"How to prepare the fit of a Gravimetric Geoid to a National Height Reference"

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Geoid: Reference surface for GPS $H_{sea\text{-}level} = h^{GPS} - N$

In local datum:

H: local datum (tide gauge link)

h: WGS84 (ITRF)

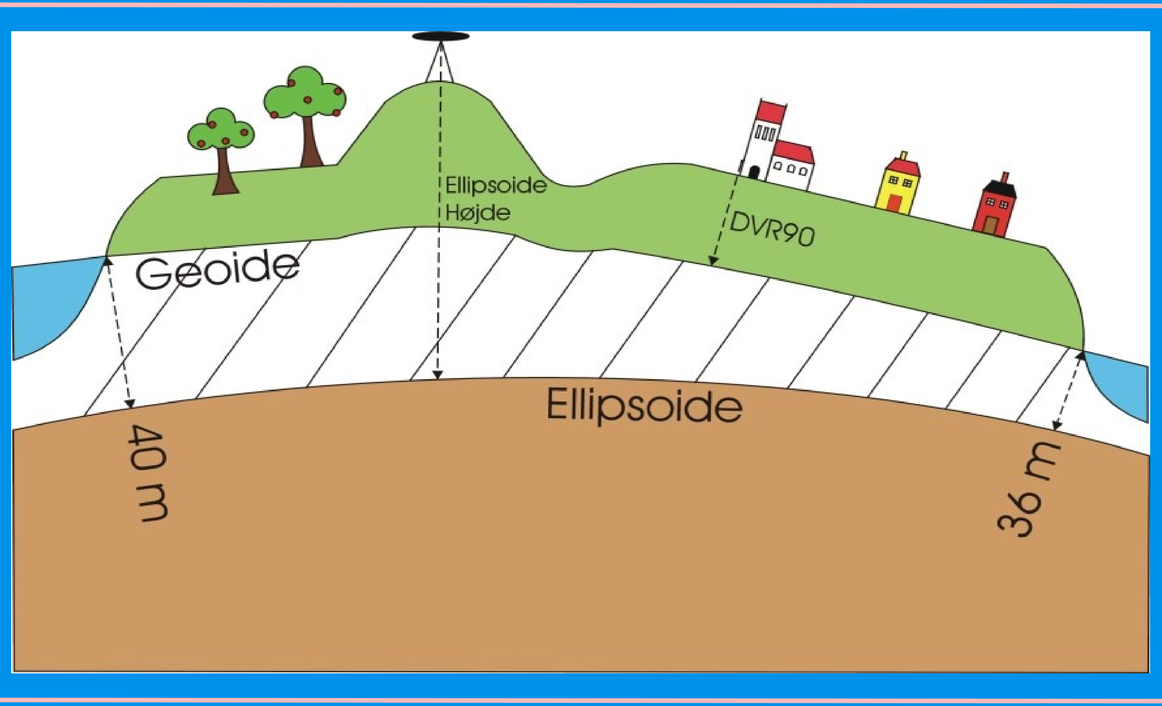
N: gravimetric geoid (from gravity and satellites)

In practice: $H = h - N + \varepsilon$

ε takes into account datum, movements and errors

At GPS-levelling point: $\varepsilon = h - H + N$

$N' = N + \varepsilon$ is the **GPS geoid** … gives heights in national levelling system when using GPS … but important to realize geodynamic effects and local movements



This year we will fit the gravimetric geoid to only 150 bench marks, instead of 700 as in 2013, as we believe that we have much higher accuracy of the heights as the bench marks have be surveyed by GNSS and levelled several times. Further the bench marks themselves are 1,5 m long steel 'screwing plugs', located, sub soil, in solid ground close to the original (100 years) sub soil precise levelling points. In this way we 'give more power' to the gravimetric geoid, which also have been enhanced by numerous new gravity surveys in the previous 10 years.

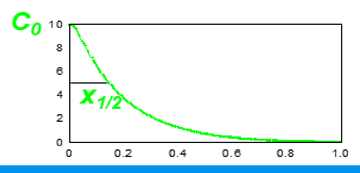
Methodology: collocation fit to GPS-levelling

Models of "the residual surface" ε_{res} – Collocation (2nd order Gauss-Markov model):

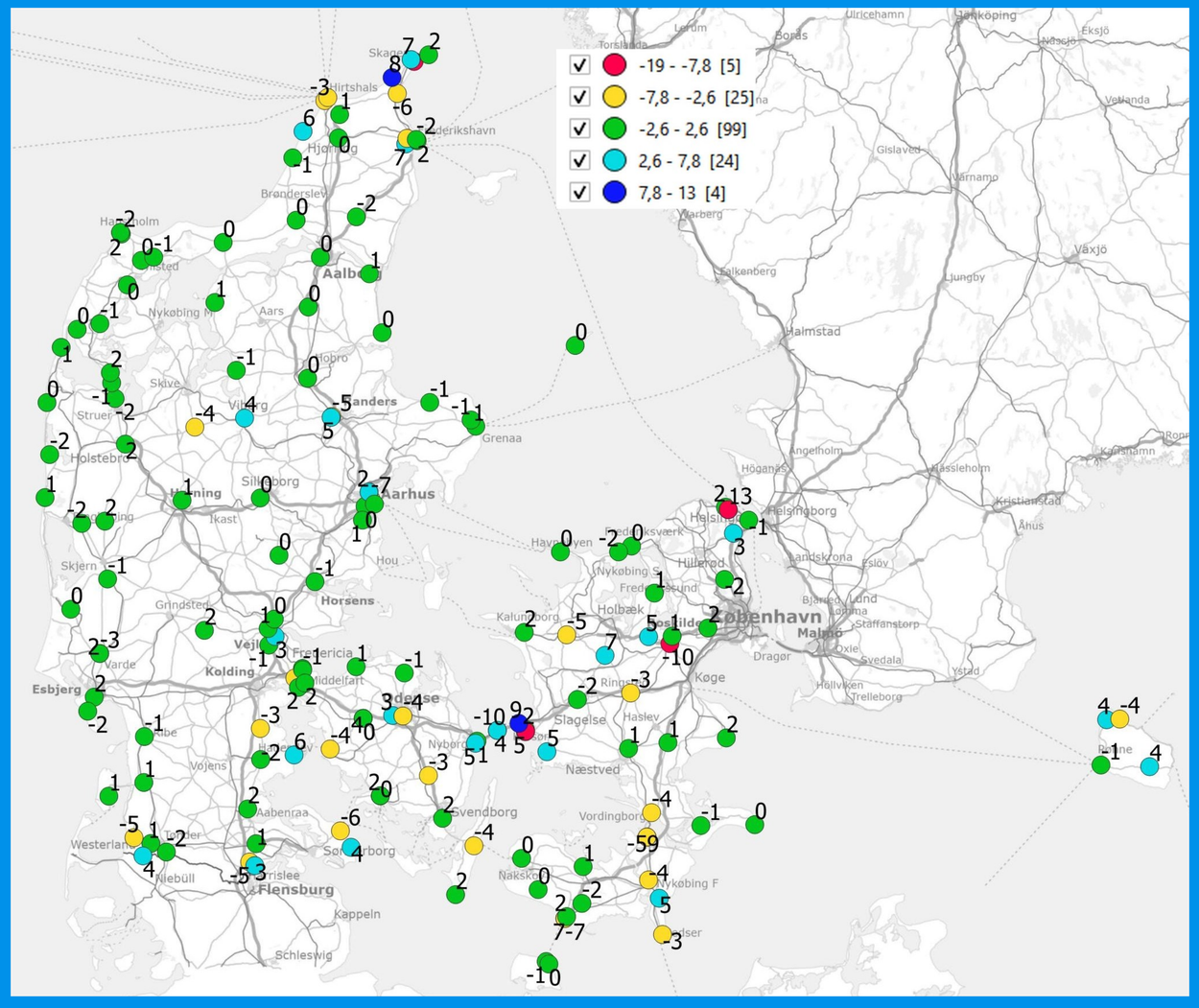
Covariance: $C(s) = cov(\varepsilon', \varepsilon')$

Covariance model: $C(s) = C_0 (1 + \alpha s) e^{-\alpha s}$

Prediction: $\varepsilon_{i'} = C_{ix} [C_{xx} + C_{nn}]^{-1} x$



Characteristic covariance parameters must usually be selected empirically … often not sufficient data to estimate reliable covariance function



The latest geoid fit to DVR90. Numbers are in mm. It does look nice however we do have some troubled areas to solve for…

Cross validation, Leave-One-Out (XV-LOO) is a nice way to evaluate the fitted geoid to the levelled GNSS points.
We make the fit without one point, then we evaluate the model in exact that point we left out. We do this with all the points one by one.
This will reveal the good points and the bad points!

- In order to use Swedish bench marks we must know the difference between the RH70 / RH2000 and DVR90 (is it constant?) and the two realizations of ETRS89.
- How do we change the heights into a unique epoch, for both levelled heights and ellipsoidal heights? (see below)
- How to calculate the best ETRS89 coordinates from older and new observations, and IGb2014 to IGb08 (7 parameter Helmert or NKG transformations)?

  We transform observed coordinates to IGb08, use the mean coordinates at the mean epoch of the observed coordinates which is transformed to ETRS89 using a 7 parameter Helmert transformation, using the ETRS89 coordinates of the permanent GNSS stations.

- Which parameters to use in order to judge a bench mark unstable or unsuited, comparison with uplift model?
- How do you deal with local height changes e.g. uplift at a salt dome etc.?
- and many more challenges…