Earthquake Hazard in Norway

A new national probabilistic seismic hazard model for Norway

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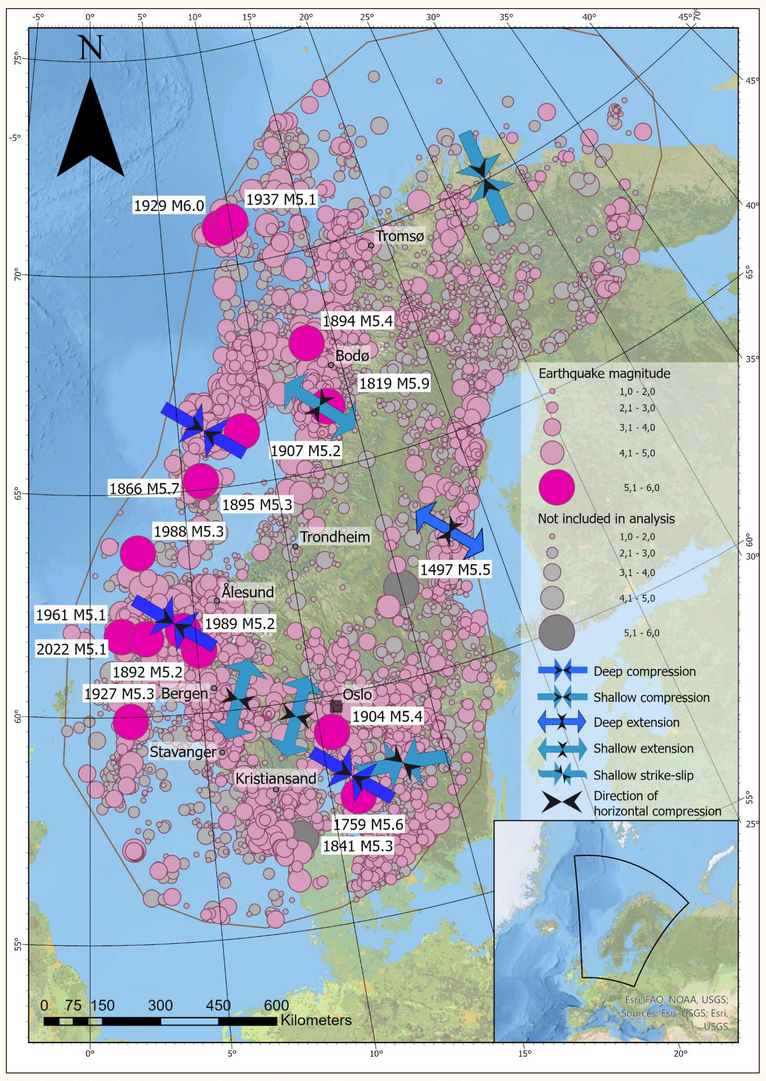
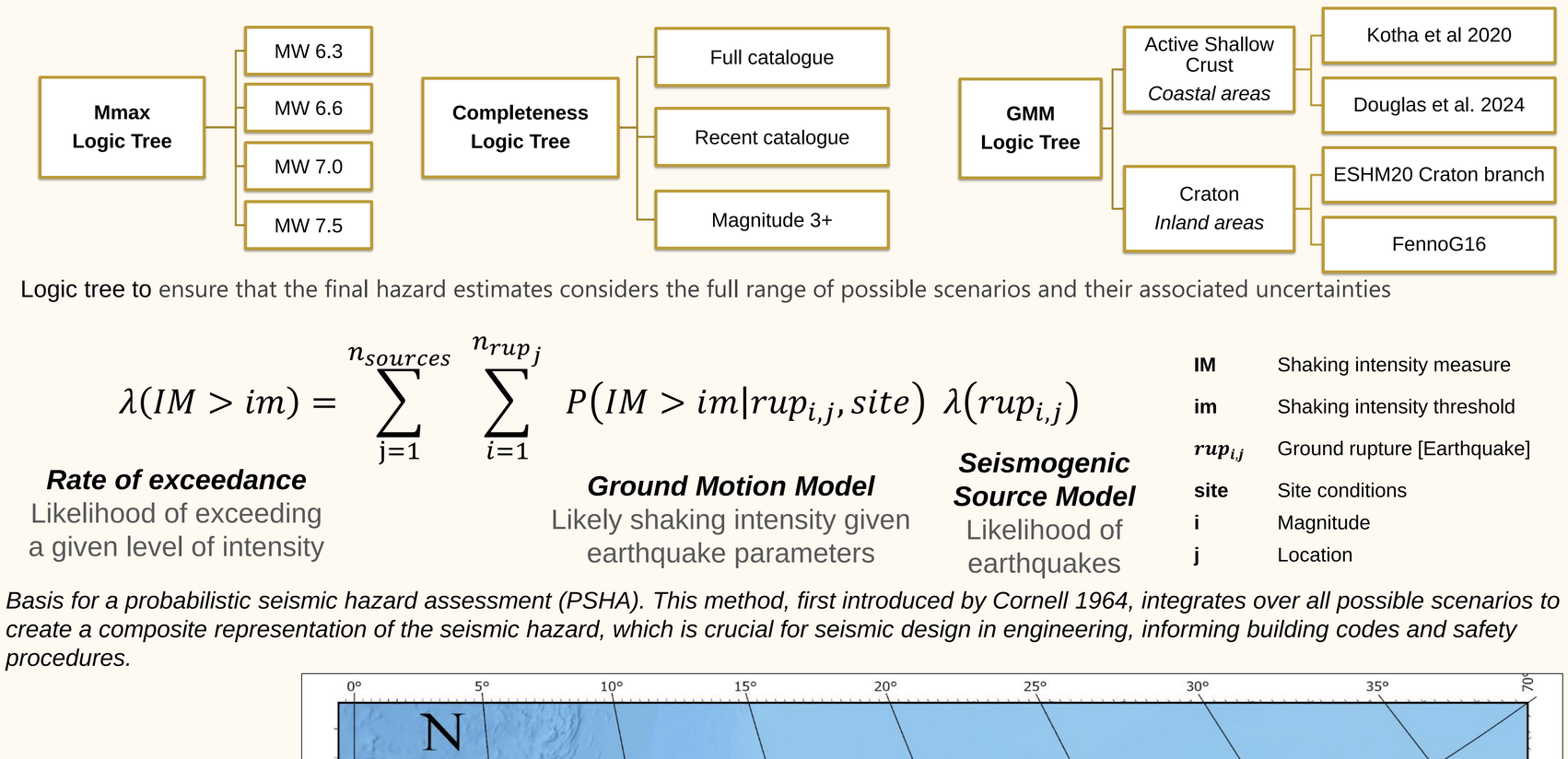
Link to online version

Summary: This study presents a new seismic hazard model for Norway, utilizing recent advancements in earthquake hazard estimation. Covering continental Norway and a 300 km perimeter, the model uses data from the Norwegian National Seismic Network and other sources. The enhanced catalogue includes more earthquake data and improved quality assurance. The study combines a smoothed seismicity model with traditional area zonation, with ground motion models validated against local data. The results offer an updated evaluation of the seismic hazard, aiding in better preparedness and understanding of earthquake risks.



Seismicity in Norway including seismotectonic forces. Data sourced from NNSN, GEUS, SNSN and FENCAT.



Logic tree to ensure that the final hazard estimates considers the full range of possible scenarios and their associated uncertainties

$$\lambda(IM > im) = \sum_{j=1}^{n_{sources}} \sum_{i=1}^{n_{rup_j}} P\left(IM > im | rup_{i,j}, site\right)\ \lambda\left(rup_{i,j}\right)$$

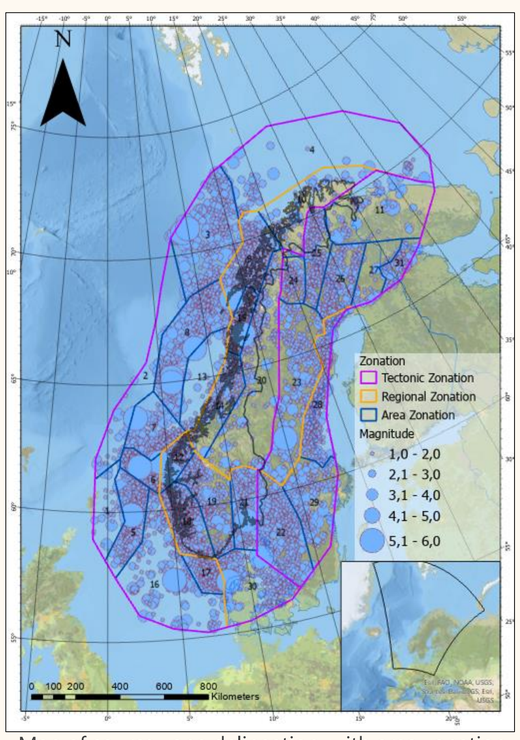
Rate of exceedance
Likelihood of exceeding a given level of intensity

Ground Motion Model
Likely shaking intensity given earthquake parameters

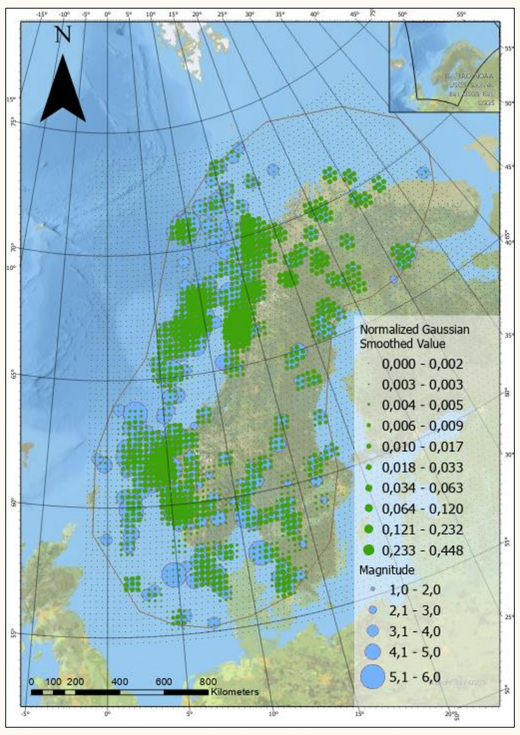
Seismogenic Source Model
Likelihood of earthquakes

IM	Shaking intensity measure
im	Shaking intensity threshold
rup_{ij}	Ground rupture [Earthquake]
site	Site conditions
i	Magnitude
j	Location

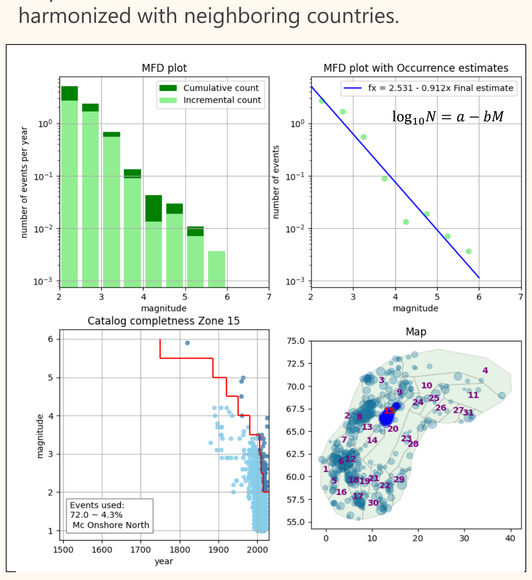
Basis for a probabilistic seismic hazard assessment (PSHA). This method, first introduced by Cornell 1964, integrates over all possible scenarios to create a composite representation of the seismic hazard, which is crucial for seismic design in engineering, informing building codes and safety procedures.



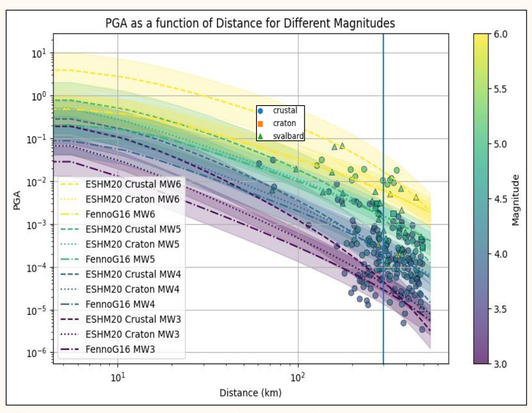
Map of source zone delineation, with area zonation harmonized with neighboring countries.



Map of smoothed seismic activity, showing estimated a-values based on a b-value of 0.8 for a grid spacing of 25 km. The values are smoothed using a Gaussian blur with a sigma of 3 and a bandwidth of 41.25 km.



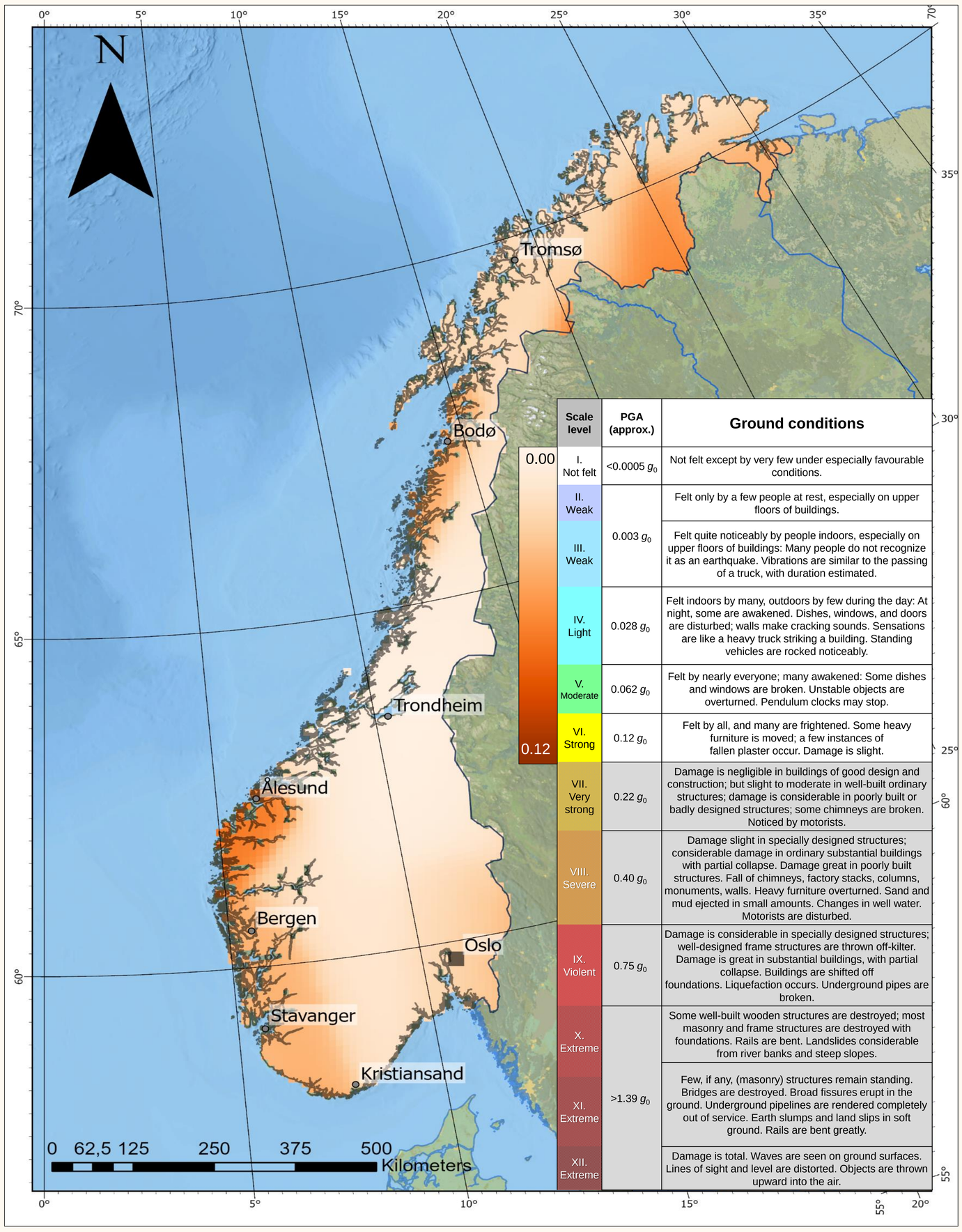
Summary of observed seismicity rates for the area source zone 'Nordland'. Seismicity rates derived using the Gutenberg-Richter–relation $\log_{10}N = a - bM$ where N is yearly event count with magnitude ≥ M



Plot comparing sourced ground motion models with locally recorded ground motion measurements.

Key findings

- The highest risk of earthquake-related shaking is found in Western Norway, primarily due to significant offshore and local onshore seismicity.
- Nordland exhibits a high level of seismic hazard, being the site of Norway's largest reported onshore earthquake and notable swarm activity.
- In Finnmark, the elevated hazard is likely linked to postglacial fault activity.
- In the Oslo region, there is a slight elevation in hazard, potentially related to the history of larger seismic events in the area.
- Anthropogenic activities, including explosions and quarry blasts, may be difficult to distinguish from naturally occurring seismicity. This can obscure the true level of seismic hazard, particularly in regions with active quarries and dense populations.
- Overall, there is a potential for moderate to strong ground motion in populated regions in the future, but with a low level of probability.



Map of Peak Ground Acceleration (PGA) values with a 10% probability of being exceeded within 50 years. Coupled with expected ground conditions associated with PGA level. Ground condition described using the Modified Mercalli Intensity (MMI) scale, supplemented with PGA values sourced from Worden et al. (2012).

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