# Report from the on-going project to compute the new NKG2014 geoid model

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# The NKG2014 geoid project

- The purpose of the project is to compute the next official NKG (quasi)geoid model, with the working name NKG2014.
- Started in 2011, still going on (see below)
- Project leader: Jonas Ågren, Sweden
- Participants:
  - Gabriel Strykowski, Denmark
  - Mirjam Bilker-Koivula, Finland
  - Ove Omang, Norway
  - Silja Märdla, Estonia
  - Tõnis Oja, Estonia
  - René Forsberg, Denmark
  - Ivars Aleksejenko, Latvia
  - Eidmuntas Paršeliūnas, Lithuania
  - Andreas Engfeldt, Sweden
  - Janis Kaminskis, Latvia
  - Lars E Sjöberg, Sweden
  - Hannu Ruotsalainen, Finland
  - Artu Ellmann, Estonia,
  - Harli Jürgenson, Estonia

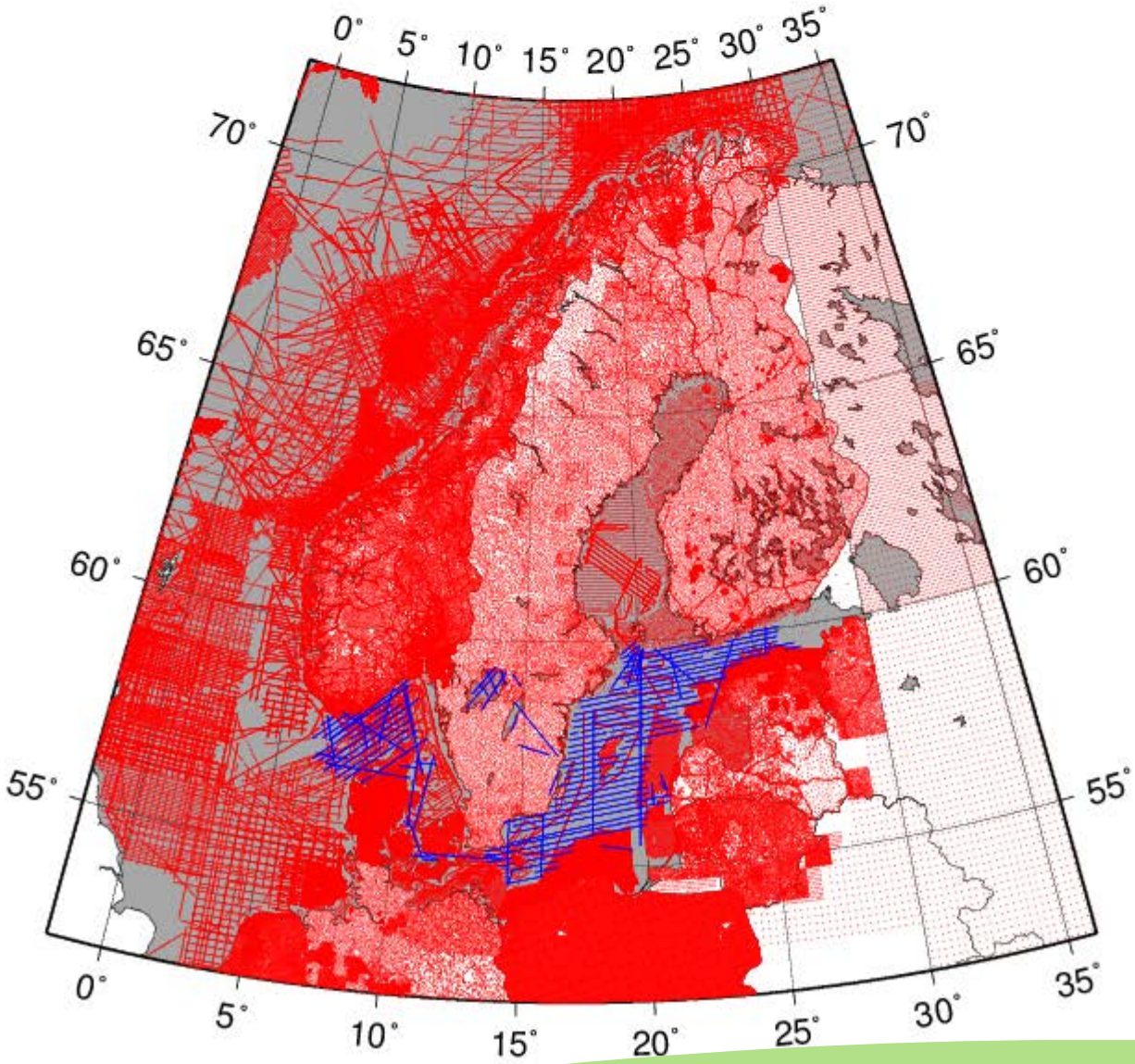
# Current timetable

1. Specification phase (responsible: Jonas Ågren): finished in March 2013
2. Data update phase:
   - Gravity database (Gabriel Strykowski): Modernised and updated with corrected data from all the Nordic and Baltic countries. Version 2 delivered August 8, 2014.
   - DEM (Mirjam Bilker-Koivula): The EGG08 DTM complemented with new national models from Estonia, Latvia and Lithuania. Version 1 delivered in June 18, 2014
   - GNSS/levelling database (Ove Omang): Data collected from all Nordic and Baltic countries, but not yet compiled and corrected/transformed (only a partial, preliminary version for this NKG GA 2014 presentation).
   - All the above datasets are still in the process of being checked, clarified and updated.
3. Computation phase:
   - Preliminary gravimetric model computed to the NKG General Assembly.
   - The computation centers continue their work during Autumn 2014.
   - Hands-on computation workshop in Estonia in November 2014.
4. Publication phase:
   - Final model is presented at the IUGG meeting in Prague July 2015.
   - Publication of one large umbrella journal paper and several small ones by participants/computation centers.

# Some decisions taken in the specification phase

- The NKG2014 geoid model is a quasigeoid model.
- The computation of the gravimetric model and the evaluation using GNSS/levelling is made in
  - common reference systems (frames) for the whole area,
  - the specified land uplift epoch 2000.0,
  - and the zero permanent tide system.
- All data types are transformed accordingly in the project. The land uplift corrections are made using the NKG2005LU model
- The different GNSS reference frames will be transformed to a common frame using the NKG2008 transformations (*result from the NKG ITRS-ETRS89 transformations project*).
- It seems clear that for practical application we will have to compute a **corrector surface using GNSS/levelling**. The question how this should be done has been postponed until after the final gravimetric model has been finalised.

# The NKG gravity DB 2014, version 2

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# Computation centers

- Sweden (Jonas Ågren)
- Estonia (Silja Märdla, Tõnis Oja)
- Finland (Mirjam Bilker-Koivula)
- DTU Space (Gabriel Strykowski, René Forsberg)
- Norway (Ove Omang)

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# Preliminary NKG2014 geoid model – version 140828

- So far, two computation centers have been active, namely Sweden and Estonia.
- Here the preliminary gravimetric model computed by Sweden (Jonas Ågren) is presented.
- The next presentation will focus on the preliminary work of Estonia (Silja Märdla et al.)
- Please note that **NKG2014_prel140828** is only **a preliminary result of one computation center**.
- A comparison with *preliminary* GNSS/levelling is also presented

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# Method and data used for NKG2014_prel140828

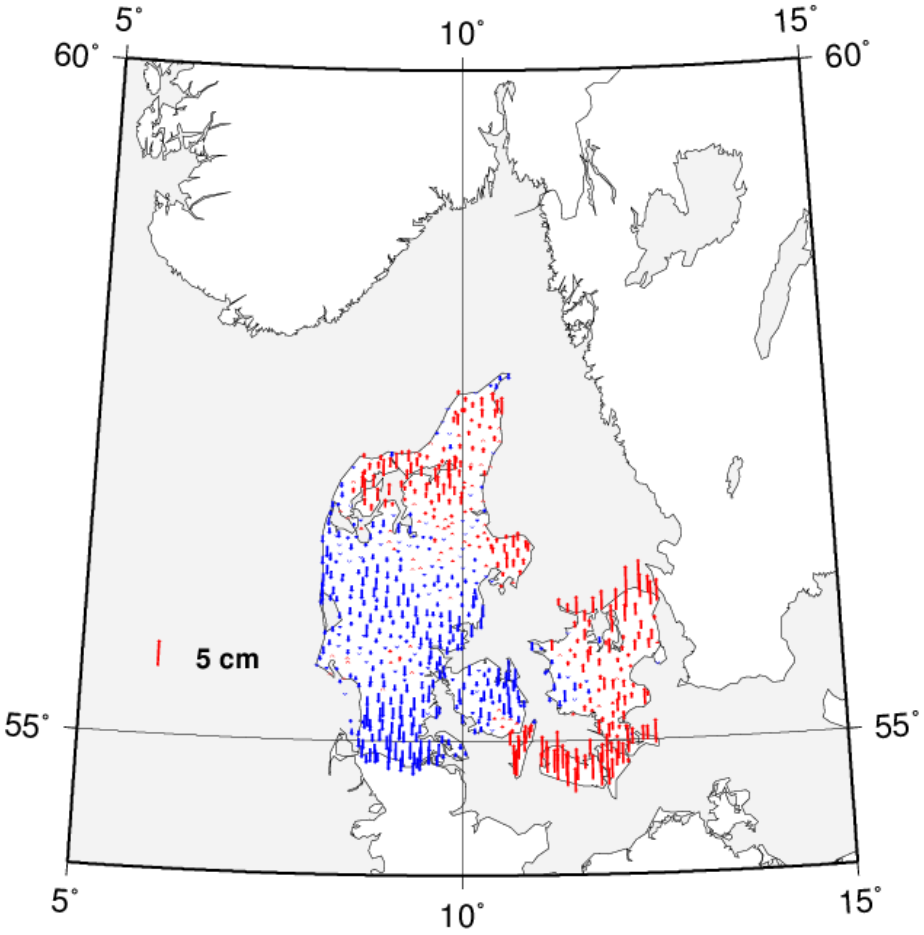
- The gravimetric quasigeoid model was computed by the Least Squares Modification of Stokes' formula with Additive corrections (LSMSA or KTH-method; see Sjöberg 1991, 2003,…) applied in a very similar way as in Ågren et al. (2009).
  - Least squares (stochastic) kernel modification (Sjöberg 1991).
  - Additive corrections for downward (analytical) continuation, atmosphere and the ellipsoidal correction.
  - Surface gravity anomalies gridded using a remove-interpolate-restore technique. EGM and RTM effects removed/restored. RTM effect computed using TC (Forsberg).
- The following observations were used:
  - Gravity observations from **NKG gravity DB 2014 version 2** (2014-08-18).
  - The brand new GRACE/GOCE GGM **GO_CONS_GCF_2_DIR_R5** with maximum degree 300.
  - Version 1 of the **NKG DEM 2014** with 3"x3" resolution (2014-06-16) preliminary averaged to 0.002°x0.004°.

# Evaluation of NKG2014_prel140828 using preliminary GNSS/levelling

- Only the Nordic countries, not the Baltic (due to lack of time)
- Normal heights in DVR 90, N2000, NN2000 and RH 2000, respectively.
- GNSS heights transformed to land uplift epoch 2000.0 and zero permanent tide system, **not** transformed by the NKG2008 transformations
- Mean values and standard deviations of the differences between GNSS/levelling and NKG2014_prel140828:

| Country | # | Mean (m) | Standard deviation (m) |
|---|---|---|---|
| Denmark | 665 | -0.685 | 0.018 |
| Finland | 50 | -0.682 | 0.022 |
| Norway | 901 | -0.660 | 0.035 |
| Finland | 197 | -0.678 | 0.022 |

# GNSS/levelling residuals after a 1-parameter fit – Denmark




- NKG2014_prel140828
- Height system: DVR 90.

Statistics (Unit: m)

| # | Min | Max | Mean | StdDev |
|---|---|---|---|---|
| 665 | -0.039 | 0.059 | 0.000 | 0.018 |

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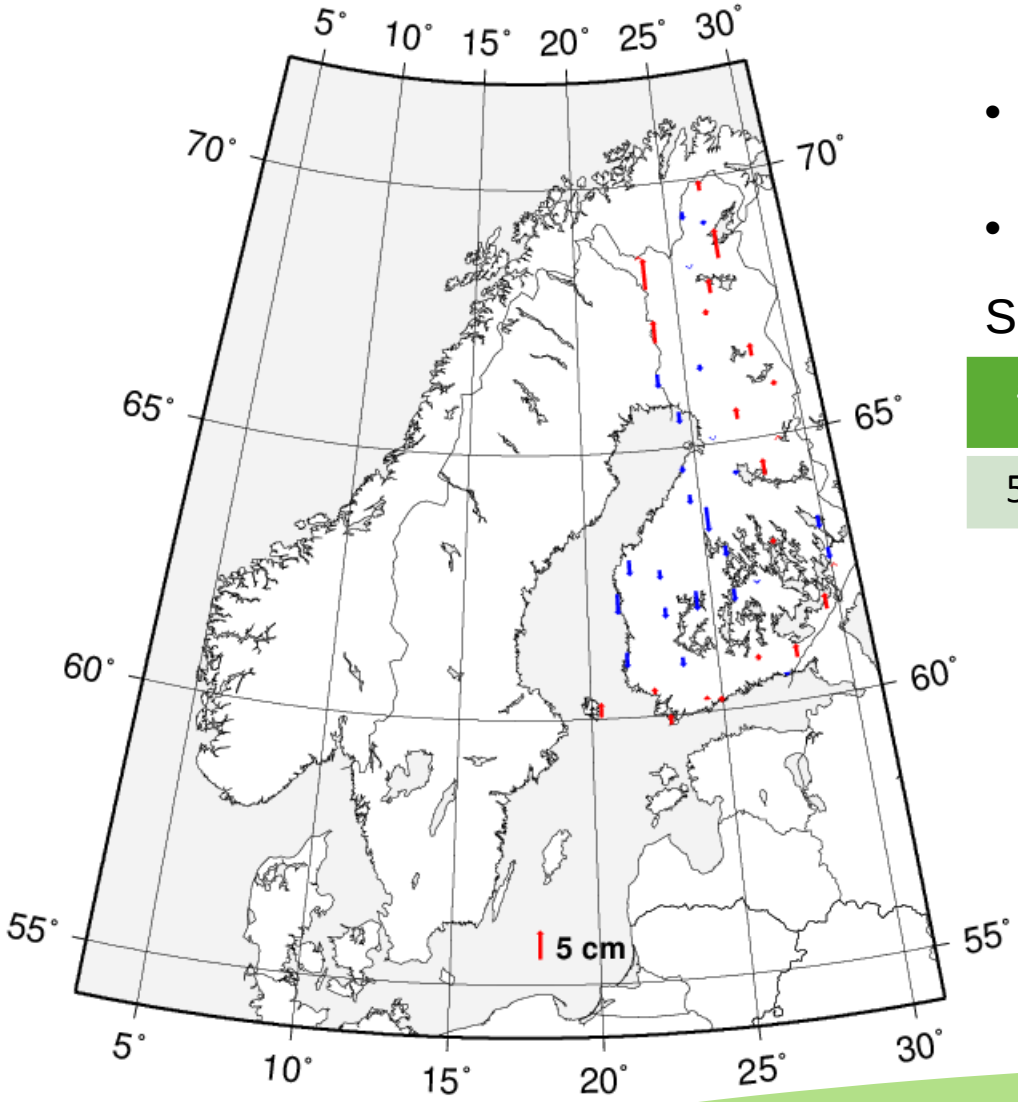
# GNSS/levelling residuals after a 1-parameter fit – Finland




- NKG2014_prel140828
- Height system: N2000

Statistics (Unit: m)

| # | Min | Max | Mean | StdDev |
|---|---|---|---|---|
| 50 | -0.039 | 0.054 | 0.000 | 0.022 |

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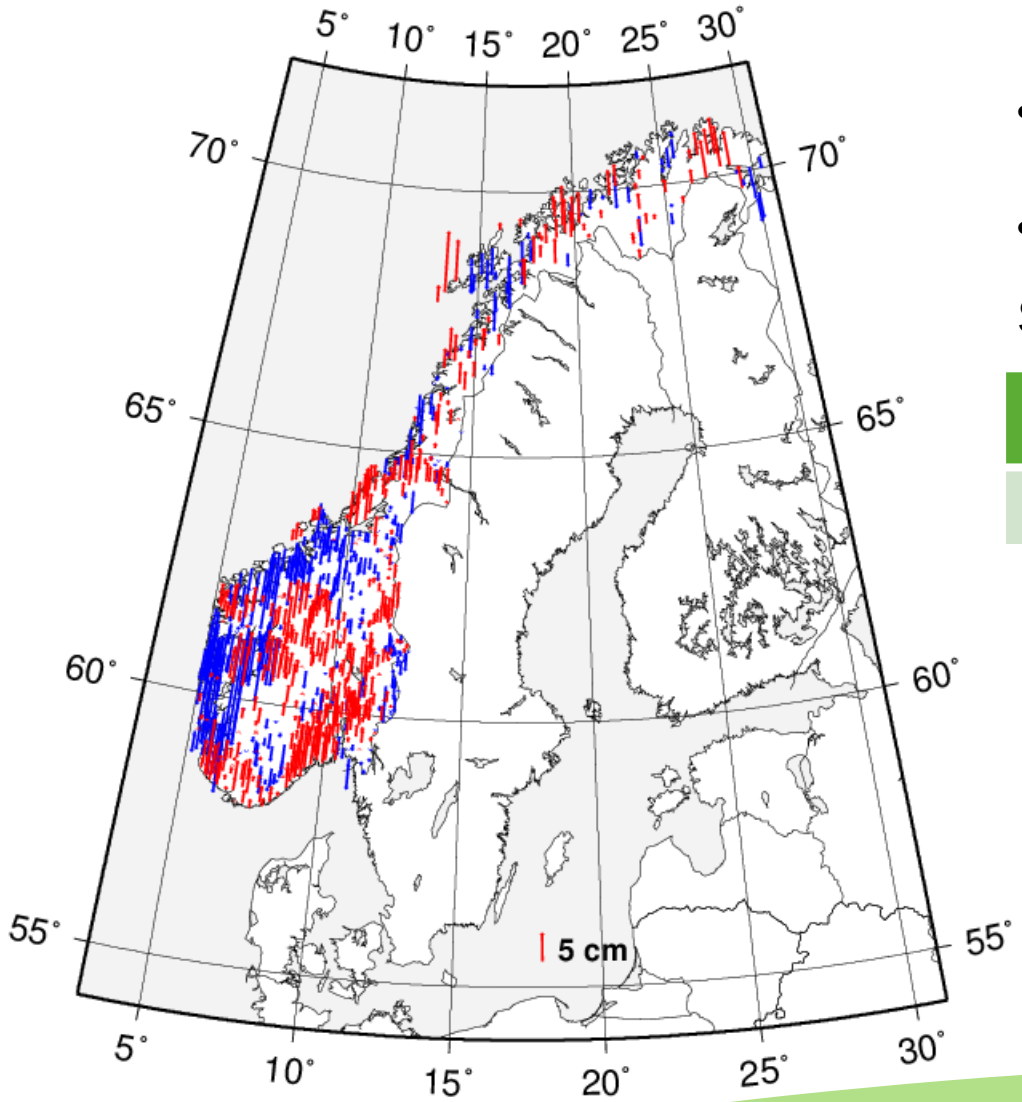
# GNSS/levelling residuals after a 1-parameter fit – Norway




- NKG2014_prel140828
- Height system: NN2000

Statistics (Unit: m)

| # | Min | Max | Mean | StdDev |
|---|---|---|---|---|
| 901 | -0.184 | 0.106 | 0.000 | 0.035 |

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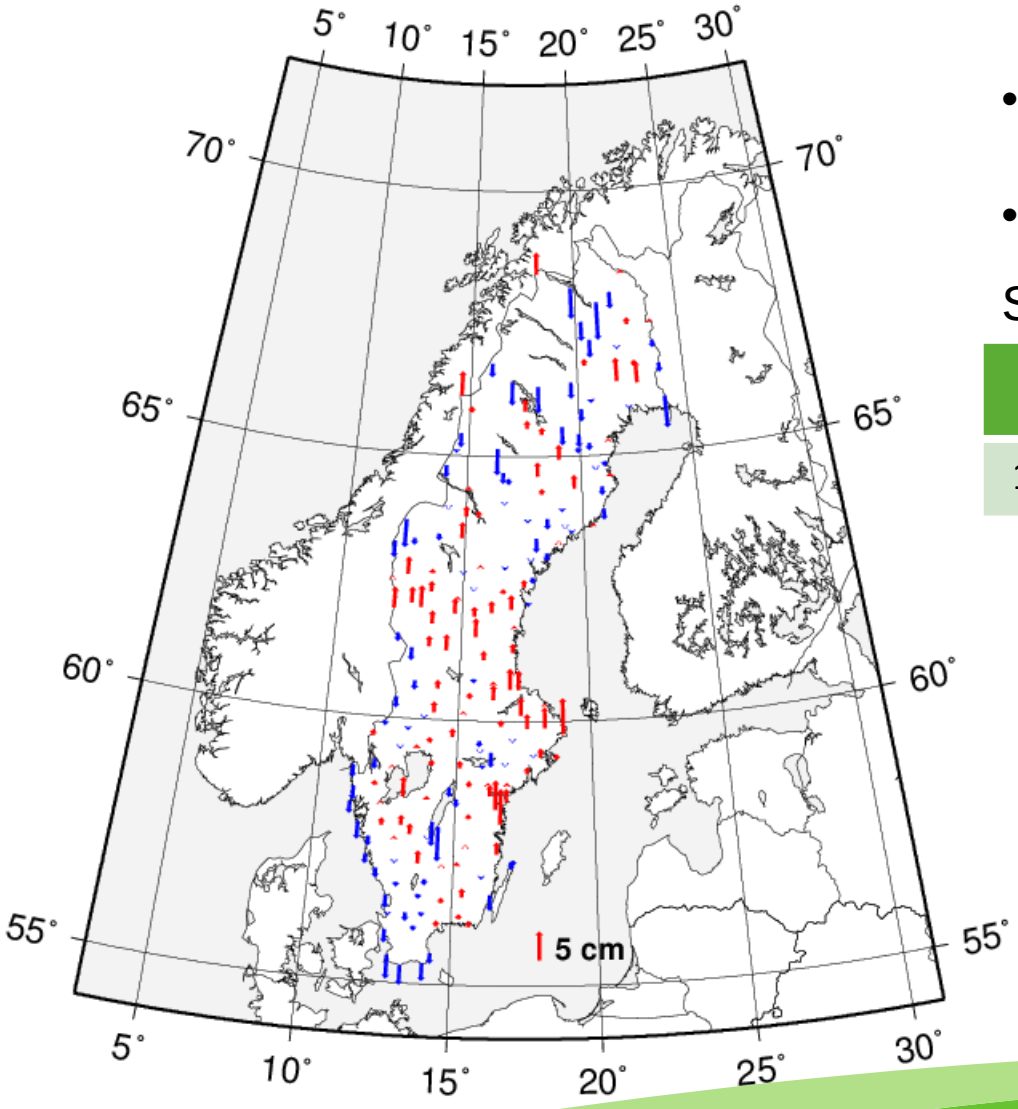
# GNSS/levelling residuals after a 1-parameter fit – Sweden




- NKG2014_prel140828
- Height system: RH 2000

Statistics (Unit: m)

| # | Min | Max | Mean | StdDev |
|---|---|---|---|---|
| 197 | -0.065 | 0.065 | 0.000 | 0.022 |

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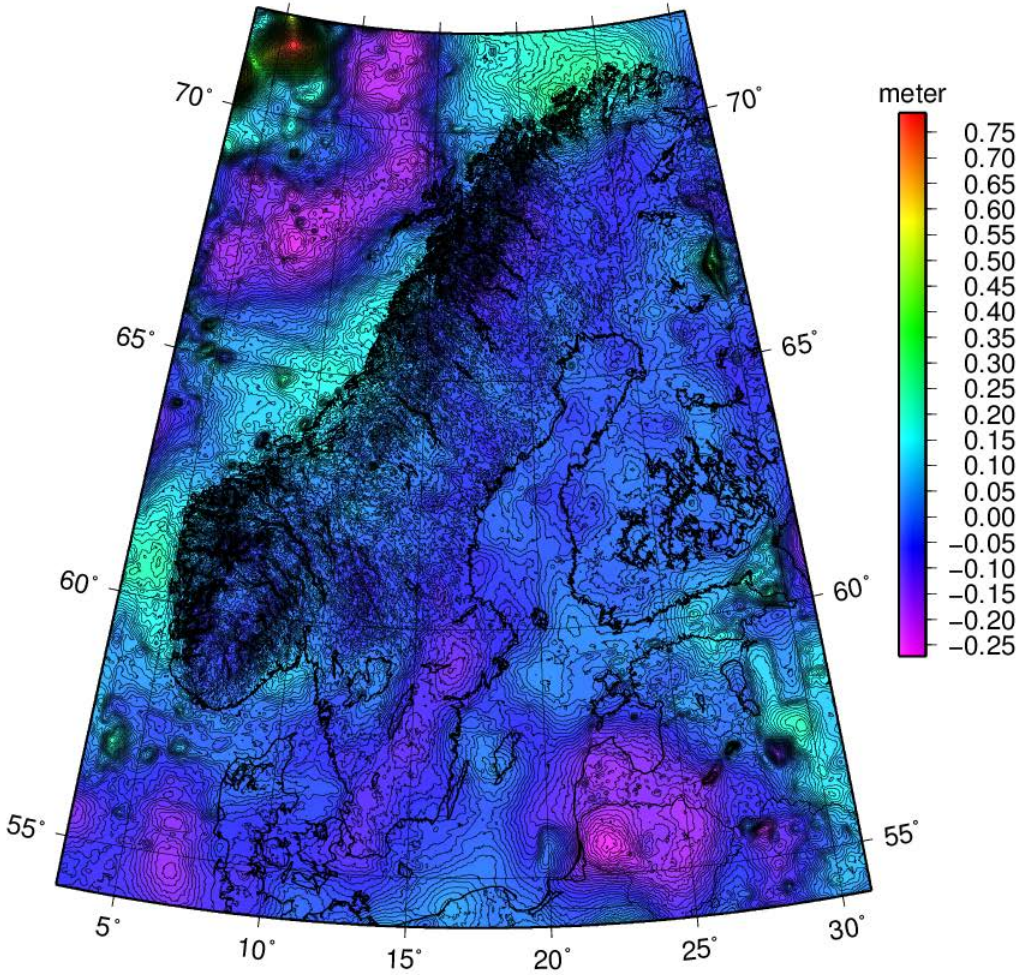
# Comparison of NKG2014_prel140828 and NKG2004




Mean value removed.

1 cm contour interval

Statistics (Unit: m)

| # | Min | Max | Mean | StdDev |
|---|---|---|---|---|
| 665 | -0.272 | 0.788 | 0.000 | 0.104 |

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# GNSS/levelling after a 1-parameter fit – all the Nordic countries

- Standard deviations for the **NKG2014_prel140828** and **NKG2004** gravimetric models.
- Height systems: DVR 90, N2000, NN2000 and RH 2000, respectively.

Standard deviations after 1-parameter fits (Unit: m)

| Country | # | StdDev NKG2004 | StdDev NKG2014_prel140528 |
|---|---|---|---|
| Denmark | 665 | 0.029 | 0.018 |
| Finland | 50 | 0.035 | 0.022 |
| Norway | 901 | 0.068 | 0.035 |
| Sweden | 197 | 0.043 | 0.022 |

# Final words

- So far, very much work have been spent on updating and quality checking the different data types.
- Especially the NKG gravity DB has required much work, from all the involved countries.
- The preliminary gravimetric model **NKG2014_prel140828** agrees well with GNSS/levelling. It is a considerable step forward compared to NKG2004.
- However, this is only a preliminary computation by one computation center.
- There are still uncertainties and suspect errors in the data, which we have to clarify and correct.
- Next, the computation centers will compute models using different methods, which will then be compared and analysed.
- We will then focus more on methodological aspects.

# Remaining tasks

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