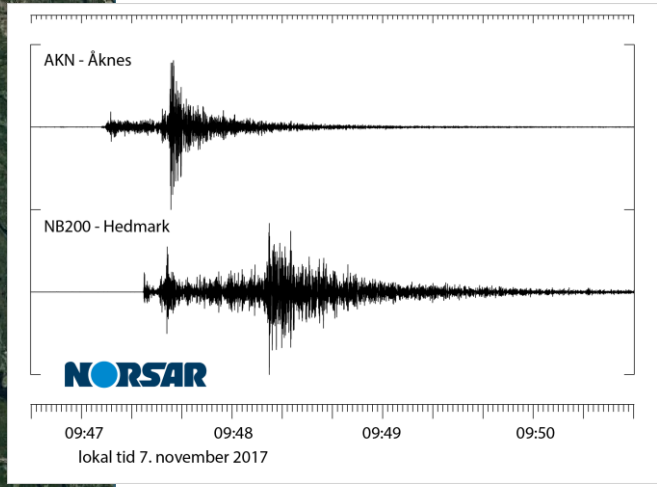
Seismicity in the Scandinavia

Earthquakes recorded and mapped over the last 30 years.

Large-scale seismicity for the Smeaheia region.

M 3.8 earthquake on Øygarden fault zone





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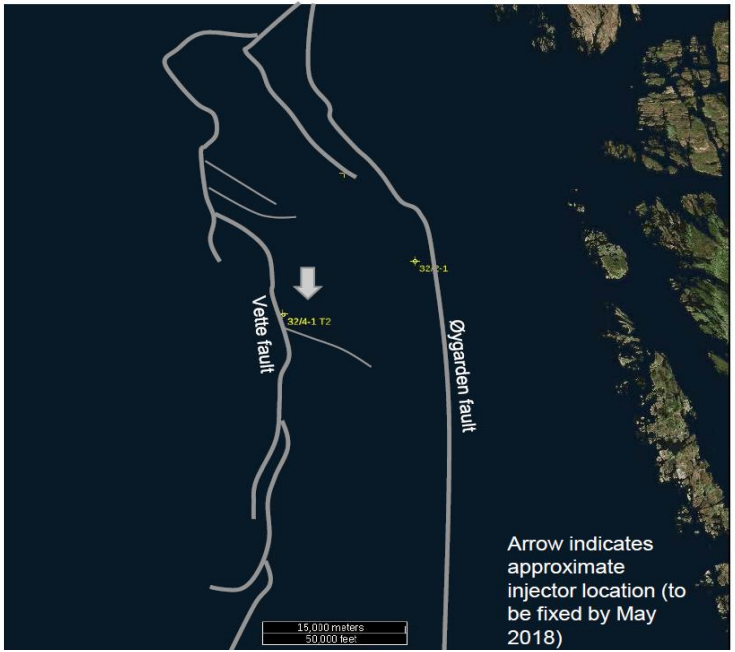
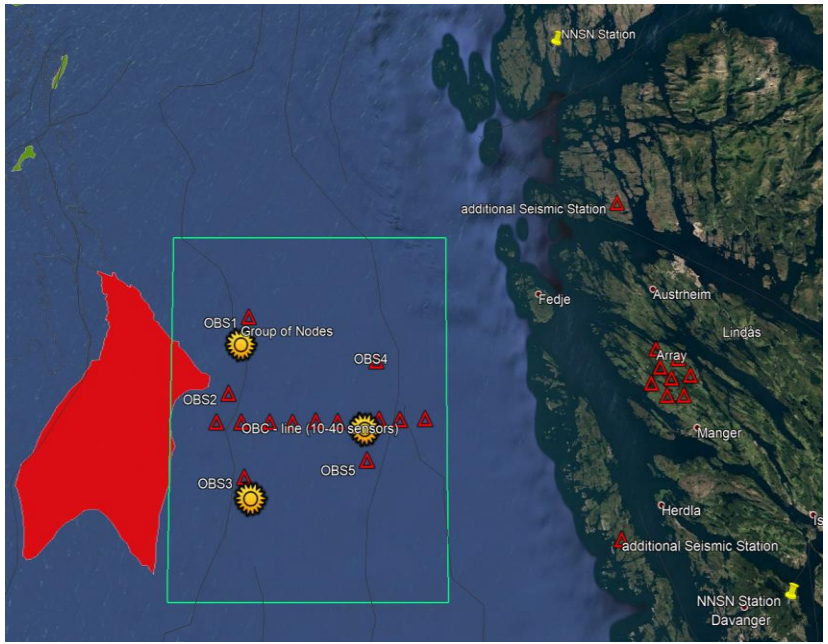
How should the «best and cheapest» network look like?

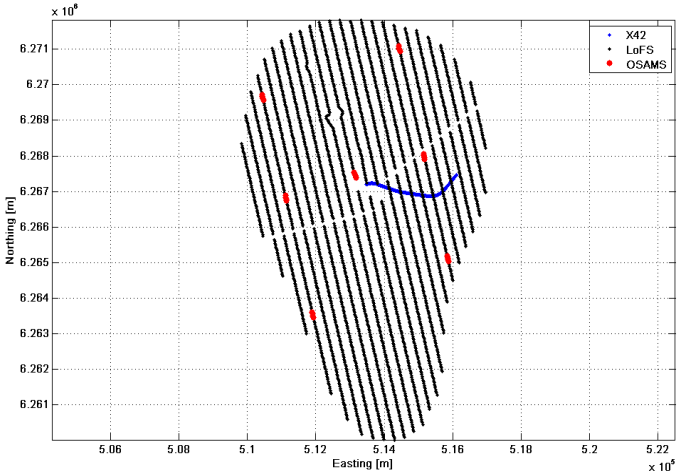




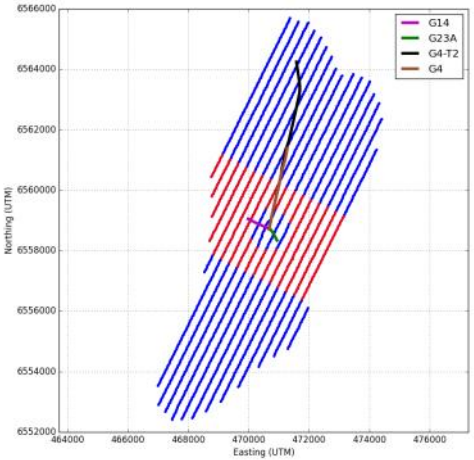
Some considerations from offshore monitoring experience

North Sea experience

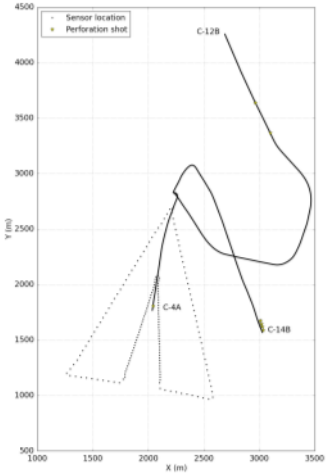
Ekofisk



Grane

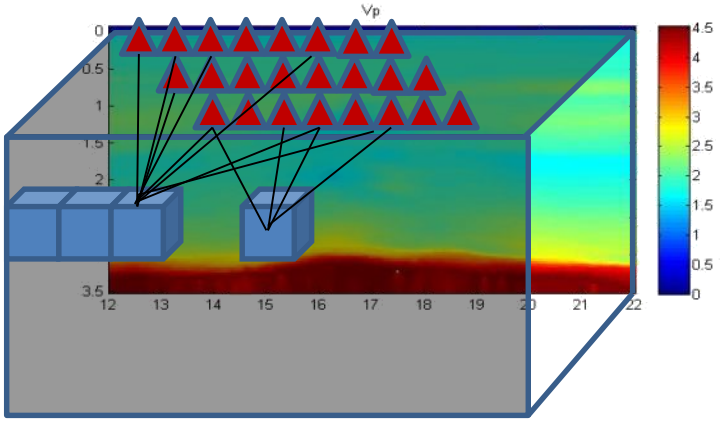


Oseberg



Travel-times

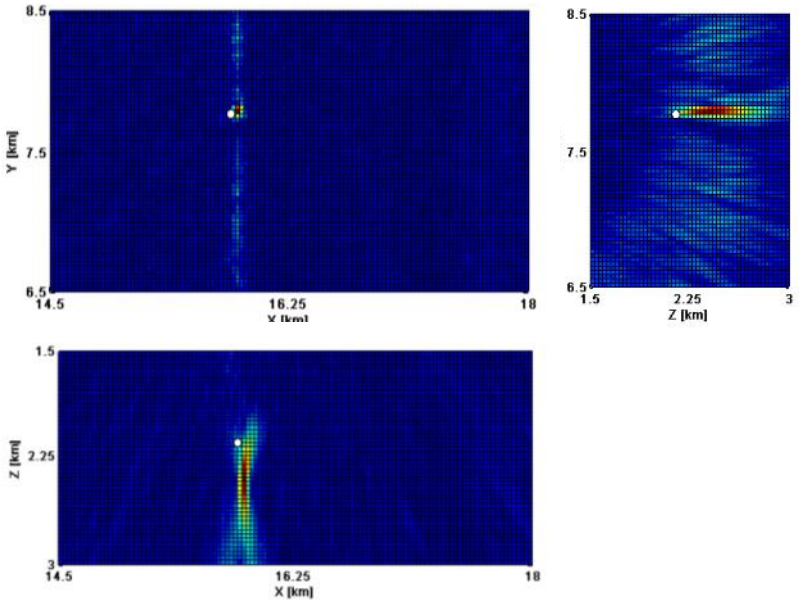
- Key to high detection and accurate locations:
  - **Accurate travel-times**
  - Enhanced noise removal
- A good velocity model is key
- 3D velocity models are used whenever possible
- Travel-times from NORSAR-3D ray-tracing or Eikonal solver



Ekofisk: travel-times

- Key to high detection and accurate locations:
  - **Accurate travel-times**
  - Enhanced noise removal
- Perforation shot imaging reveals the power of accurate ray-tracing
- Initial **isotropic 3D velocity model** located ~250 m from true location

Isotropic 3D velocity model

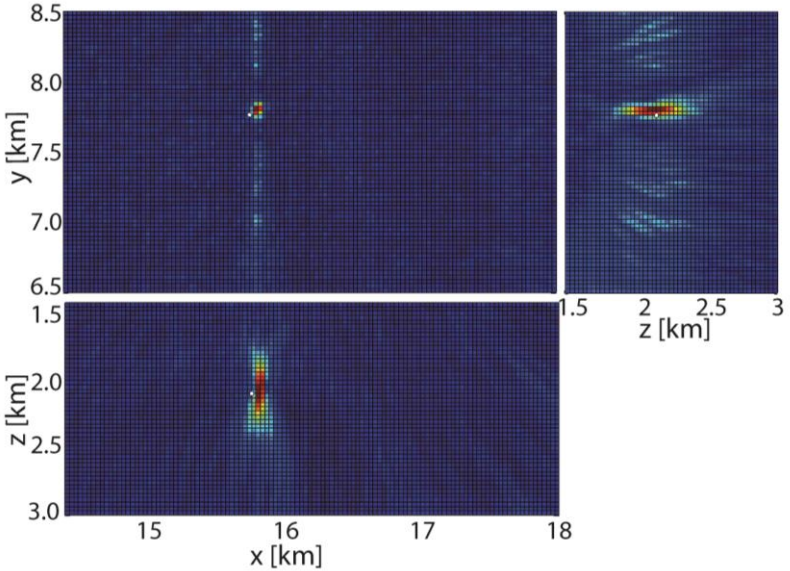


Oye et al., 2014, EAGE

Ekofisk: travel-times

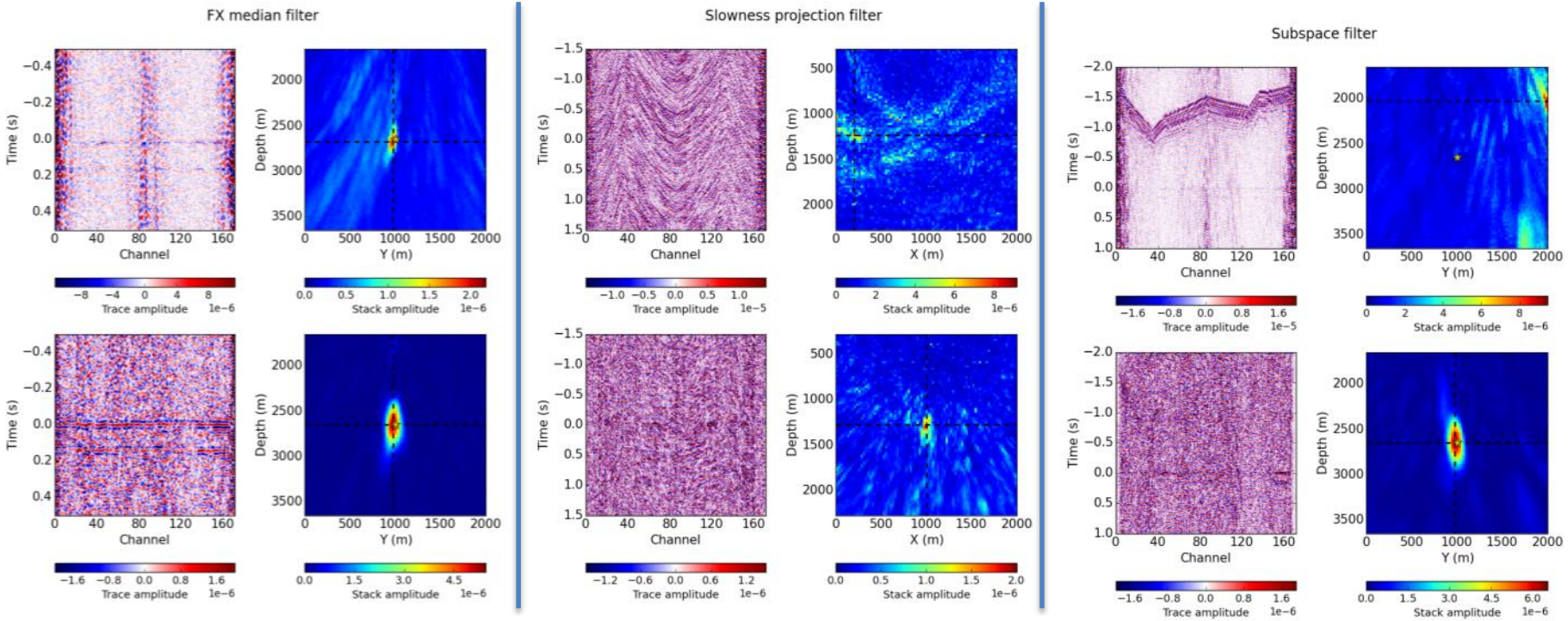
- Key to high detection and accurate locations:
  - **Accurate travel-times**
  - Enhanced noise removal
- Perforation shot imaging reveals the power of accurate ray-tracing
- **Anisotropic 3D velocity model locates accurately**

Anisotropic 3D velocity model



Oye et al., 2014, EAGE

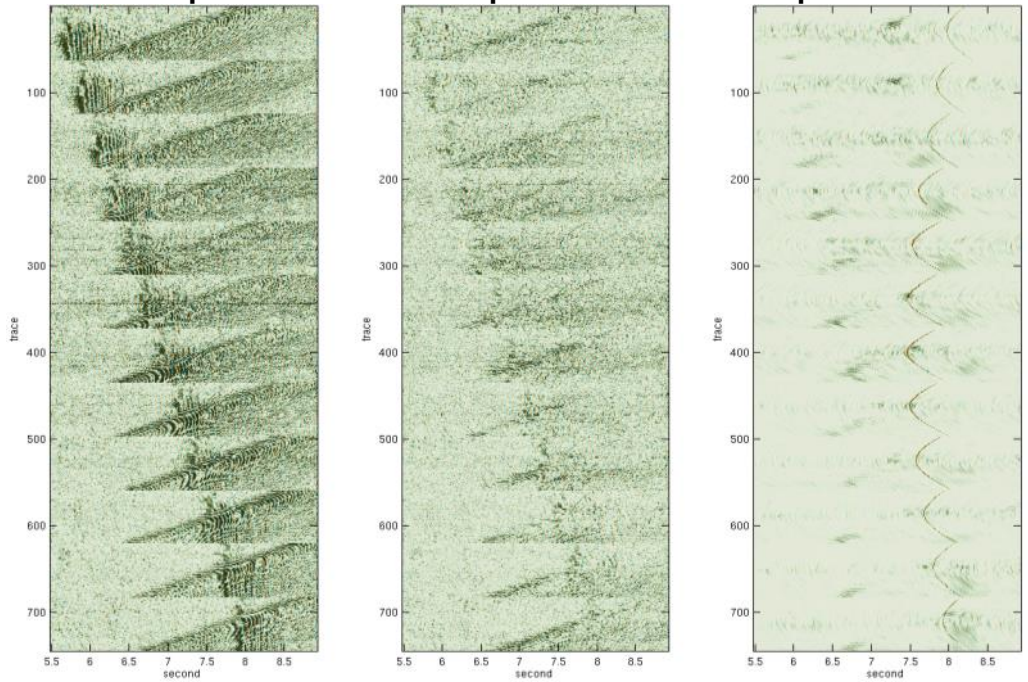
Enhanced noise removal



Dando et al., in prep.

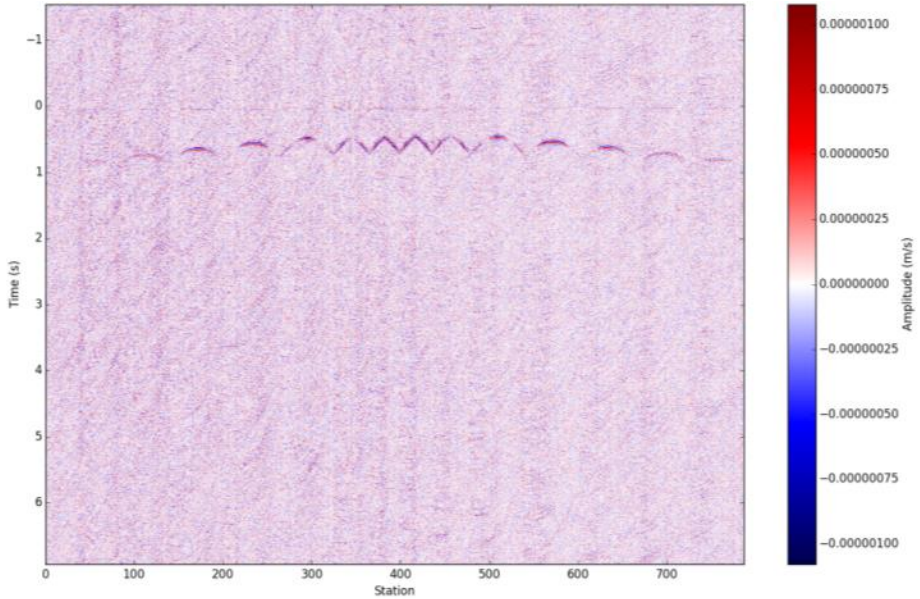
Enhanced noise removal

Bandpass +subspace filter +spatial filter

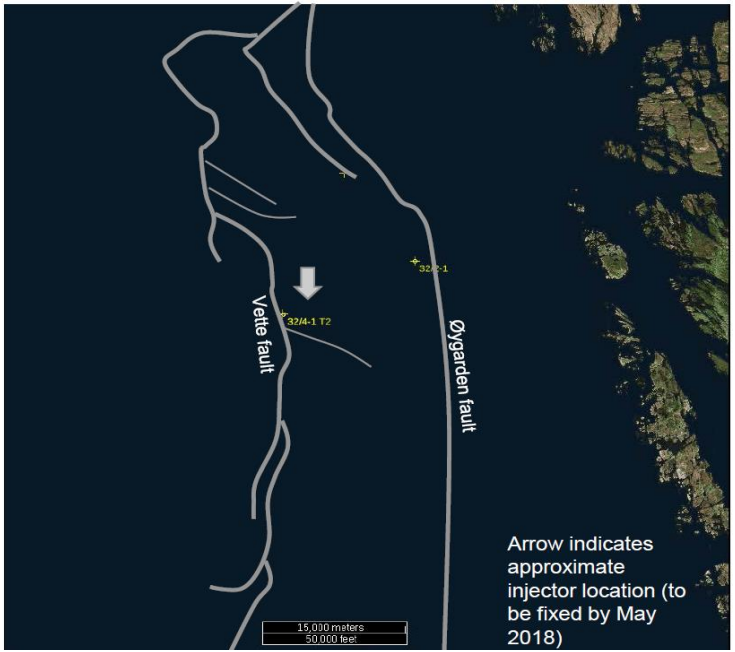


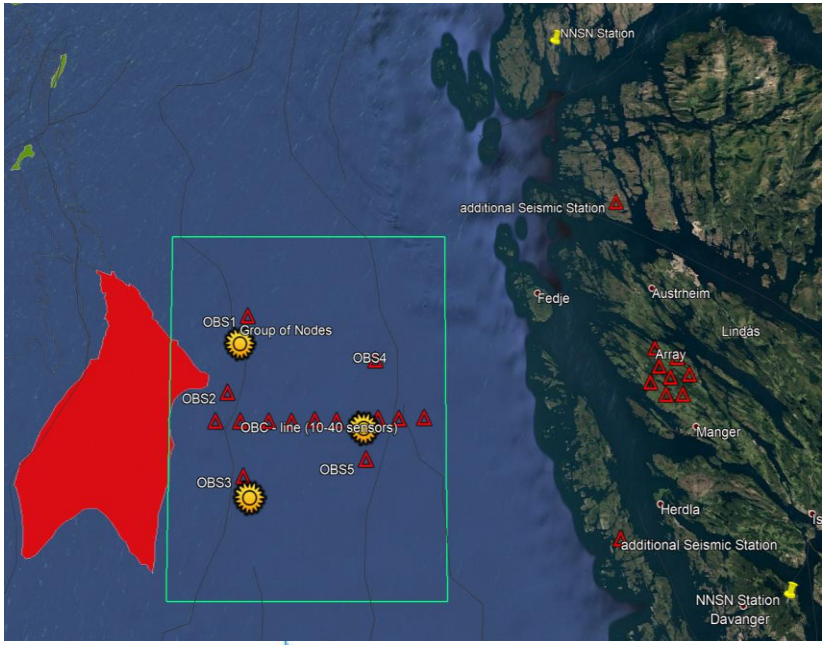
Full waveform modelling

- Determine detectability
- Compute accurate synthetics for any given source mechanism
- Test range of magnitudes
- Test range of real noise models
- Assess the detectability



Need to conduct modelling study including real data to identify a preferred network configuration





Conclusions

- Natural, tectonic pattern of seismicity needs to be estimated
- Human actions might influence the tectonic loading scheme – if no adequate monitoring is in place, difficult to argue against.
- Offshore challenges are mainly noise, costs, subsea power/data transfer
- There is potential to use improved onshore data

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Thank you

Volker@norsar.no