Presented at the FIG Congress 2018
May 6-11, 2018 in Istanbul, Turkey

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RG 2000 – the New Gravity Reference frame for Sweden

Andreas Engfeldt, **Martin Lidberg**, Marcin Sekowski, Przemyslaw Dykowski, Jan Krynski, Jonas Ågren, Per-Anders Olsson, Henrik Bryhske, Holger Steffen, and Jens Emil Nielsen

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Why a new gravity reference frame?

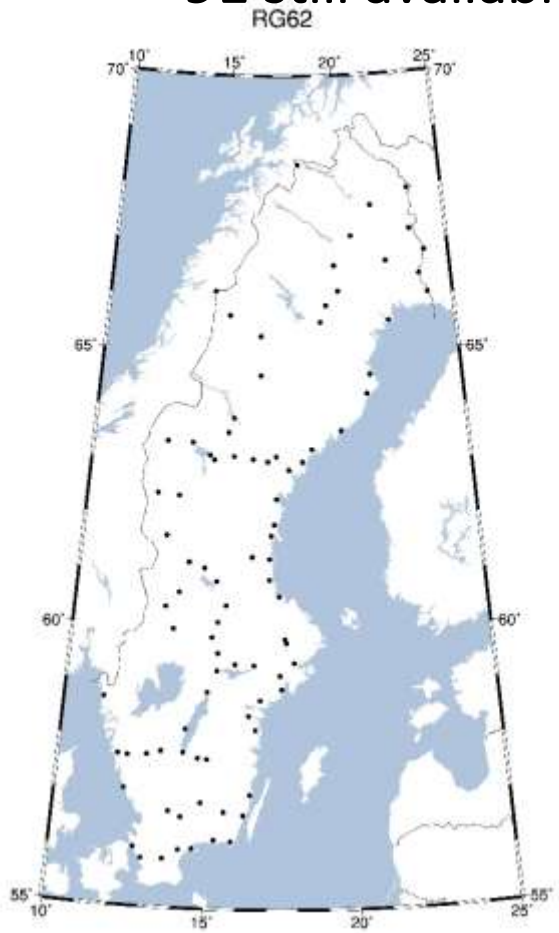
- Today we can see an increased **need for improved geoid models** for GNSS height determination,
- This calls for **additional gravity observations and quality assurance** of existing gravity data.
- In this perspective, a new modern gravity system and the renovation of the high order gravity network is considered as **a moderate strategic investment**, which will provide a firm foundation for further activities.

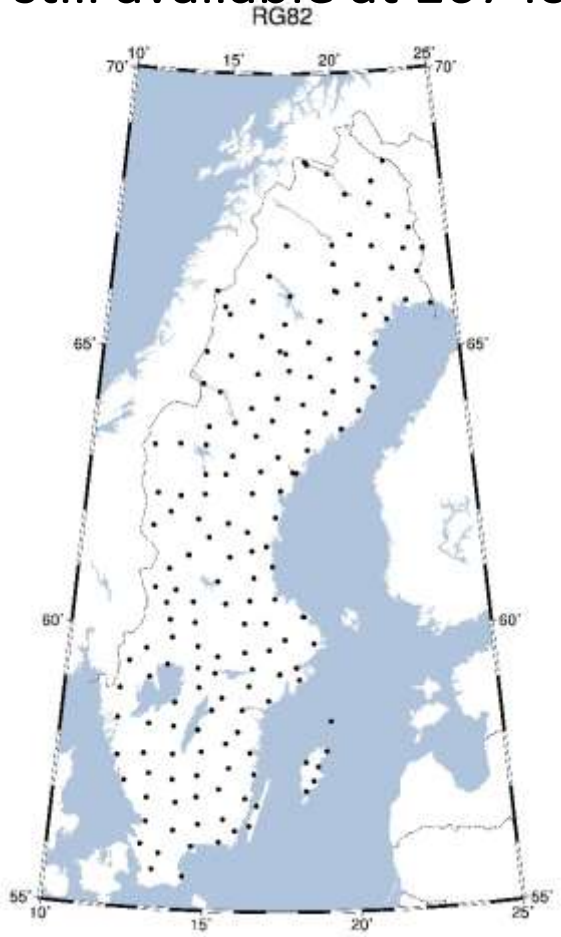
The situation at the start of the RG 2000 work

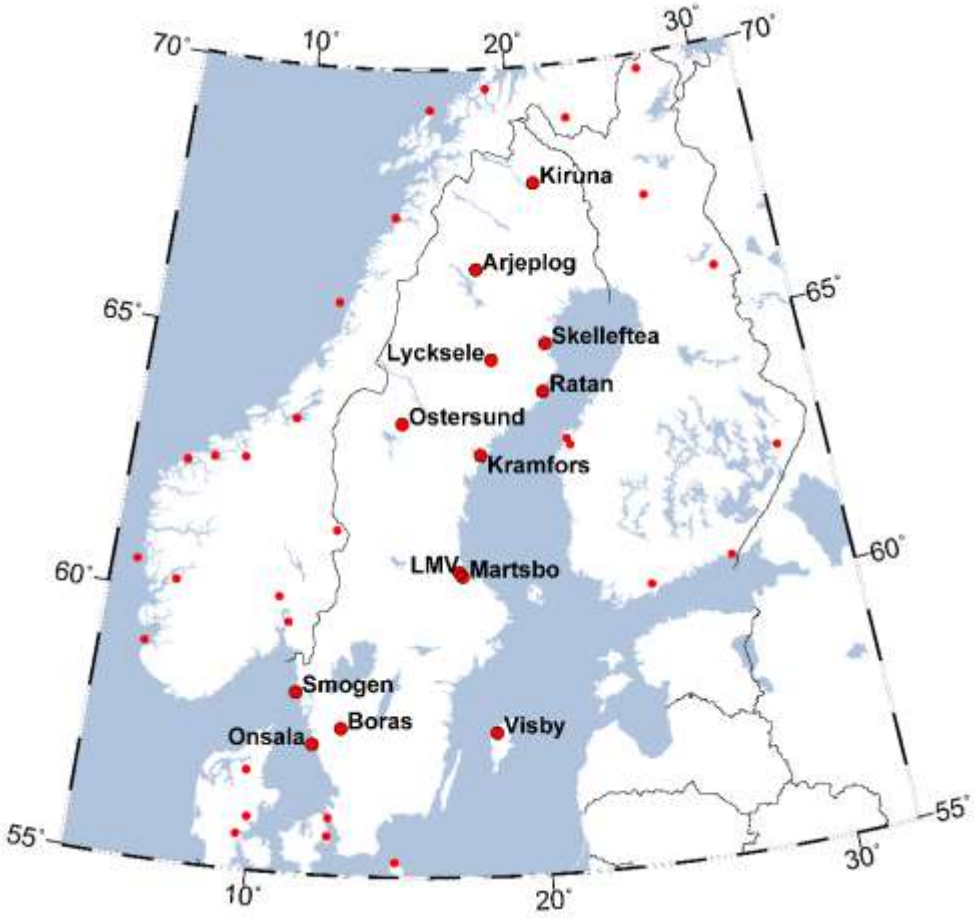
RG 62 – not marked points, 91 still available

RG 82 – points on benchmark, 190 still available at 167 locations

FG5 points – 17 at 13 locations (4 in Onsala and 2 in Mårtsbo)







Absolute gravimeter FG5

- Standard uncertainty for one observation: about 2 µGal
- Time series from 2007-2016 (FG5-233) and 2004-2008 (FG5-220)
- At 13 locations in Sweden
- Only indoors, at very stable surfaces and at almost constant temperatures (between 17 and 27 degrees)

Absolute gravimeter A10

- A-10 is a smaller and more portable absolute gravimeter than FG5
- A-10 can measure outdoors, but does not work well in **direct sunlight, rain or wind**
- Standard uncertainty for one observation: **5-10 µGal**
- Instrument: A-10-020 of IGiK in Warsaw
- 95 points in 5 campaigns during 2011-2015

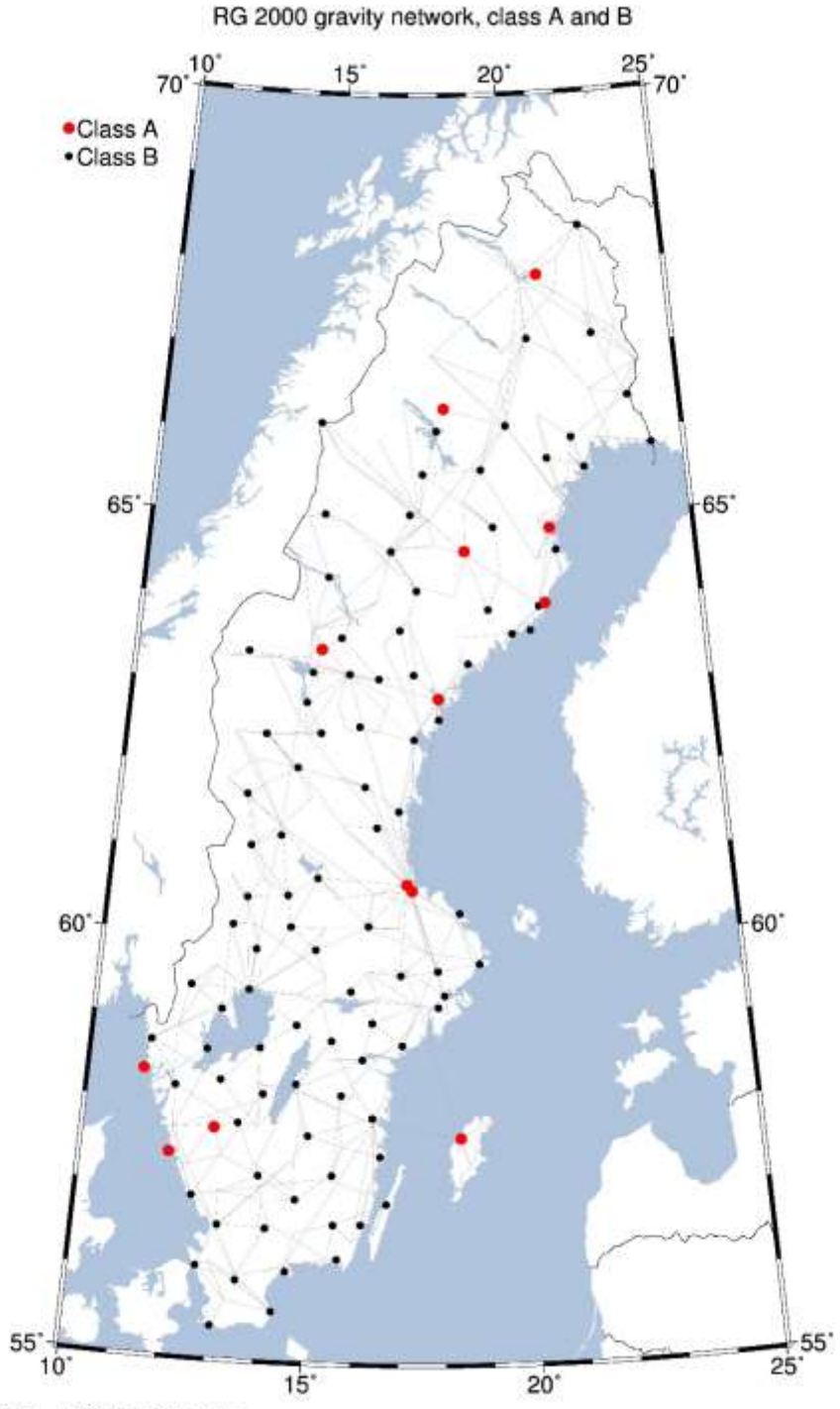



Relative gravity observations

- Existing precise relative gravity observations have been re-used (1975-2002)
  - LaCoste & Romberg G-meter
- RG 2000 campaign (2015-2017):
  - LaCoste & Romberg G54
  - Scintrex CG5
- In total some 3900 observations

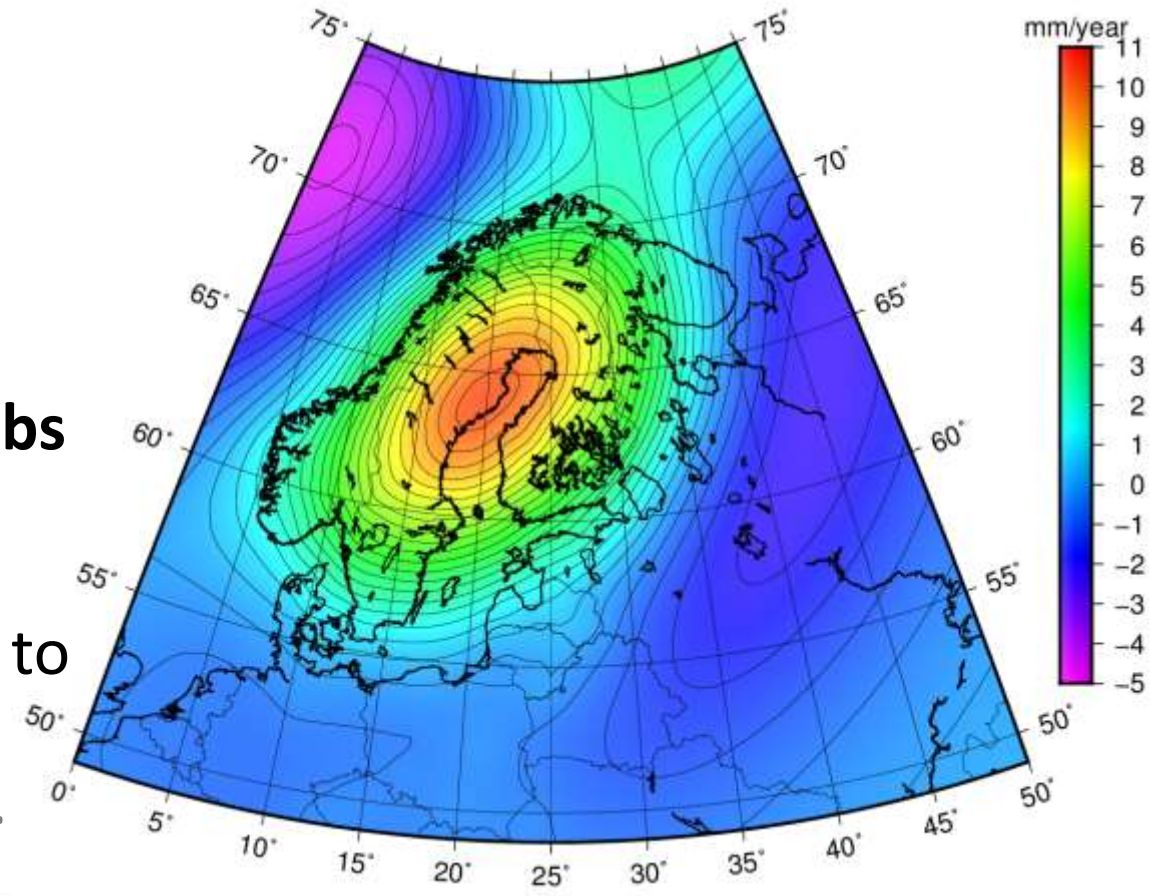
RG 2000 - definition

- The gravity reference level as obtained by **absolute gravity** observations according to international standards and conventions
- The post glacial rebound **epoch 2000.0**
- It is a **zero permanent tide** system



RG 2000 - realization

- The FG5-233 observations are corrected based on results from **international comparisons** (Olsson et.al. (2015b))
- The **land uplift model NKG2016LU_abs** was used to get to the post glacial rebound epoch of **2000.0**
- The value **-0.163 µGal/mm** was used to convert the geometric absolute land uplift to gravity change (Olsson et. al. (2015a) and Olsson et. al. (2018))



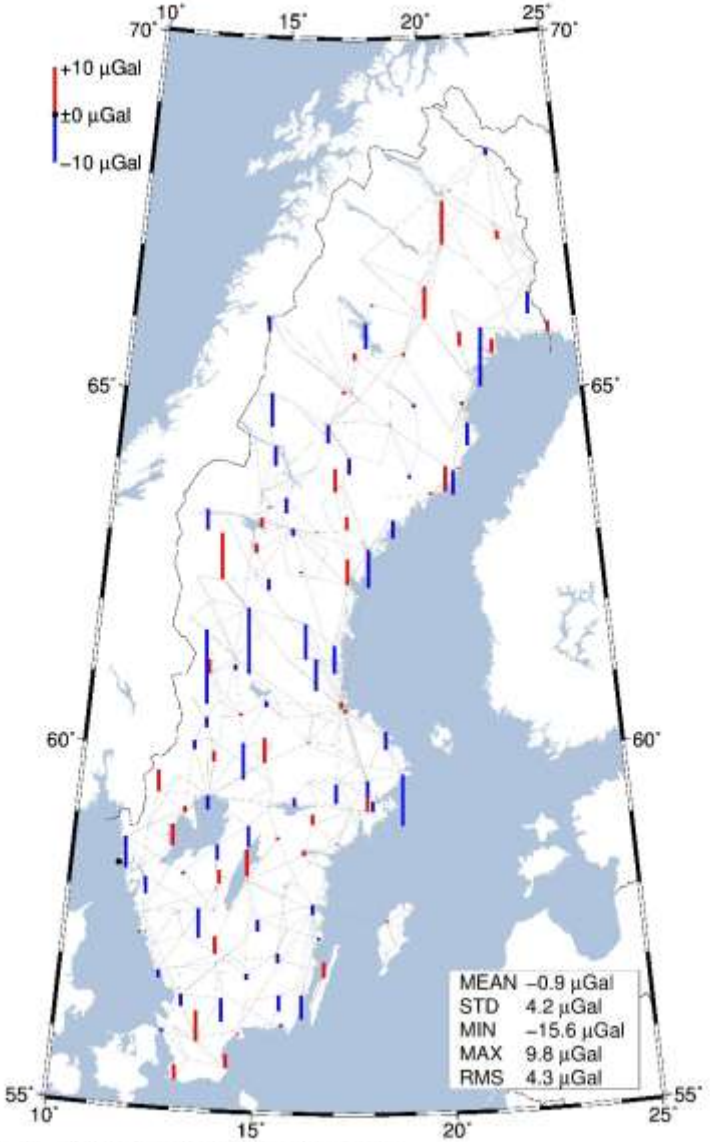
NKG2016LU_abs

Adjustment of RG 2000 – weighting

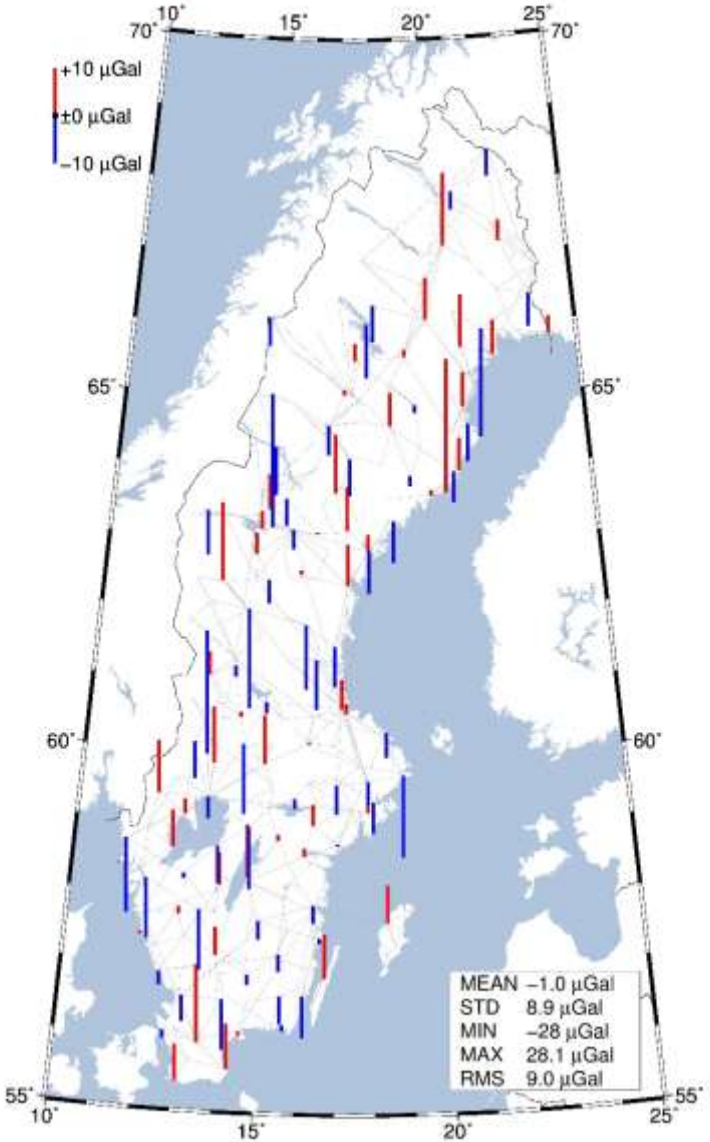
	A priori standard uncertainty (µGal)	A posteriori standard uncertainty of unit weight
FG5	1.0	1.28
A10	5.0	1.32
Rel. grav	Varying, but typical ~10	0.74
All obs		0.76

Results final adjustment of RG 2000

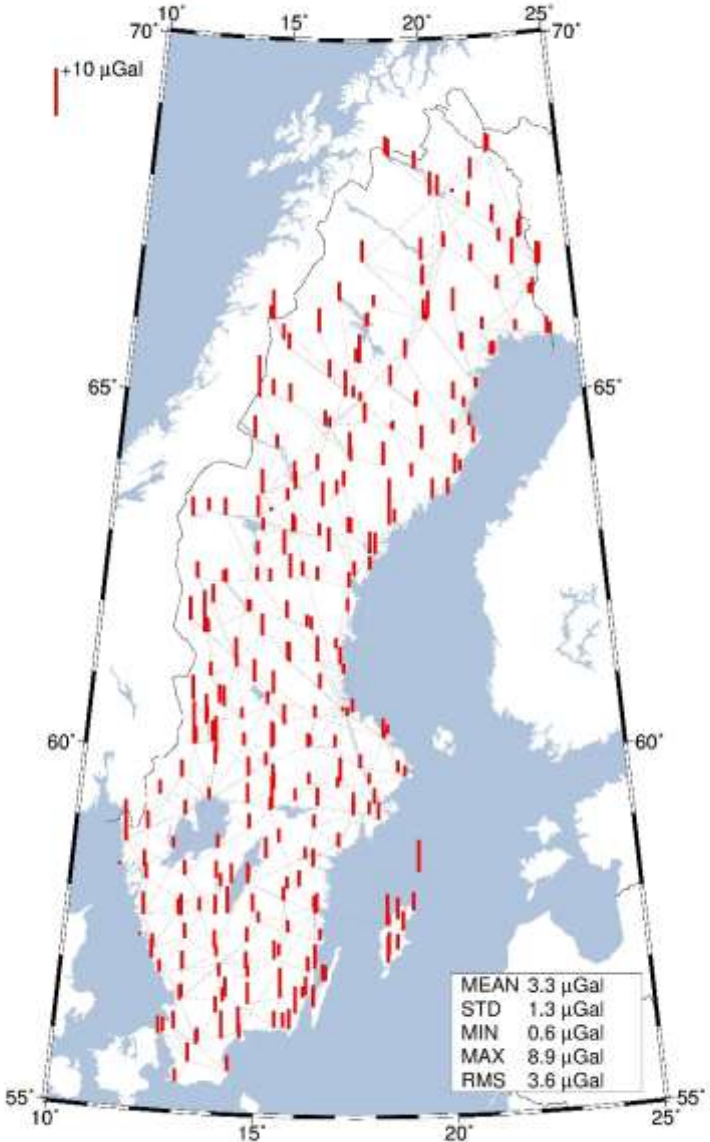
AG residuals
4.3 µGal RMS



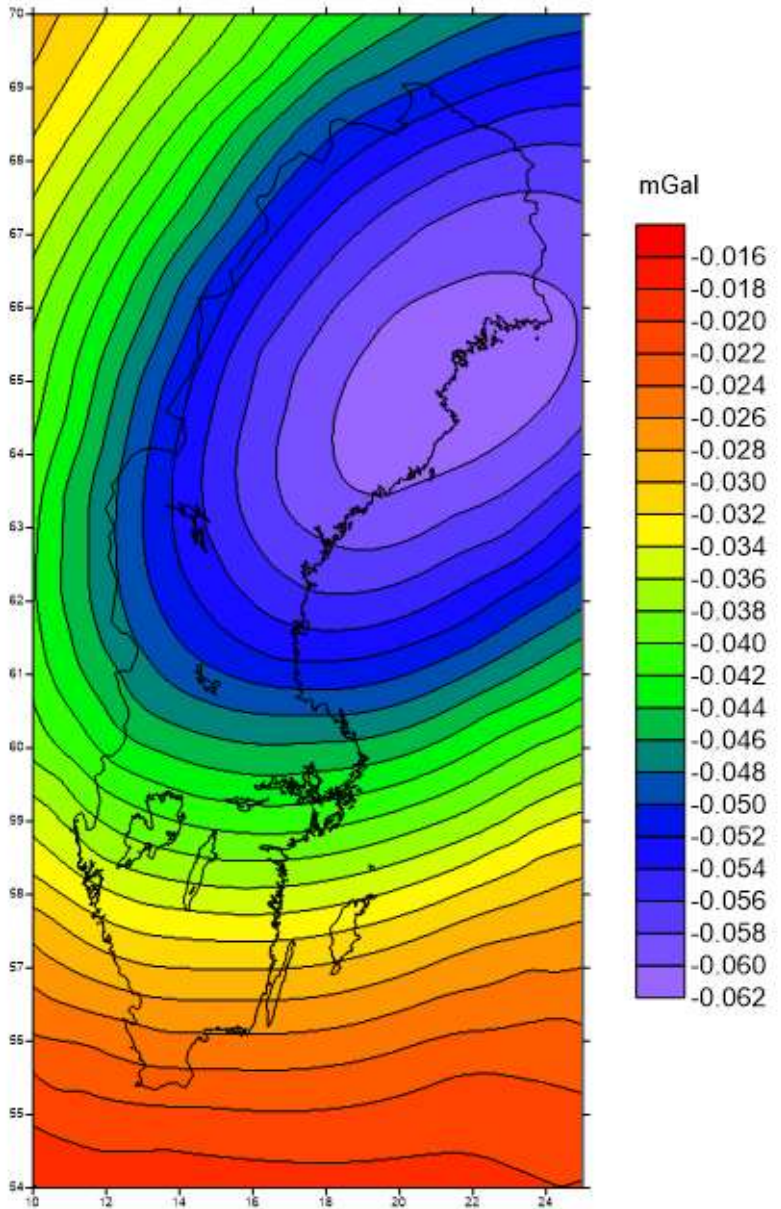
AG cross validation
9.0 µGal RMS



Estimated standard uncertainty
3.6 µGal RMS



RG 2000 - transformations



- Transformation from old RG 82 to RG 2000 is needed
- Apply correction for land uplift (2000-1982)
- Make 3 par fit using 1st order points of RG 82
- RMS of fit: 4.5 µGal (right)
- Direct correction grid (left) (-16 to -62 µGal)