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Separation models in Norway

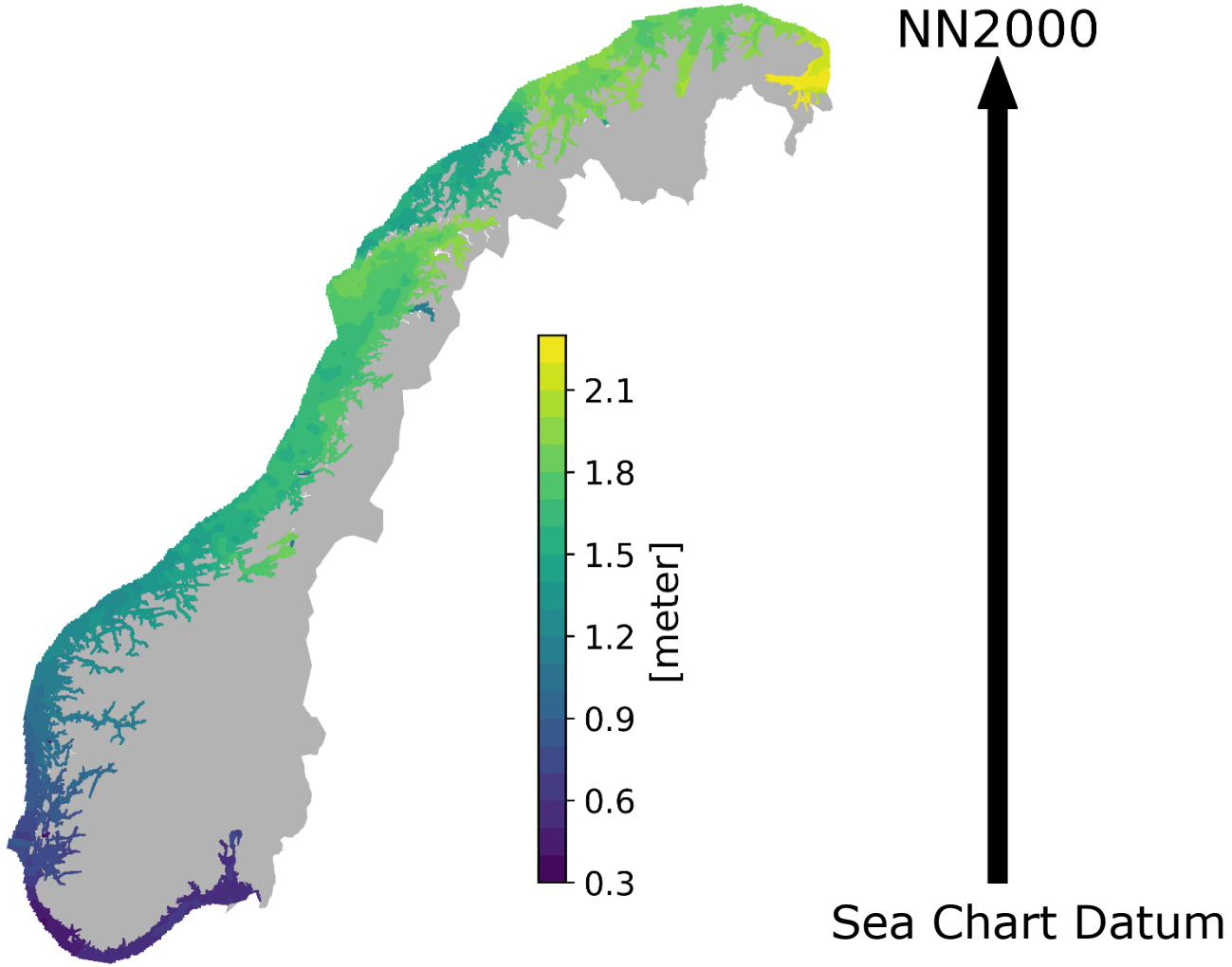
NKG General Assembly 2022 - Copenhagen

Two reference levels

- On land: NN2000
- On sea: Sea Chart Datum =
  LAT (Lowest Astronomical Tide)

- **Make a model of the difference!**

Problem:
We have few direct observation of this difference



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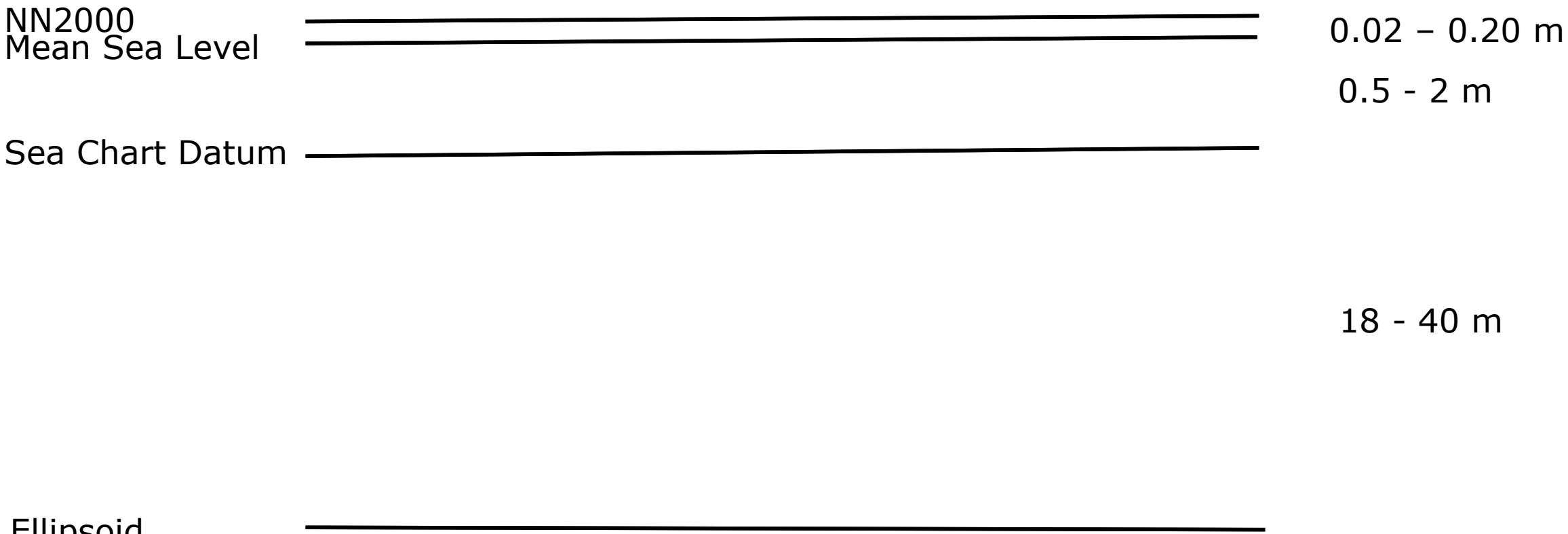
Other relevant reference levels



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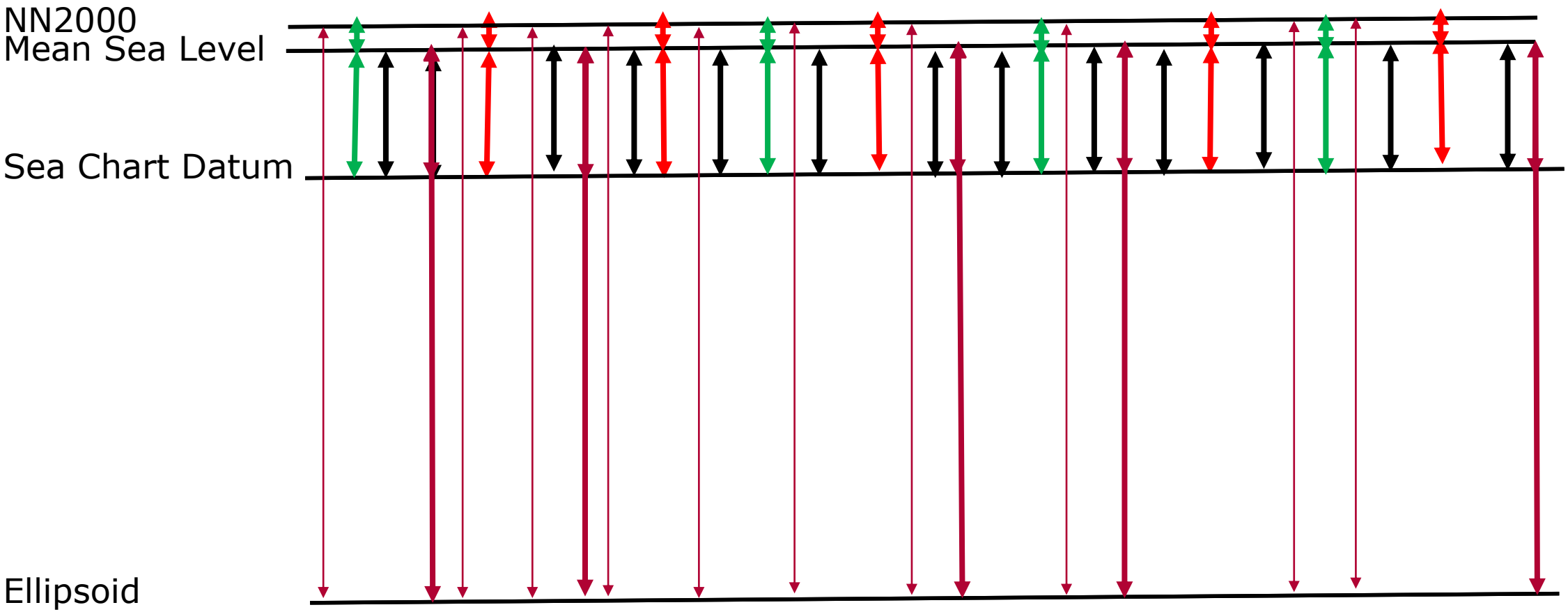
Observations of distances between reference levels



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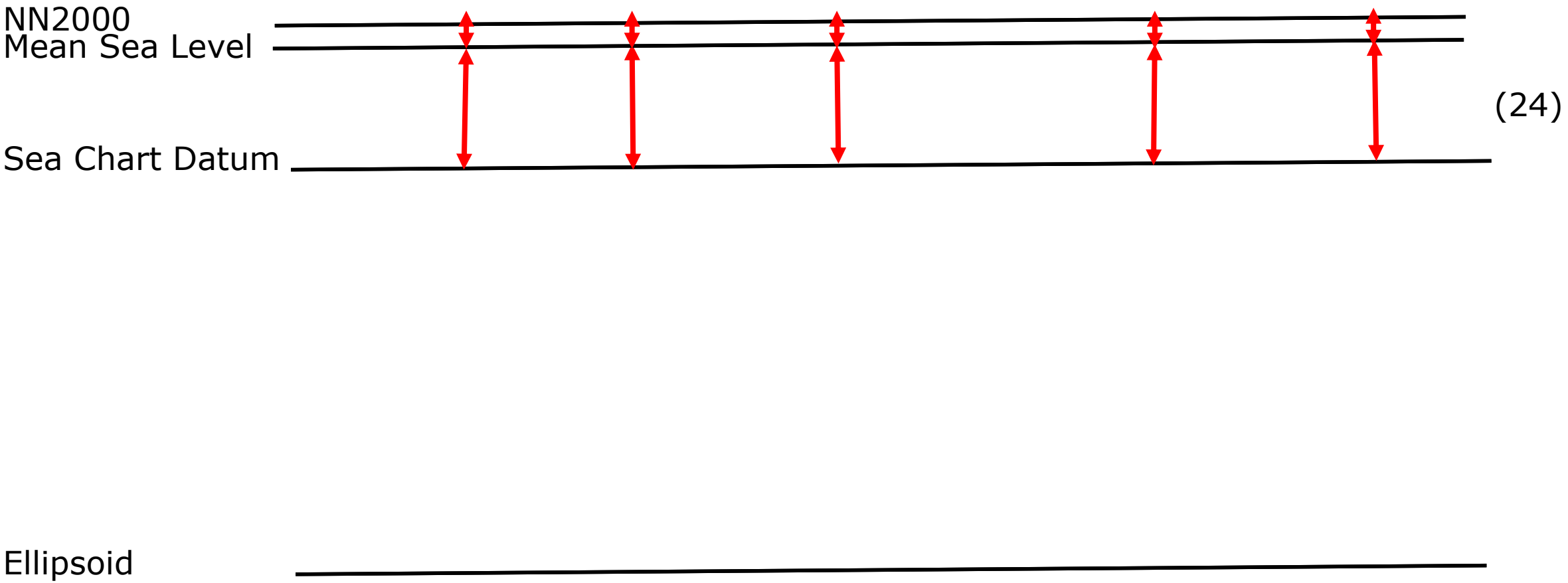
Permanent tide gauges



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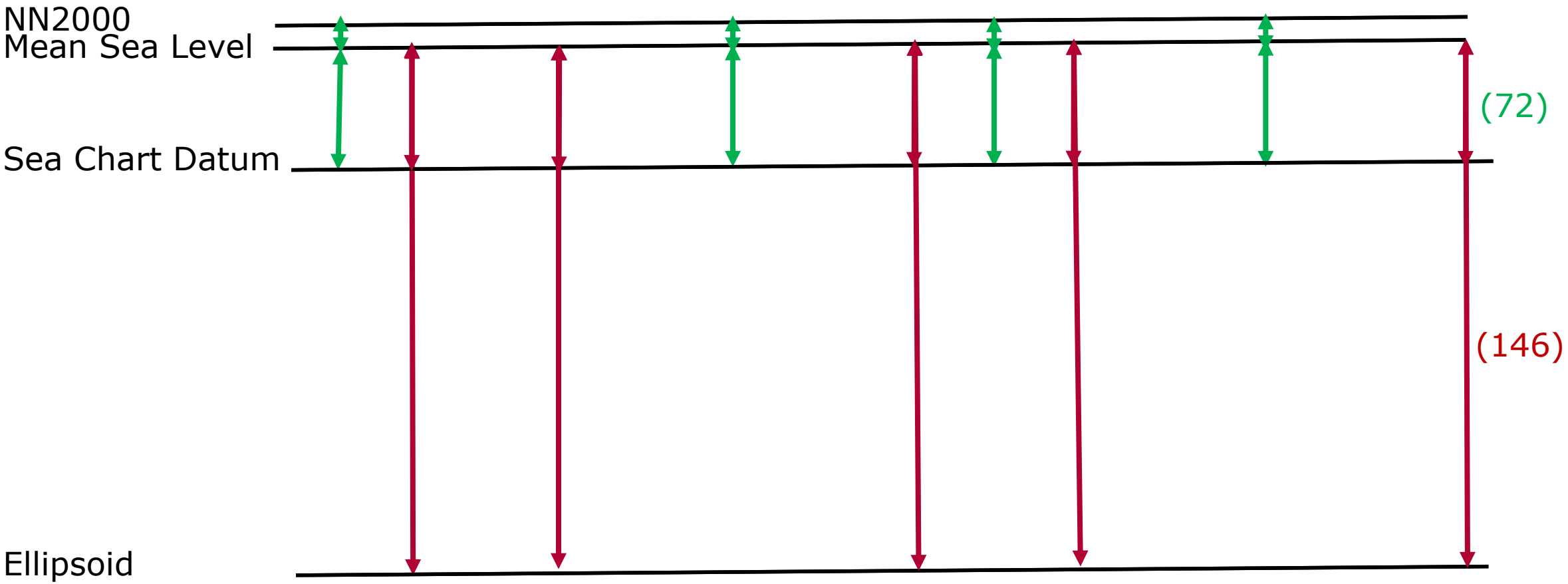
Temporary tide gauges



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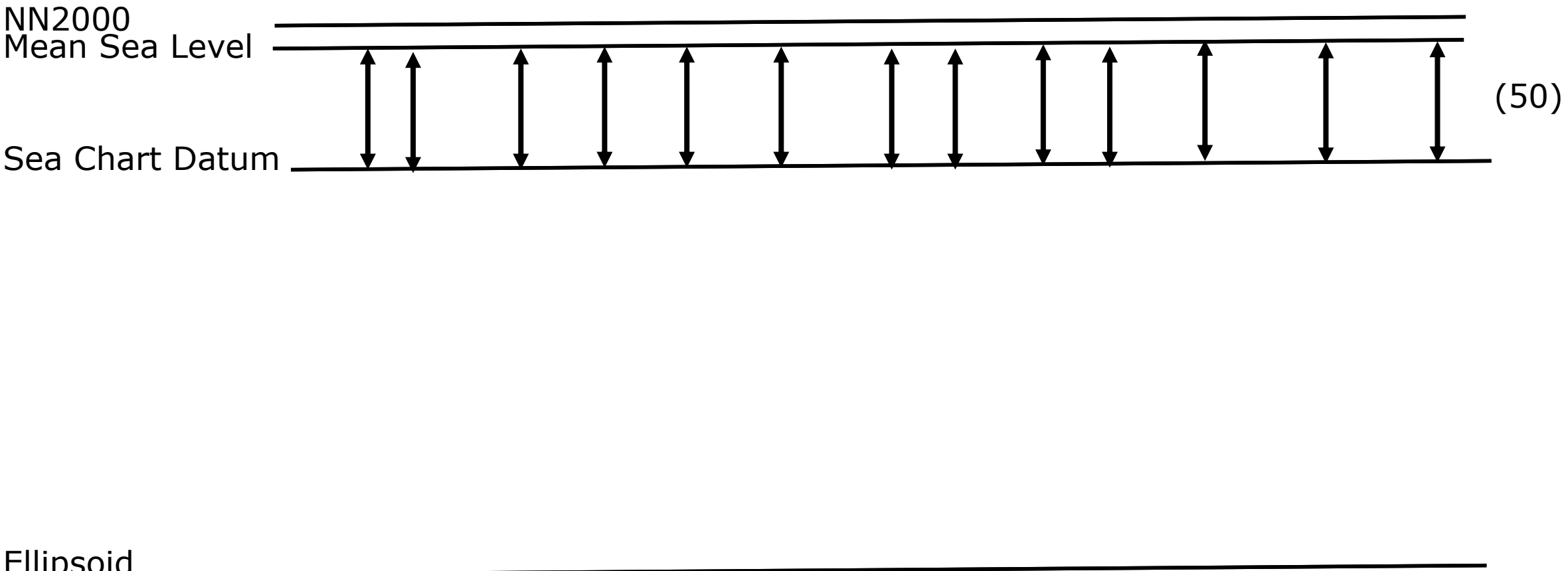
Temporary tide gauges, not connected to any benchmark



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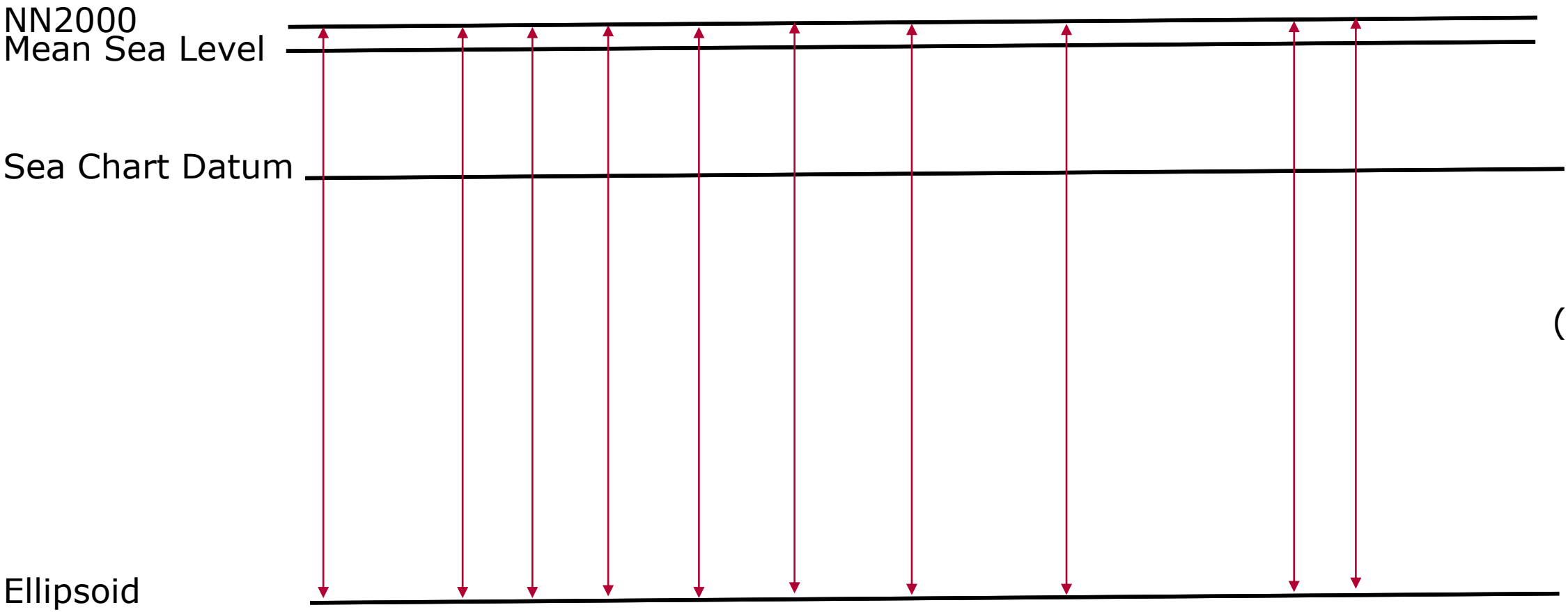
GNSS/levelling points



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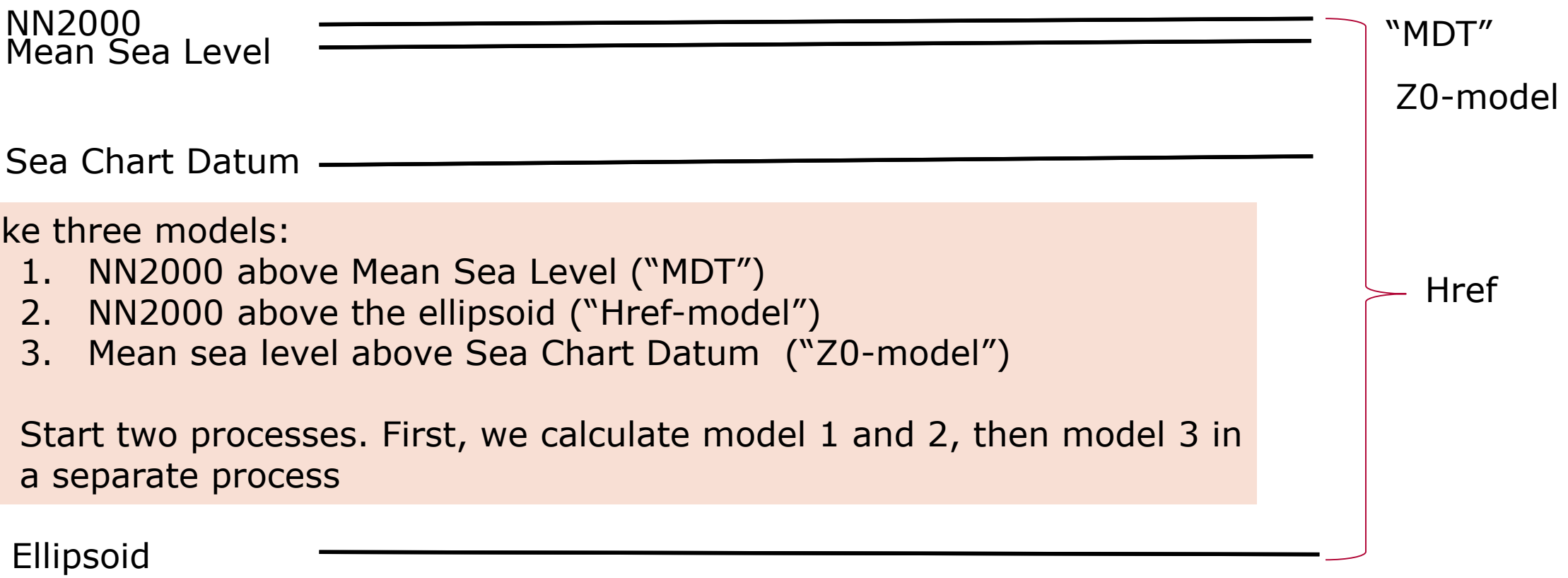
Kartverket

Strategy

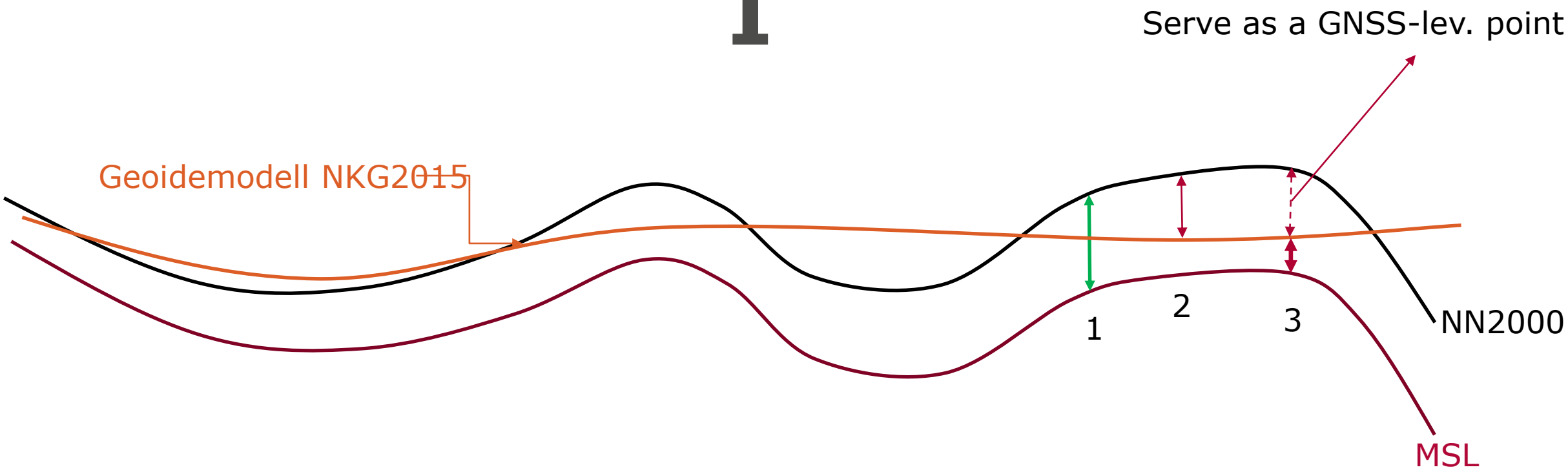


Make three models:

1. NN2000 above Mean Sea Level ("MDT")
2. NN2000 above the ellipsoid ("Href-model")
3. Mean sea level above Sea Chart Datum ("Z0-model")

Start two processes. First, we calculate model 1 and 2, then model 3 in a separate process

The first prosess – 'MDT' and Href I



1: Tide gauge connected to levelling network

2: GNSS-levelling point

3: Tide gauge connected to the ellipsoid

The first prosess – ‘MDT’ and Href II

- Least square collocation
- Two trend functions (calculated deterministic):
  - Distance between NN2000 and Mean Sea Level (‘MDT’)
  - Corrections to the gravimetric geoid model NKG2015
- Two set of signals (calculated stochastic):
  - Distance between NN2000 and Mean Sea Level (In addition to the trend)
  - Corrections to the gravimetric geoid model (In addition to the trend)

Some remarks on the new Href-models and NN2000

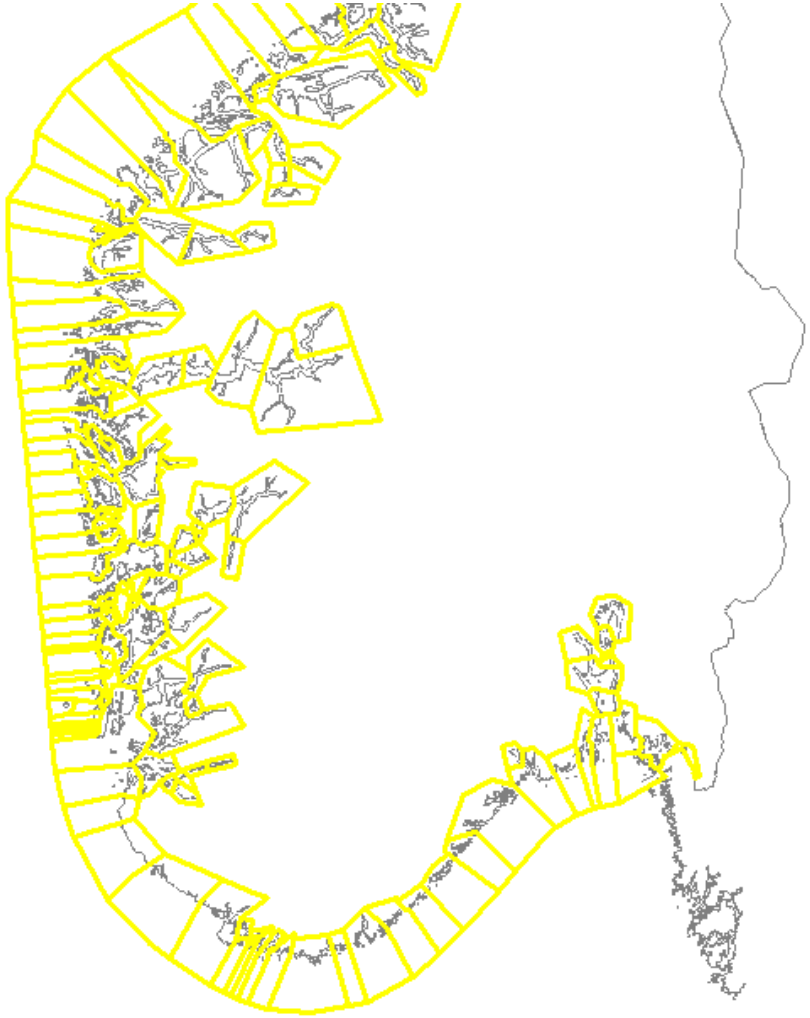
- The new Href-model enable us to improve the realizations of NN2000 far away from the levelling lines
- We know already that current realization in some regions have errors of 10 – 20 cm
- For consistency we cannot take the model in use for height determination without changing our current realization of NN2000
- However, the new Href-model is used as an internal model to make other separations models in combinations with others

The second process – the Z0-modell I

Use existing zone information as start values:

- Each zone has an individual Z0-value
- From each zone we pick the Z0-value for one or more positions.
- From these values a first model is calculated – a “zero model”

All available tide gauge observations are then used to correct this first “zero model”



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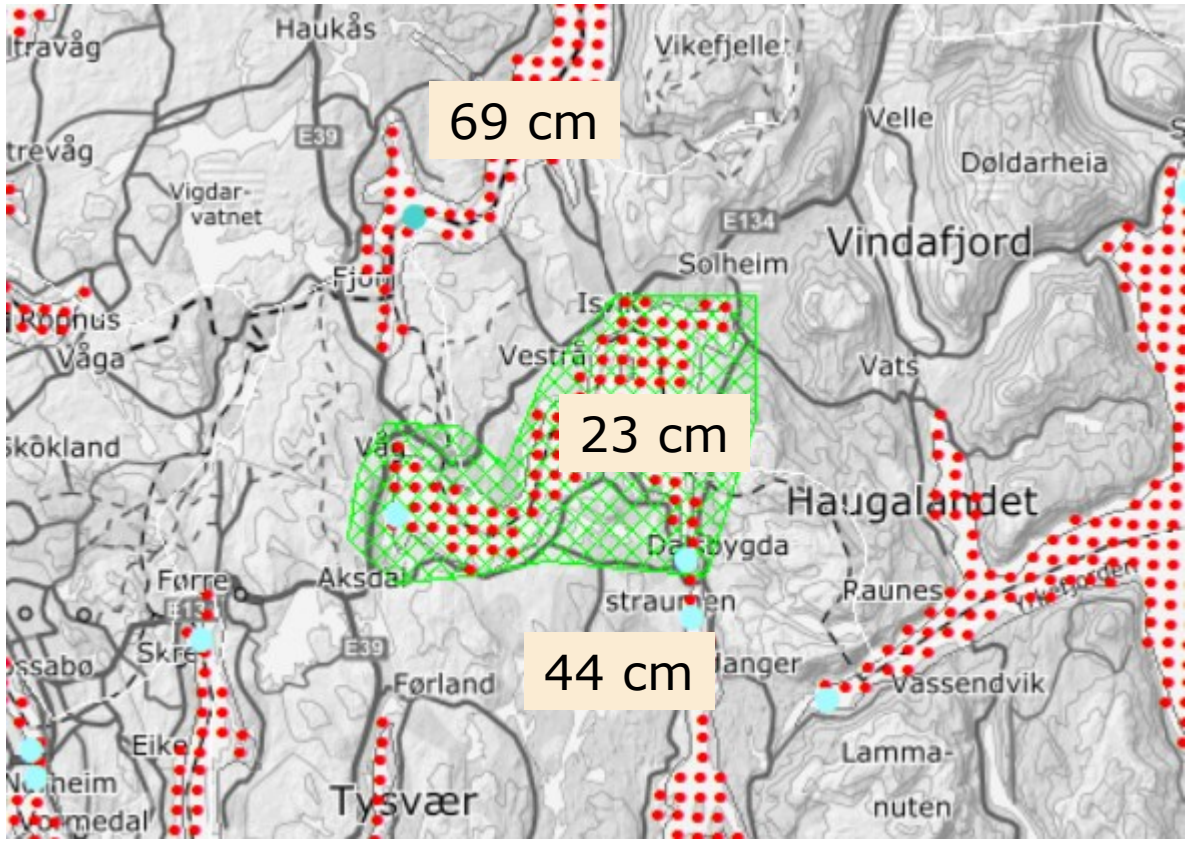
The second process – the Z0-modell II

- In open sea the valiation of LAT is as smooth as MSL.
- In complex fjord system, the variation can be huge over short distances.
- A common covariance function will not work in both situations
- Trick: Isolate fjord systems inside polygons and add 200 km to all distances to point inside the polygon.
- Use sea-distances – not the direct distance!



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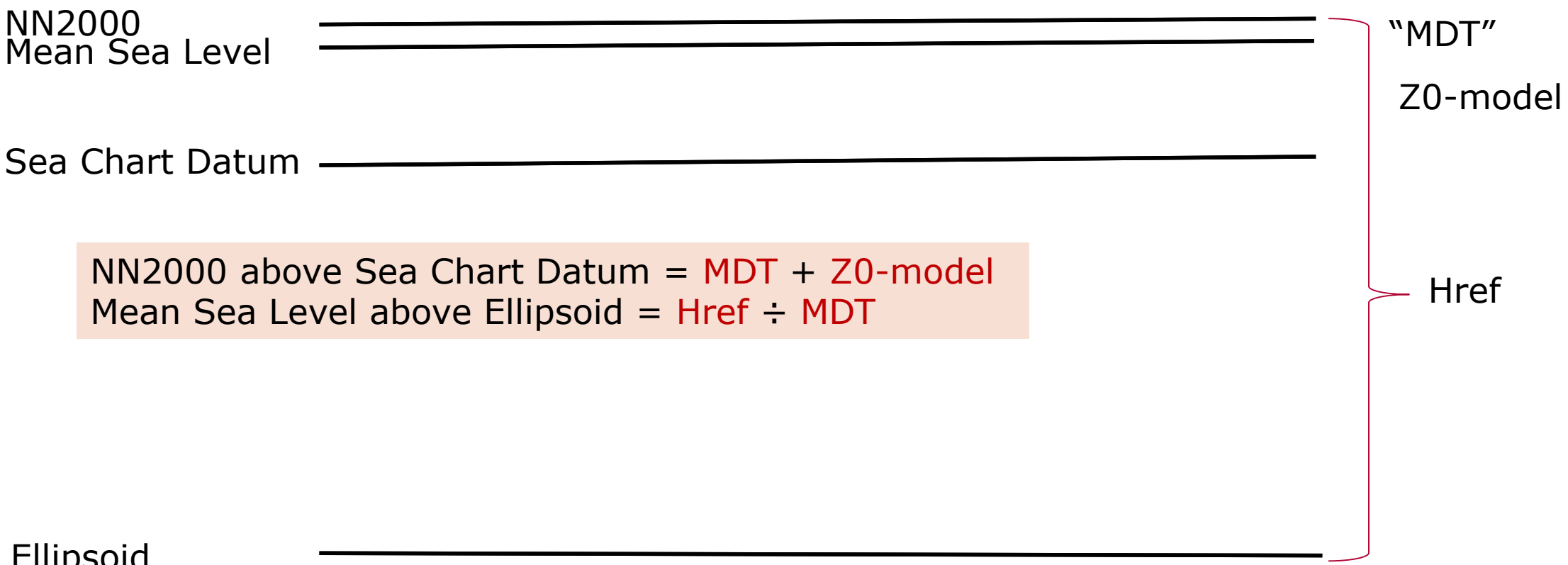
Combinations:



NN2000 above Sea Chart Datum = MDT + Z0-model
Mean Sea Level above Ellipsoid = Href ÷ MDT

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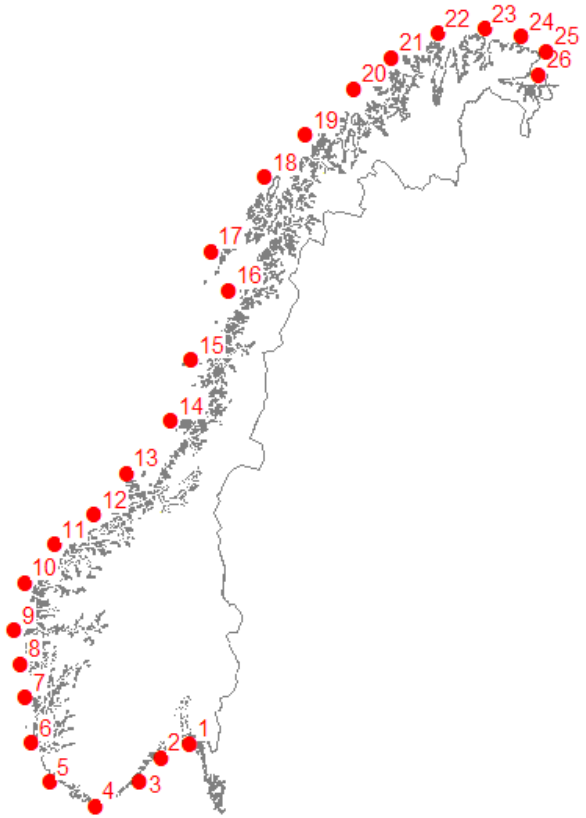
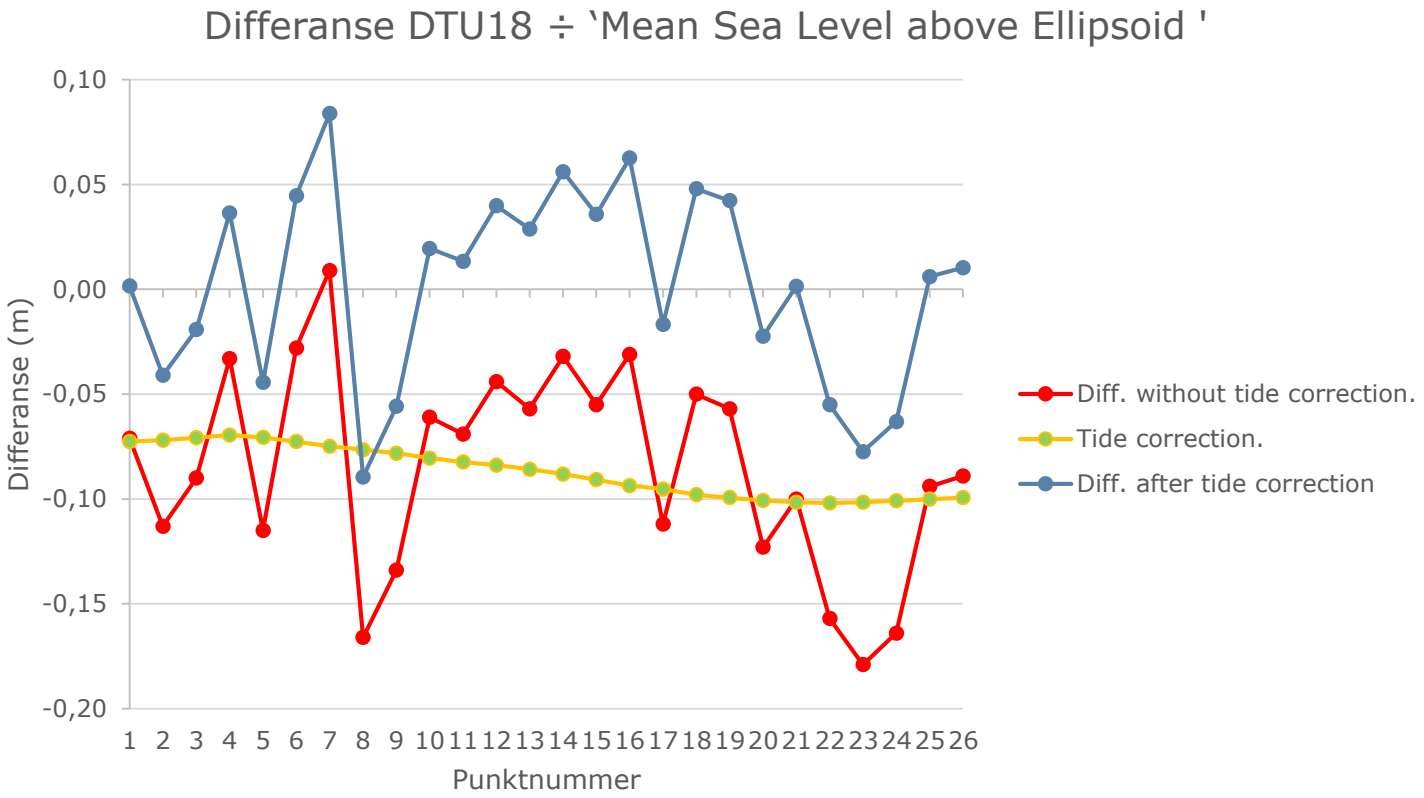
Comparision with DTU18 (Danish Technical University)





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Conclusions and further work

- Combination of tide gauge data and GNSS/levelling point gives consistent separations models between relevant reference levels along the Norwegian coast line
- These separation models make it easier to transform data referring to Sea Chart Datum, NN2000, Mean Sea Level or Euref89 to a common reference level.
- Without a new realization of NN2000 the improved Href (fitted geoid model) can not be taken publicly in use
- The models will be regularly updated when more observations are available
- We are working on uncertainty estimates of the models
- A seamless connection to international altimetry based models, for instance DTU18.