NORSAR
Exploring the Earth

Monitoring offshore seismicity

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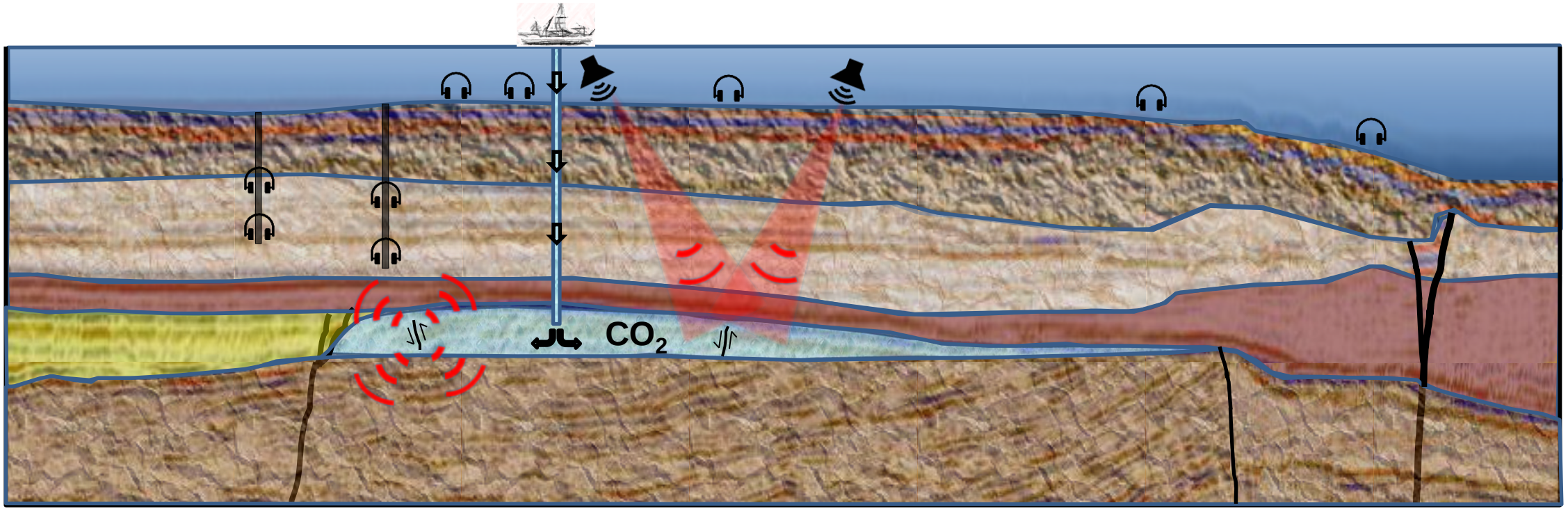
Verification of safe subsurface CO_2 storage



- Storage integrity verification
- Map tectonic vs. induced seismicity
- Real-time early warning system

- Pressure vs. CO_2 saturation
- Reservoir events vs. caprock/basement
- Joined interpretation (4D, ANT, EM, gravity,...)

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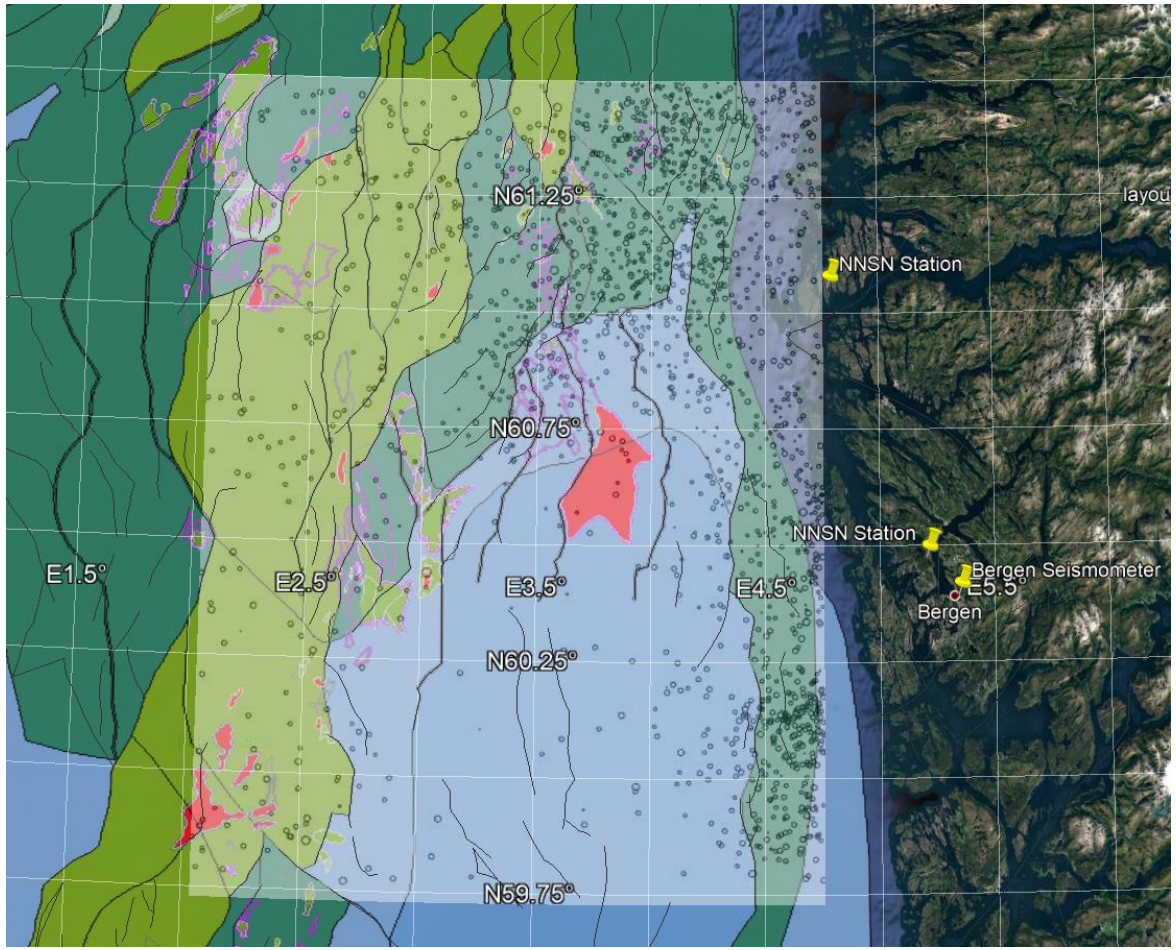
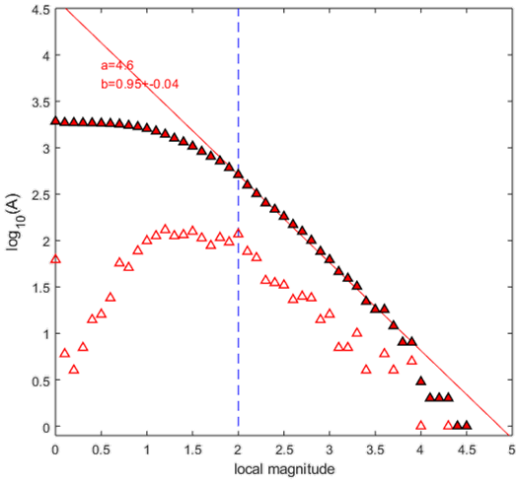
Distribution of large-scale faults in the Troll region catalog of located earthquakes (1985-2018)

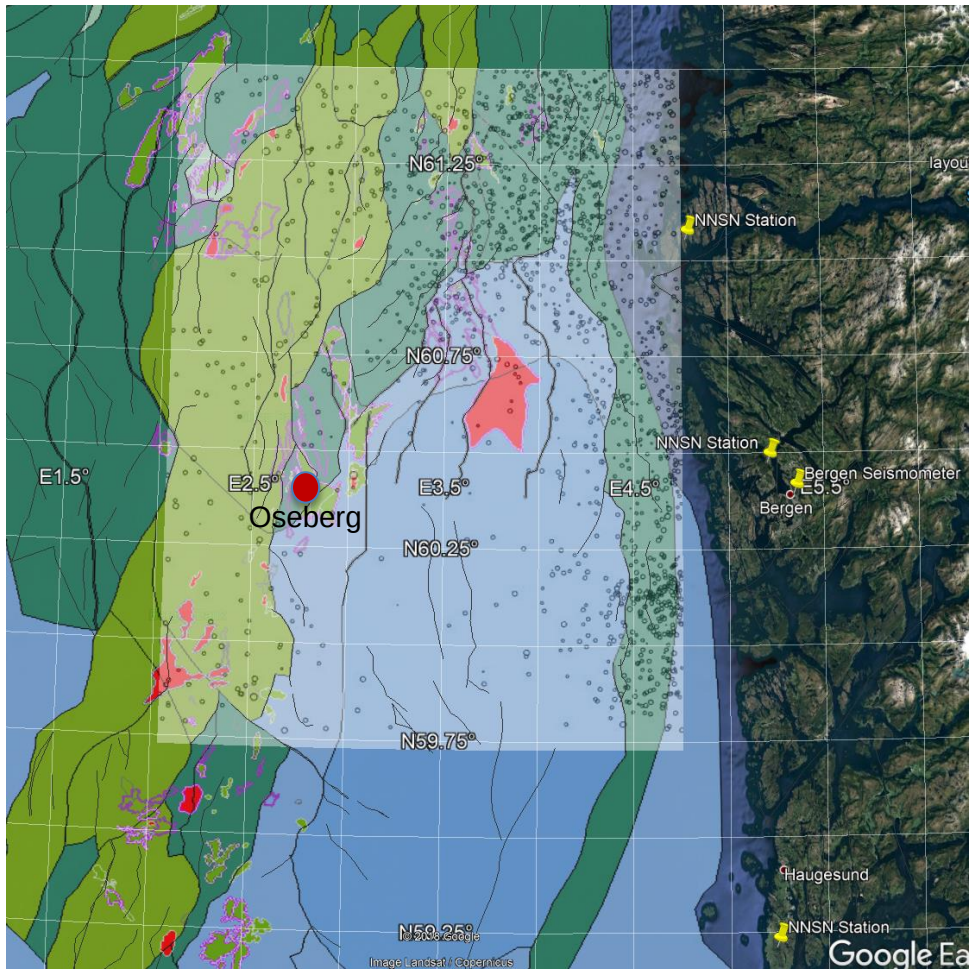


Earthquake catalog from 1985-2018 (NNSN/UiB):
~ 2 M3 events/year
~ 15 M2 events/year
Detectability is decreasing with distance to shore, for Troll region about M2.5



- Large uncertainties in event depth location
- Earthquakes cannot be linked to individual faults
- There are many smaller faults in the region, but are they active?

Today’s seismic network



- Only two to three onshore stations record seismicity in the area as part of the Norwegian National Seismic Network (NNSN)
- Single sensors are vulnerable to noise and susceptible to false event identification
- Closest existing offshore network is at Osberberg, which is too far away for event detection

Future solution is:

- Installation of high-quality, onshore seismic array
  - many sensors in one local area
  - suppresses noise and beams signal energy
  - provides directional location
  - low rate of false positive detections
  - low-cost, continuous monitoring solution
- Installation of offshore sensor nodes close to potentially active faults for precise depth locations.

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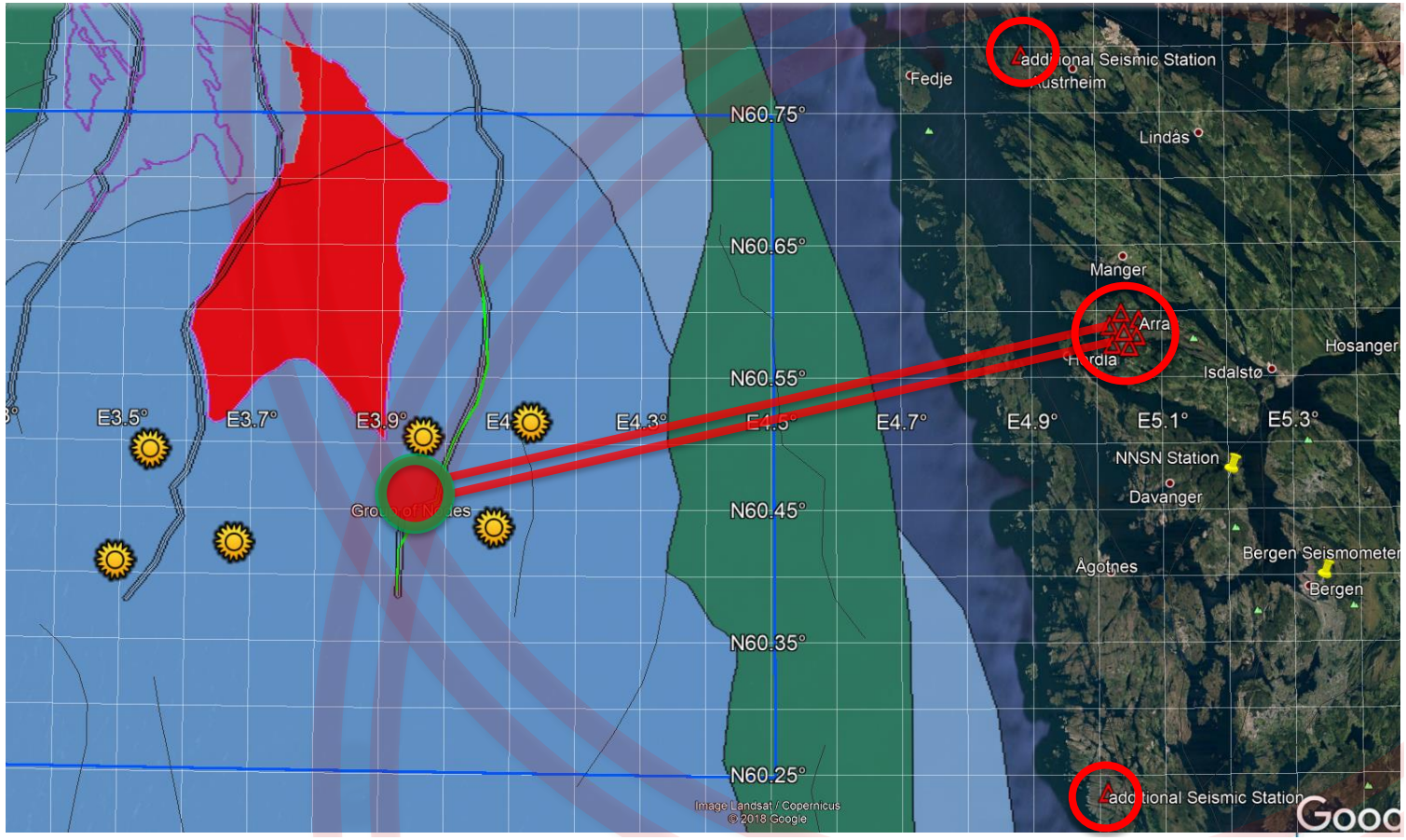
Comprehensive monitoring network



Onshore:
9-element array
2 auxiliary single stations

Offshore:
several patches consisting of ~10 geophones and a central OBS in each patch.

Conclusions

- Background seismicity monitoring for about 1-2 years that ensures to capture low-magnitude events is required before any CO_2 has been stored.
- A permanent onshore array solution is a cost-effective starting point, boosting the performance in offshore seismicity monitoring, followed by offshore network installations.
- Once injection has started, the same infrastructure can be used to verify containment
- We have a responsability to make this project safe.