Common reference frame for sea and land – challenges and recommendations

Aksel Voldsund, NSHC-TWG

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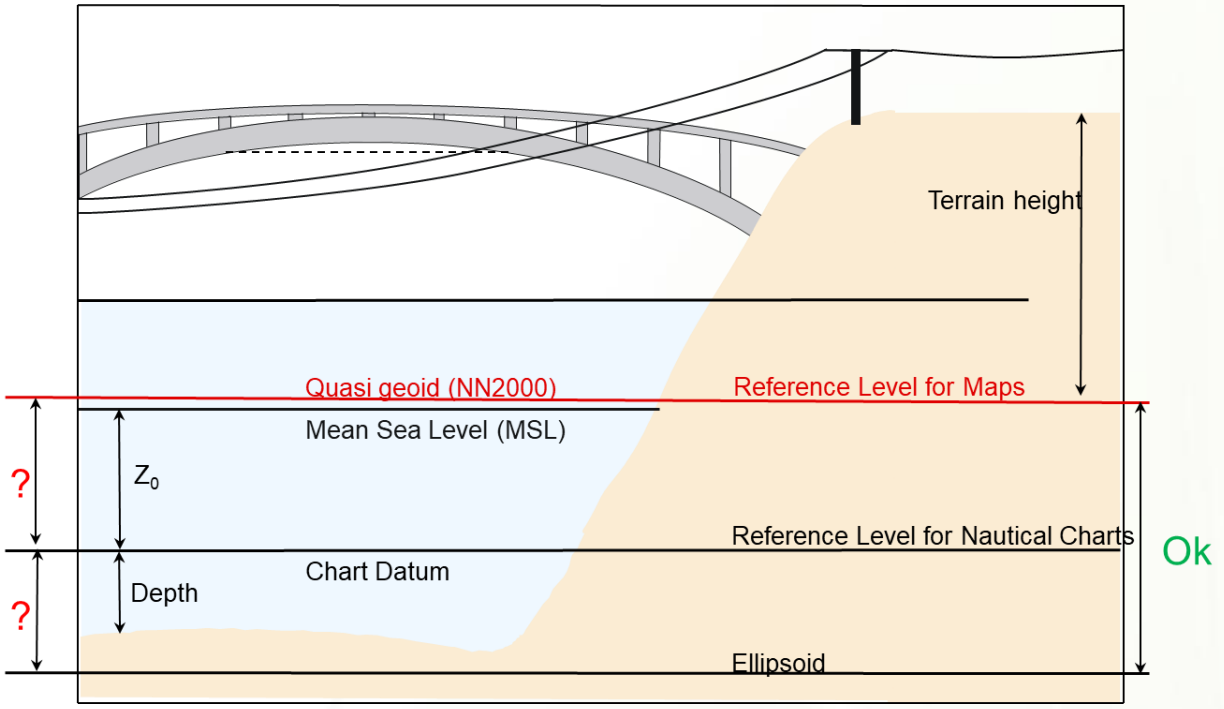
Project objective

- Determine the relationship between the height datum on land and the Chart Datum, using the ellipsoid as a common reference
- Develop guidelines for a method that can be used along the entire Norwegian coast
- Collaboration between the Hydrographic Service and the Geodetic Institute within the Norwegian Mapping Authority



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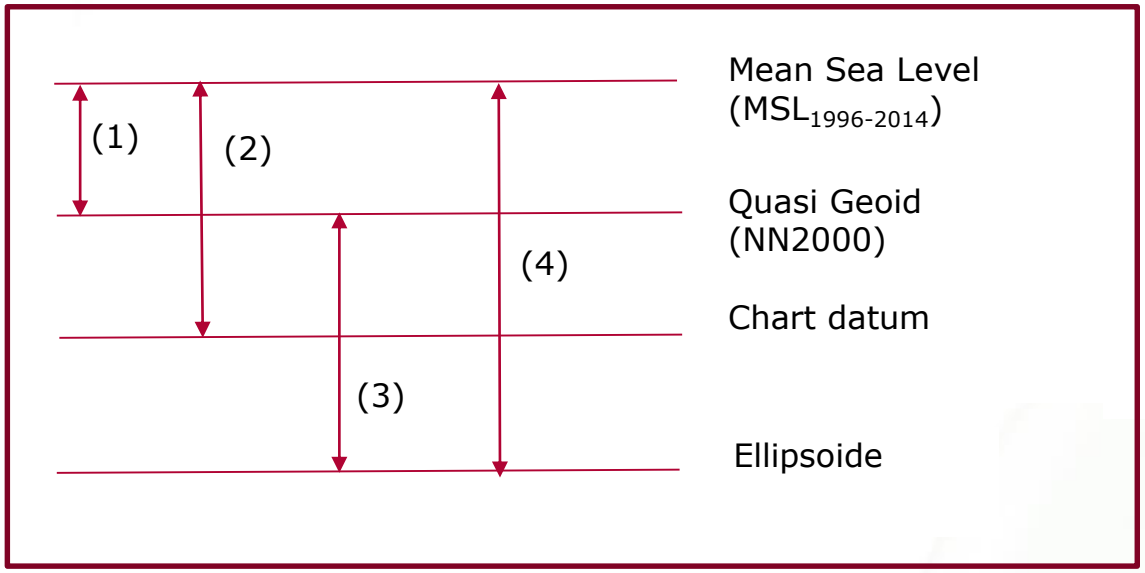
Surfaces and models involved



(1) = Mean Dynamic Topography (MDT) model

(2) = Z0-model

(3) = Quasi Geoid model

(4) = Mean sea level model

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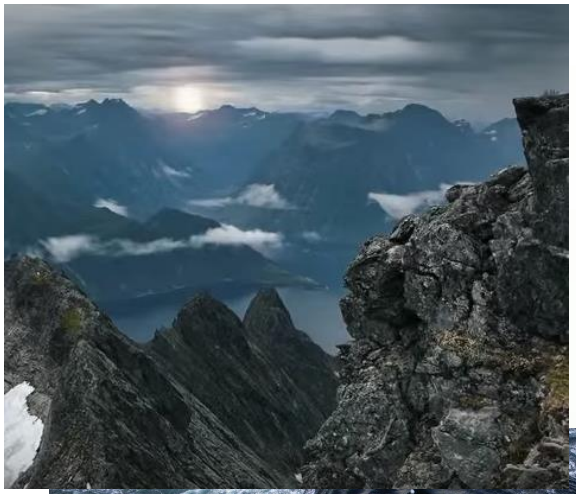
Challenging topography

- Rough topography
- High mountains
- Deep fjords
- Complex coastline



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Study areas

First phase (2015-2017)

- Many types of measurements

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Fieldwork phase 1

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Study areas

First phase (2015-2017)

- All measurements into a collocation «engine»
- The requested models were calculated
- …but…

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Study areas

First phase (2015-2017)

- All measurements into a collocation «engine»
- The requested models were calculated
- …but…
- Gradients in MDT hardly significant
- The focus area might be too kind

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Phase 2

- Check the method in an area where changes in the MDT was expected to be more significant
- Hydrodynamic modelling to investigate spatial variations in the MDT
- Use satellite altimetry to close the gap between the MSS carried out in the coastal zone and the altimetry derived MSS for the open ocean

Study areas

Second phase:
2018-19

Study in the
Sognefjord

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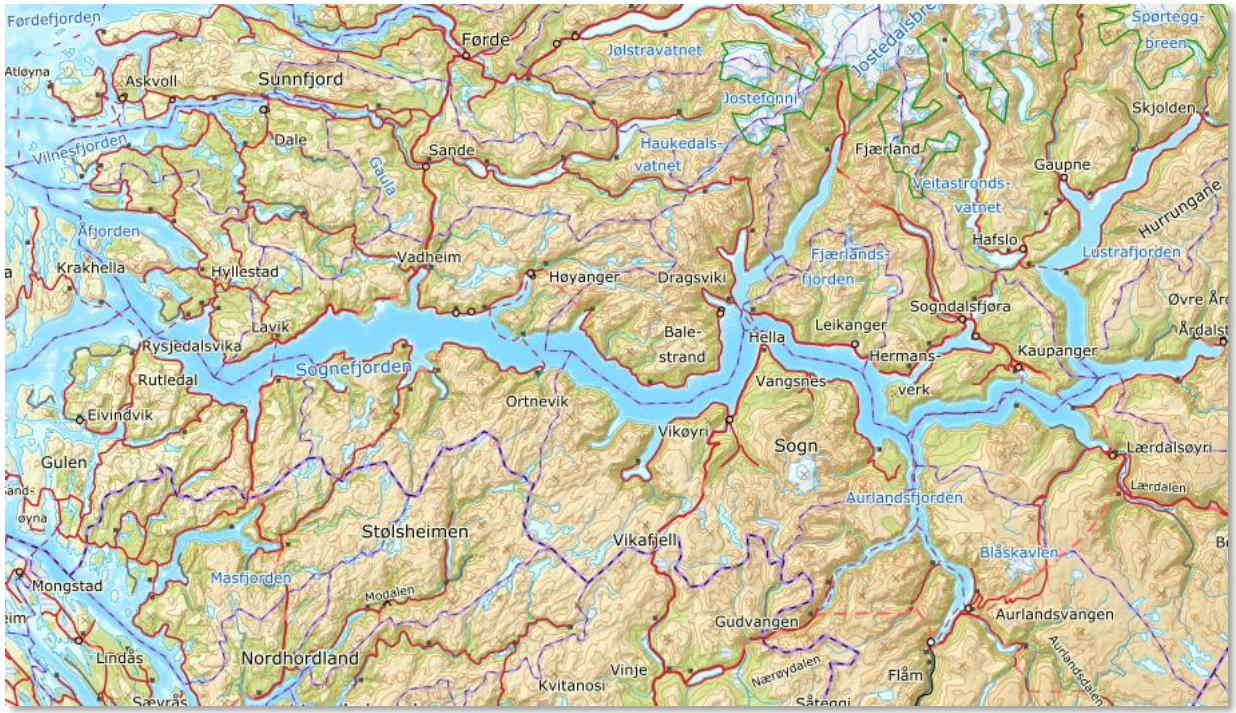
The Sognefjord

- 204 km long
- East-West (across the coastline)
- 1300 m deep
- Surrounded by 1700 m high mountains
- 1-2 km broad at its most narrow



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Field work and measurements

- Temporary tide gauges
- Levelling campaigns
- GNSS measurements

- Altimetry data
- Hydrodynamical models

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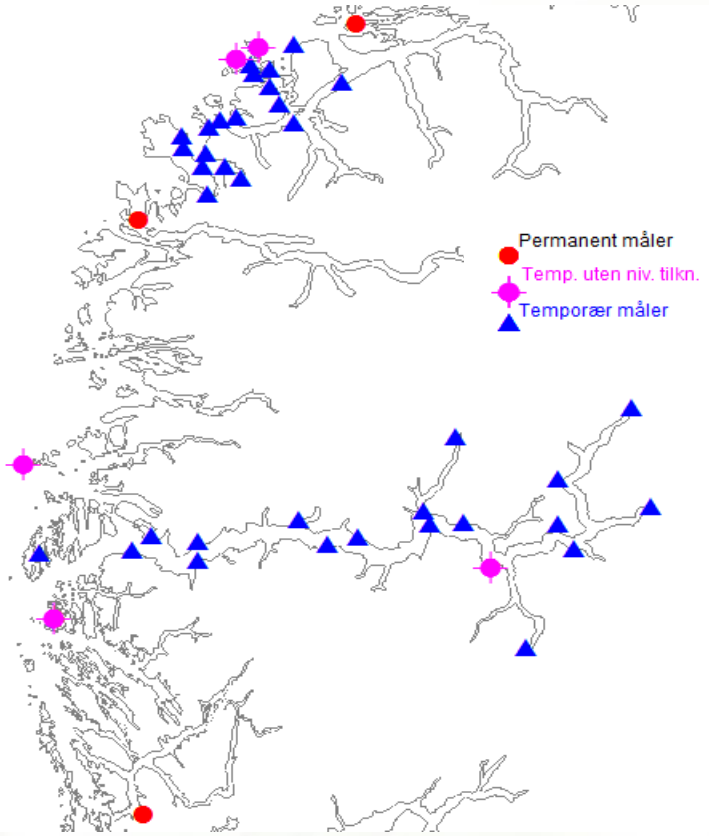
Water level measurements (phase 1 and 2)

- All measurements are used to make models for the entire area
- The tide gauges in the Sognefjord have been collecting data for more than a year
- 6 of the gauges are still collecting data



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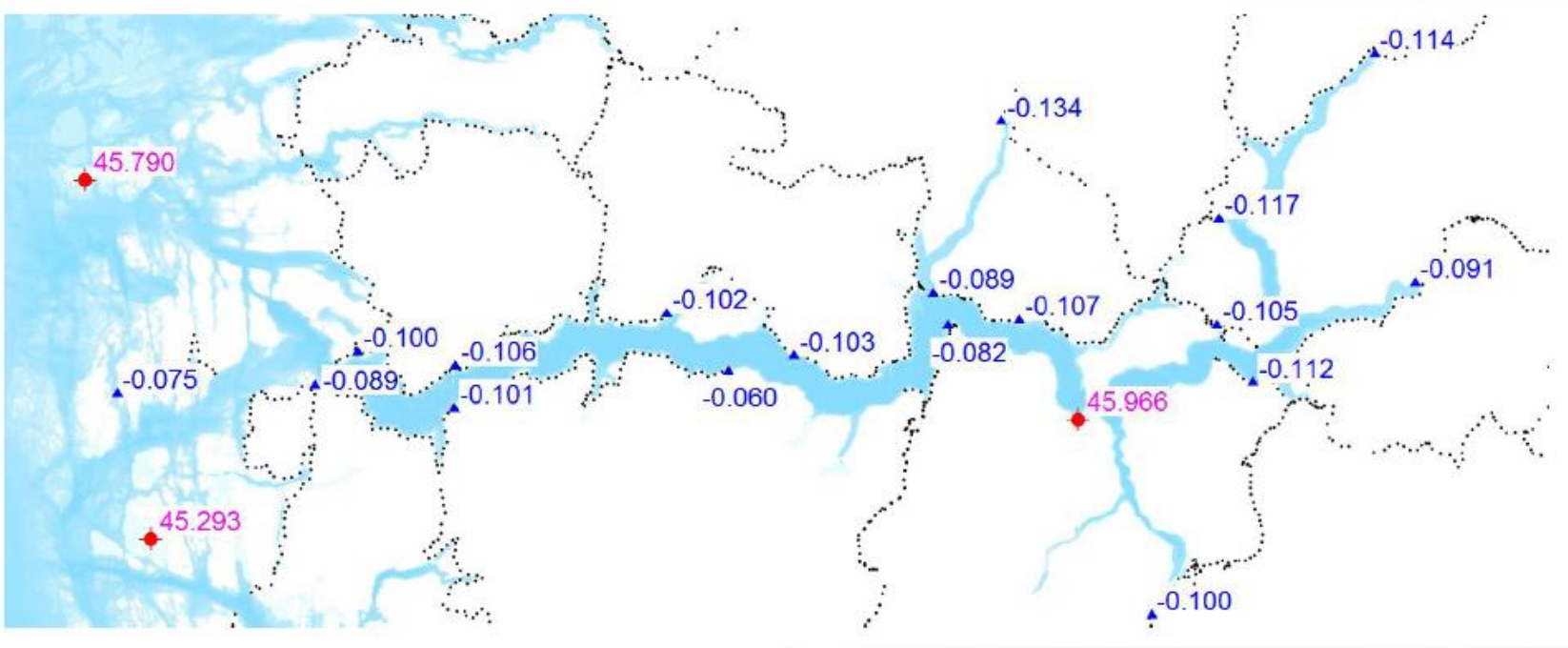
Average water level



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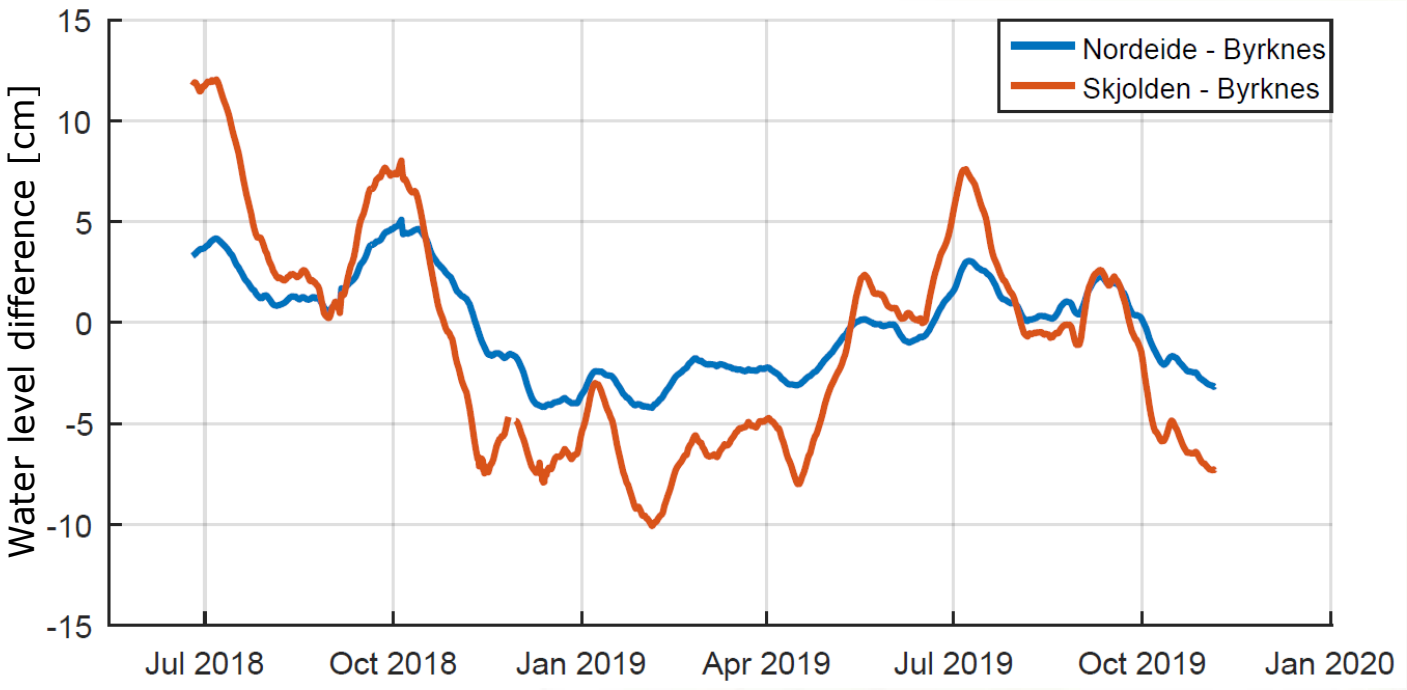
Tilting Sea Surface



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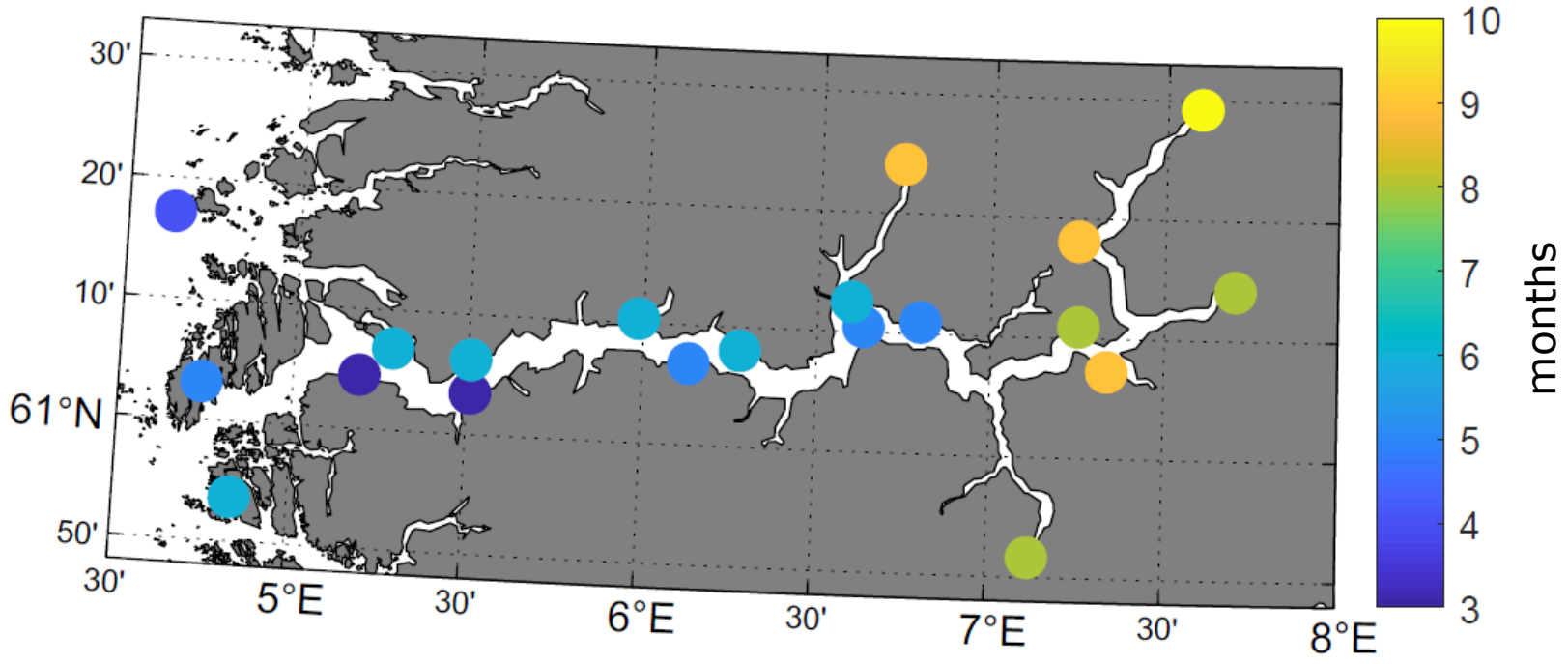
Period of observations to reach a standard deviation of 1 cm

Mean Sea Level transfered from Bergen



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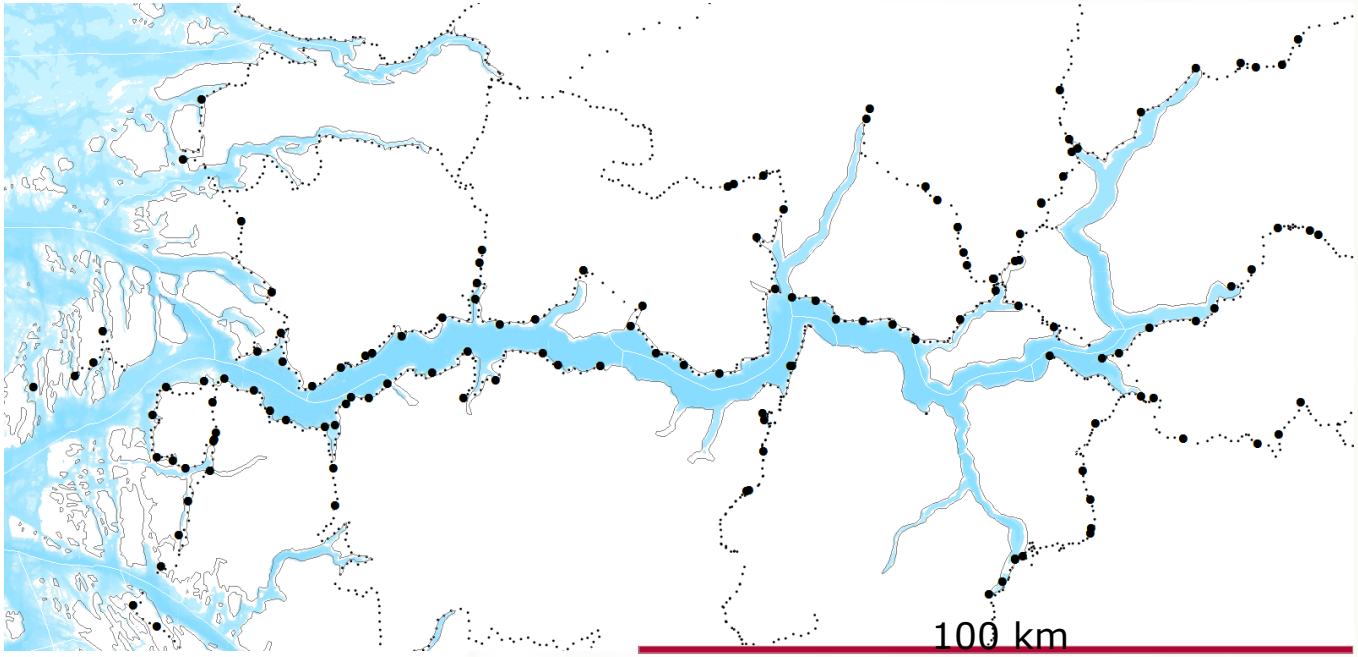
GNSS/levelling points

- Mainly levelled points in the national network
- Some are levelling benchmarks measured in a five days GNSS campaign



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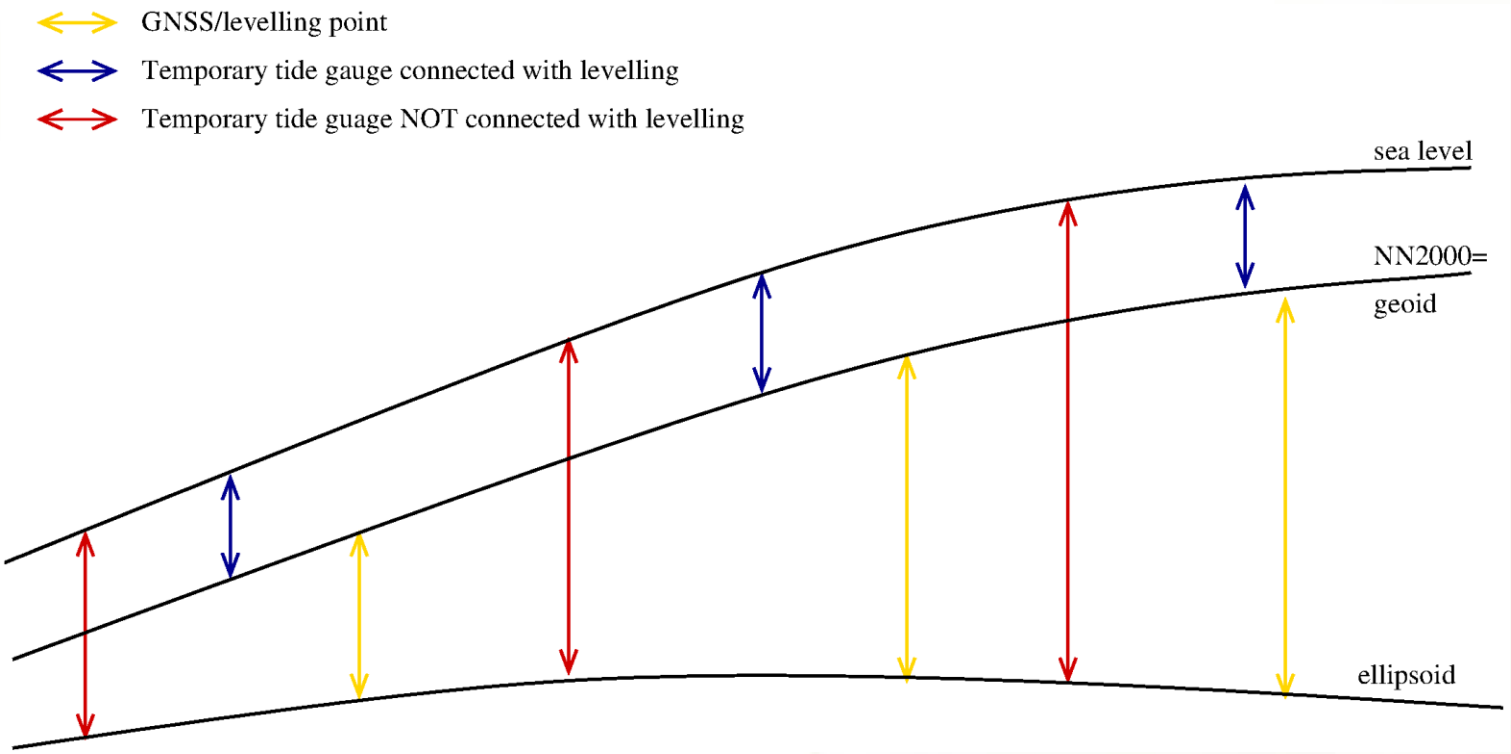
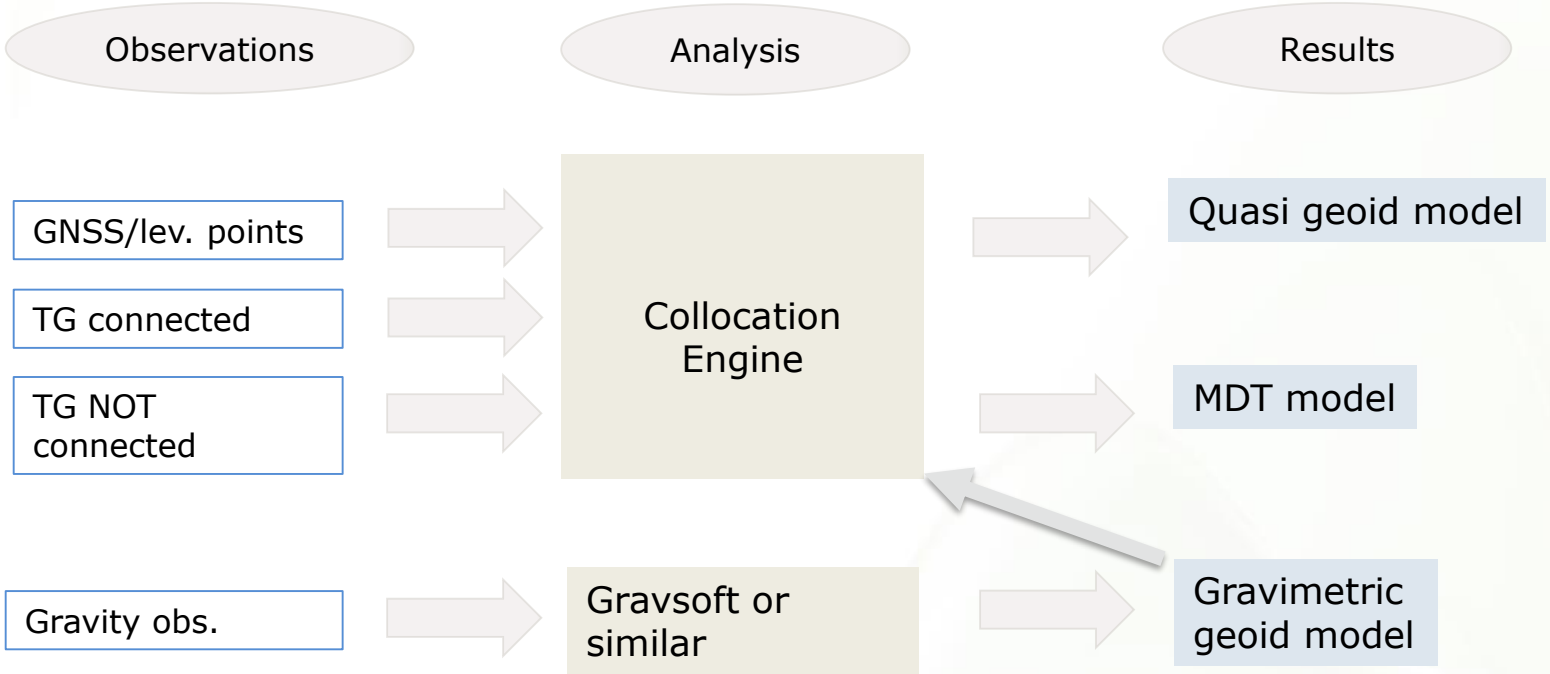
How to calculate the models?



Calculation strategy



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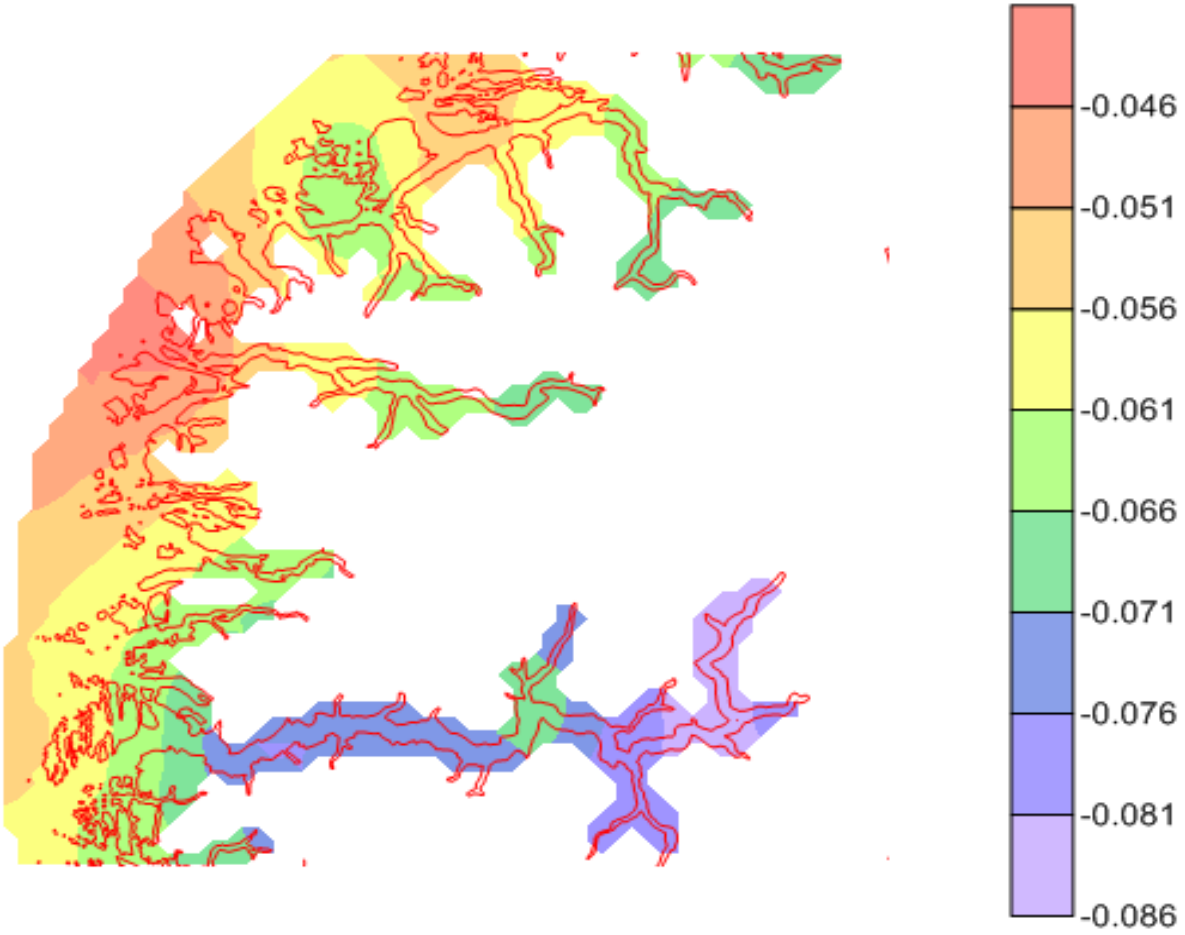
Mean Dynamic Topography



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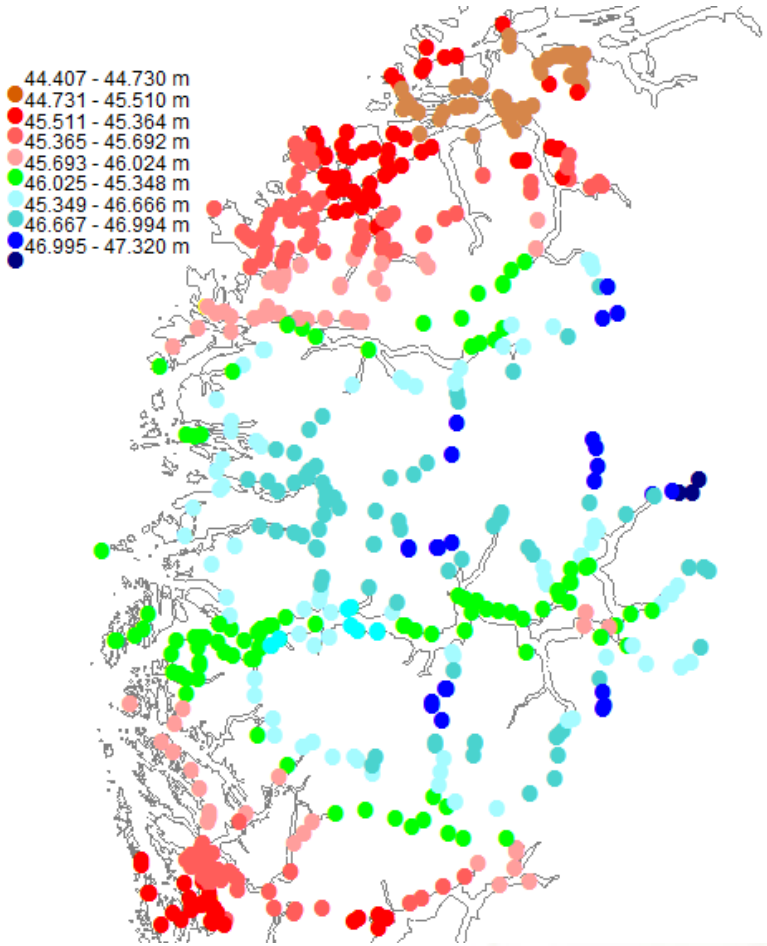
Quasi geoid-model



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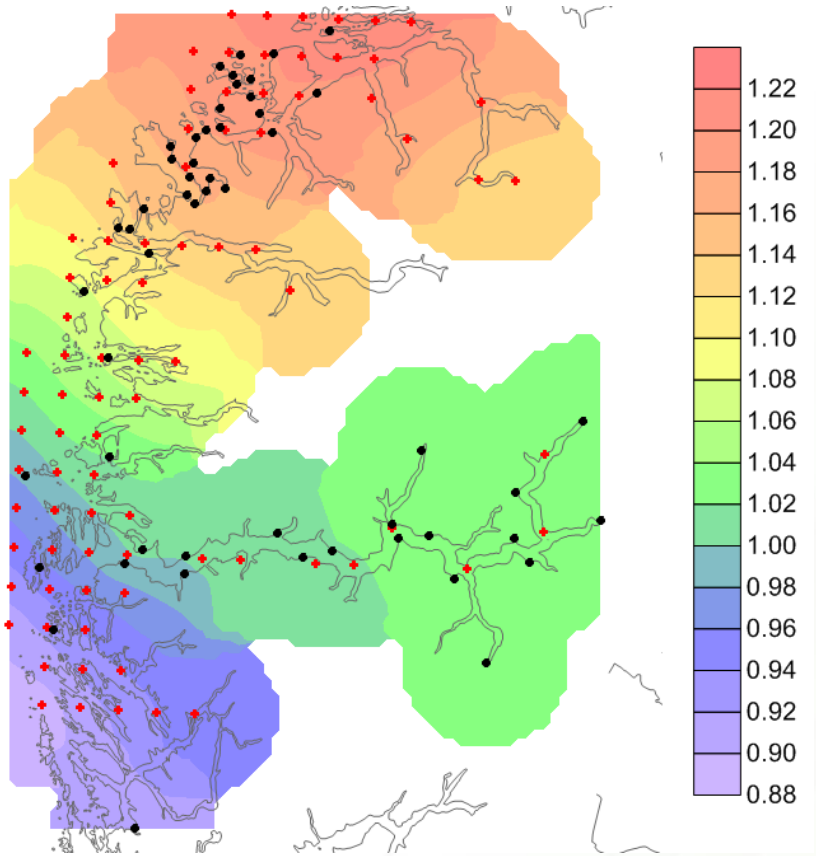
Z0-model – the amplitude of the tides



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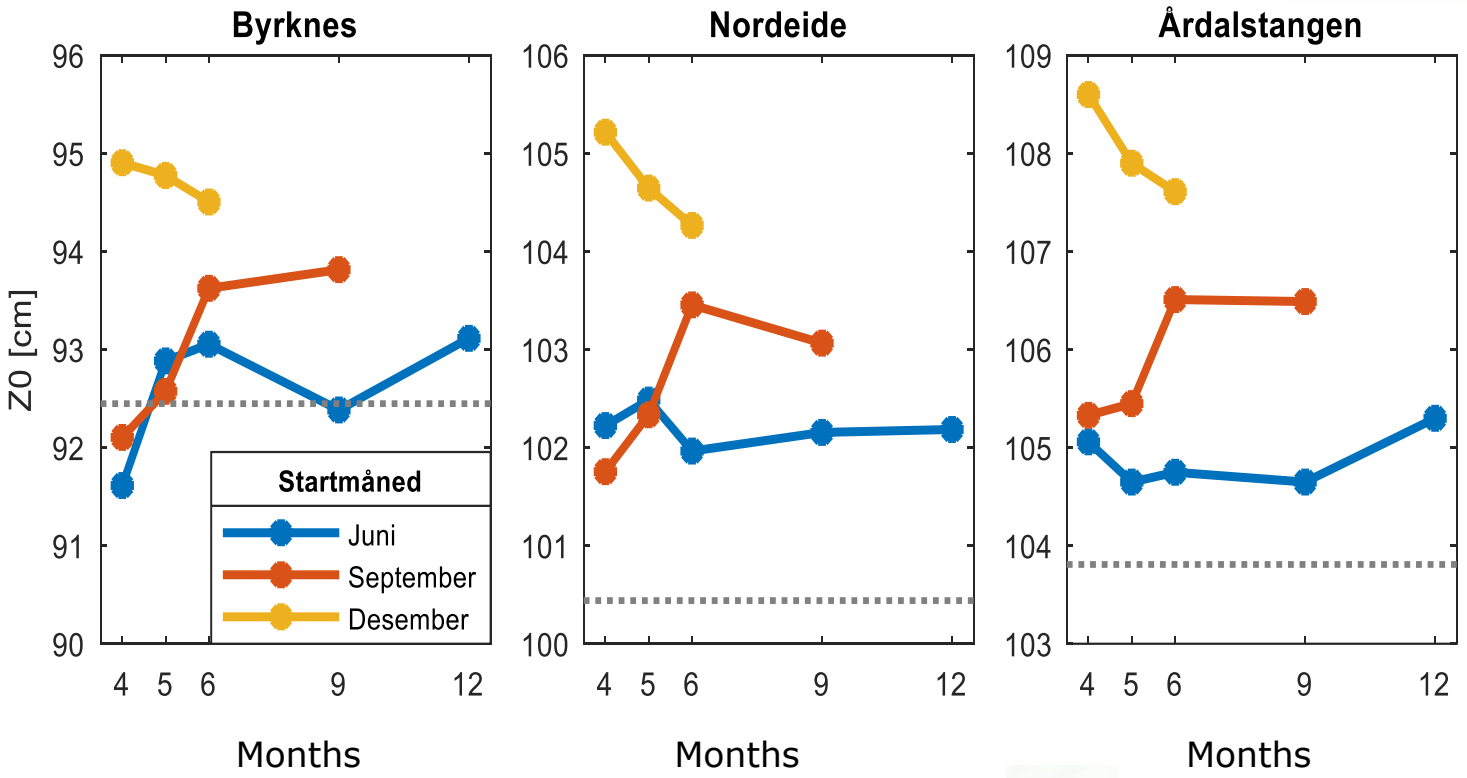
Z0-calculations and seasonal variations



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Test of Hydrodynamical models

- Three different runs from two different models were tested
- Aim was:
  - To connect the average water level from short time series to MSL
  - To reduce the need for water level measurements
  - To find the MDT directly by averaging the model output over 19 years

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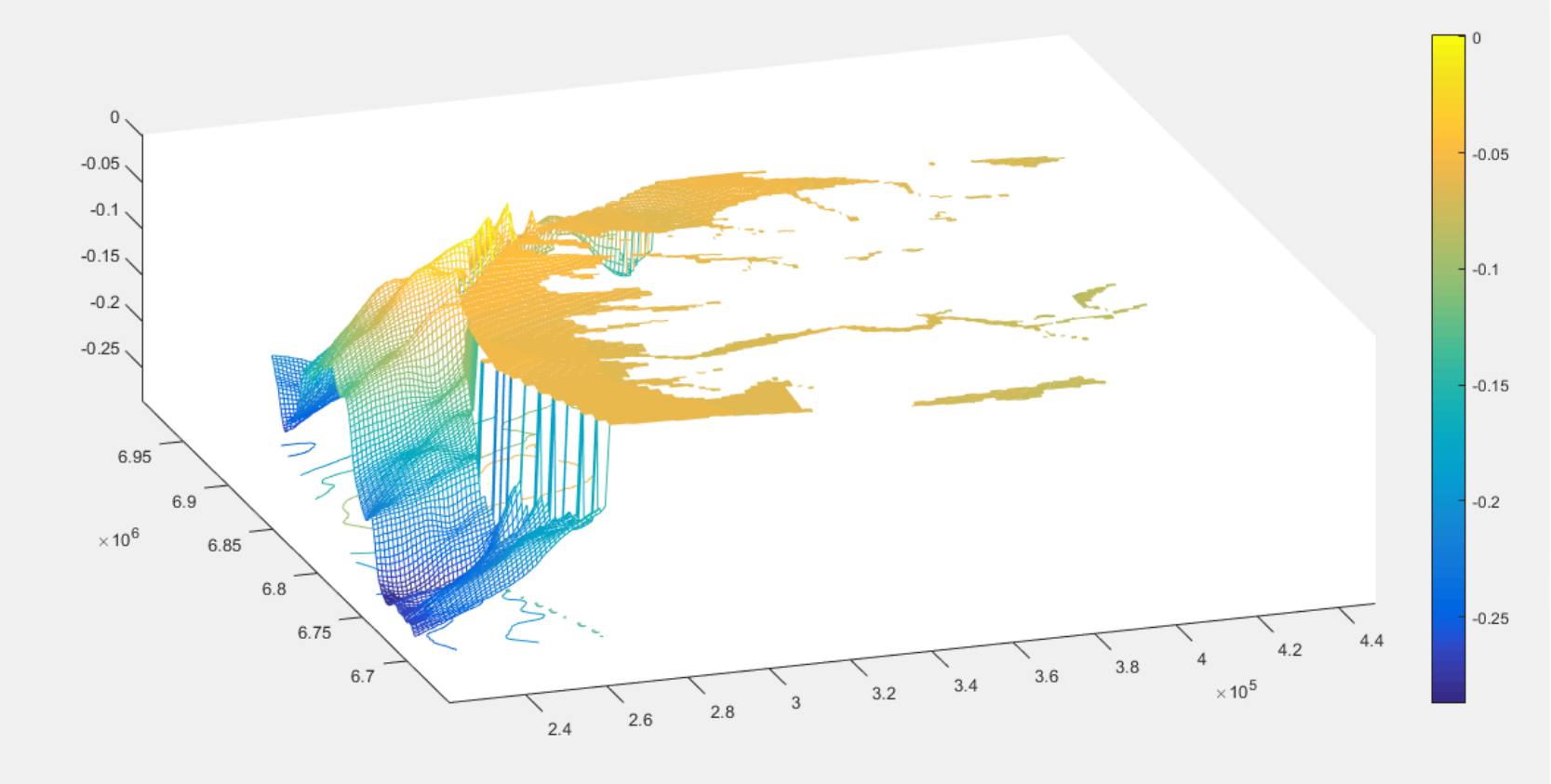
Test of Hydrodynamical models

- Never before validated against water level observations
- None of the models were able to give realistic results inside the fjords
- Some issues related to resolution, tidal forcing, storm surge and inverse barometric corrections
- Comparison of MDT from the models and the permanent tide gauges at the coast show promissing results
- Feedback is given to the owners of the models. Assume that models will be usefull in making MDT-models in the near future

Satellite Altimetry
Comparison with the altimetry model NMBU18MDT



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Conclusions

- The variations in the MDT are much smaller and have longer wavelengths than variations in the Quasi geoid
- Water level observations could contribute to improve the Quasi geoid at large distances from the levelling network
- There are challenges related to transfering information from the permanent tide gauges to the temporal tide gauges
- At the time being, hydrodynamic models are not suitable for calculating the MDT inside fjords, but we are optimistic regarding the future
- Satellite altimetry has its primar strengths off shore, but this might change in the near future

Recommendations

- Start by calculating separation models covering the entire Norwegian coast based on existing data, and update these models continously as more data is collected
- Continue improving the source data by measuring the water level, and carry out GNSS and levelling campaigns
- Increase the density of the permanent tide gauge network to minimize errors associated with transfering information from long to short time series

Recommendations

- Follow the development regarding satellite altimetry and hyrodynamical models
- Start the work where the need for information is largest
- Just get started!

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