Institut für Erdmessung

Present-day mass variations in Fennoscandia as determined from joint analysis of absolute gravity and GRACE data

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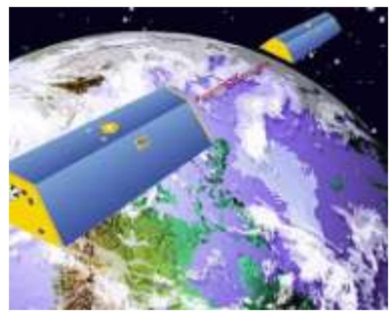


DFG Priority program SPP 1257:
Mass distribution and mass transport in the Earth system

Centre of excellence:
Quantum Engineering and Space Time-Research

Introduction

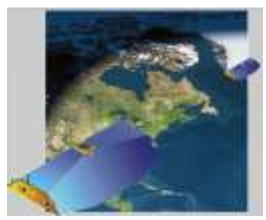
- GIA-induced effects are observed by geodetic techniques in Fennoscandia
- GRACE monthly solutions reflect the integral effect of mass variations in the atmosphere, hydrosphere and geosphere
- Absolute gravity and GPS campaigns have been run under the umbrella of the Nordic Geodetic Commission, also providing geometric features

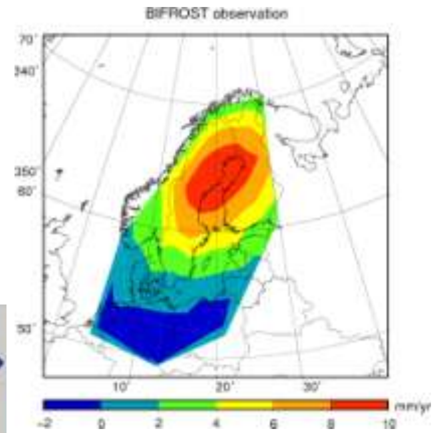
Observation of GIA-induced effects

Land uplift (1 cm / year)

Observed by

- GPS
- GRACE
- terrestrial gravimetry $\sigma_g = \pm\ 20\ nm/s^2$





BIFROST GPS network,
Lidberg et al. (2007)

Analysis of GRACE monthly solutions

General strategy for the computation of trends:

a) Computation of grid values dg from spherical harmonic coefficients up to degree and order n

b) Filtering and synthesis of a time series of grids

c) Pixel-wise least-squares adjustment

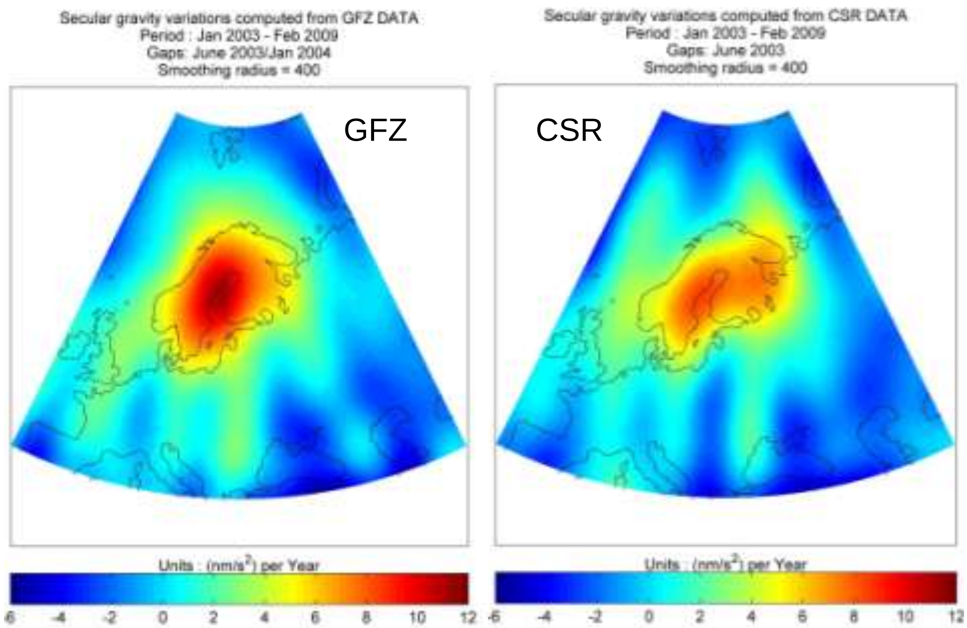
$$dg(\varphi,\lambda,t) = A + B\,t + \sum_{i=1}^{k} C_i \cos(\omega_i\, t) + D_i \sin(\omega_i\, t)$$

trend periodic variations

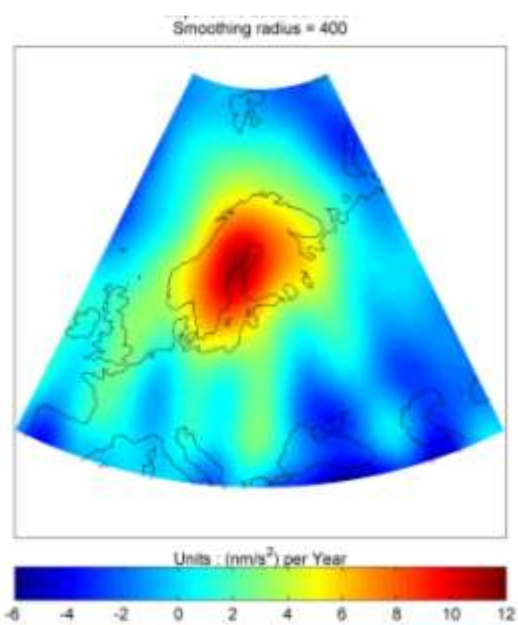
Which periods should be considered?

Also a quadratic term in time?

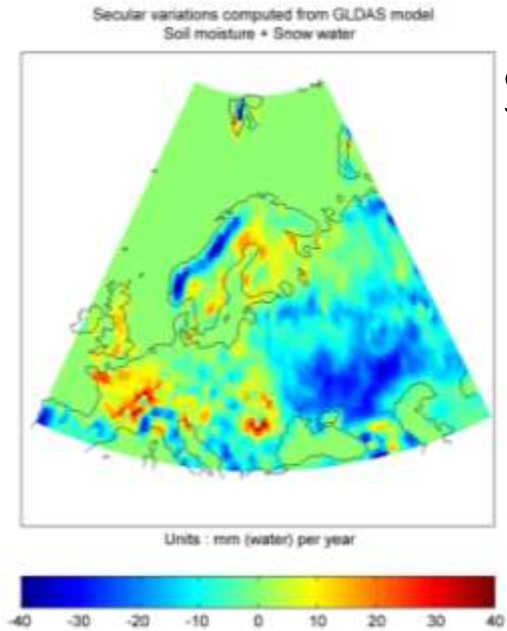
Secular trend in Fennoscandia



Comparison of different filter radii



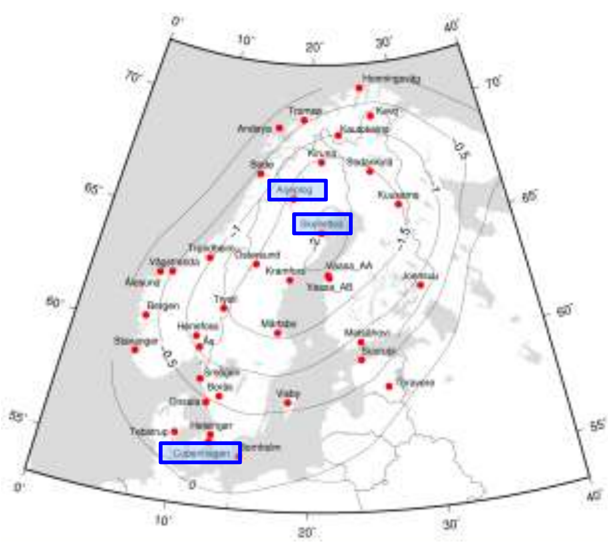
Possible hydrology contribution



GLDAS,
Jan. 2003 – Feb. 2009

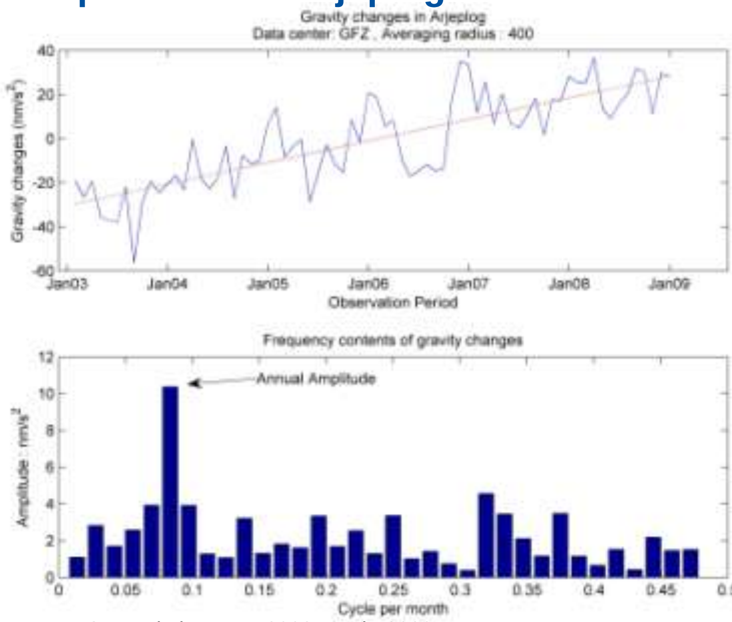
GRACE gravity variations at AG sites

FG5-220 from IfE (Photo: Gitlein)



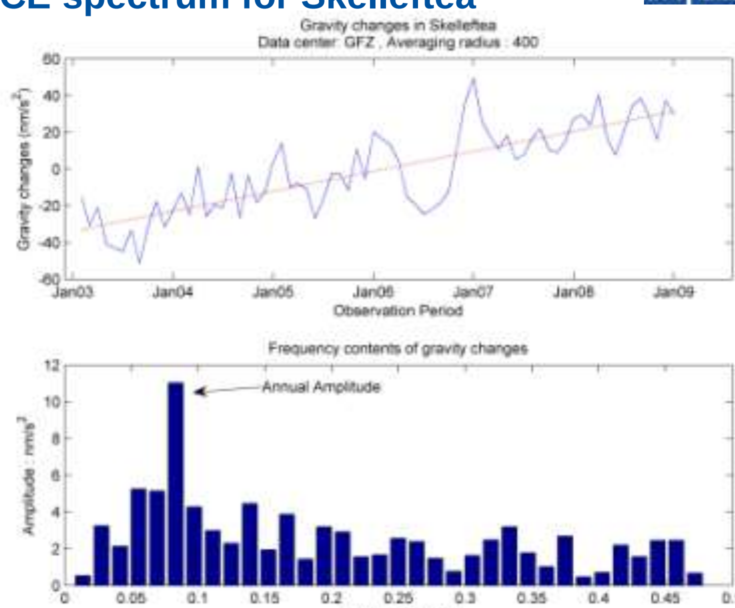
Gravity change after Ekman and Mäkinen (1996)

GRACE spectrum for Arjeplog



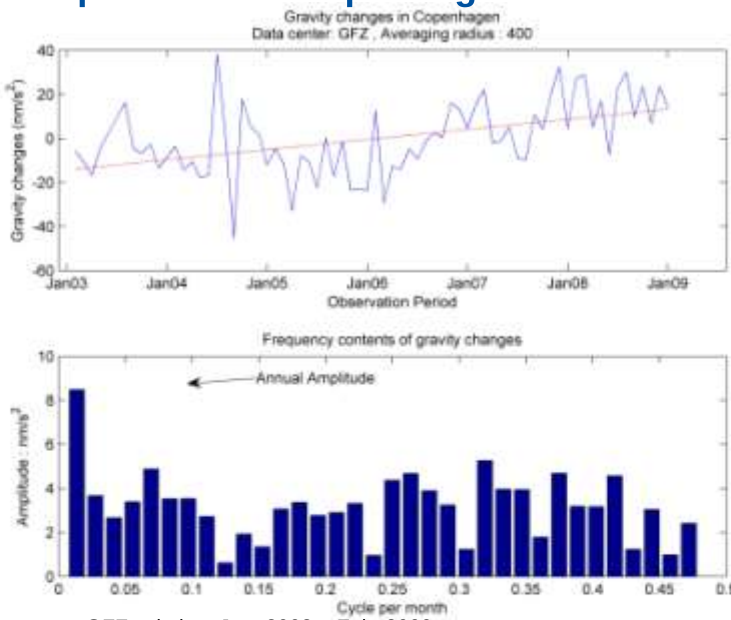
GFZ solution, Jan. 2003 – Feb. 2009

GRACE spectrum for Skelleftea



GFZ solution, Jan. 2003 – Feb. 2009

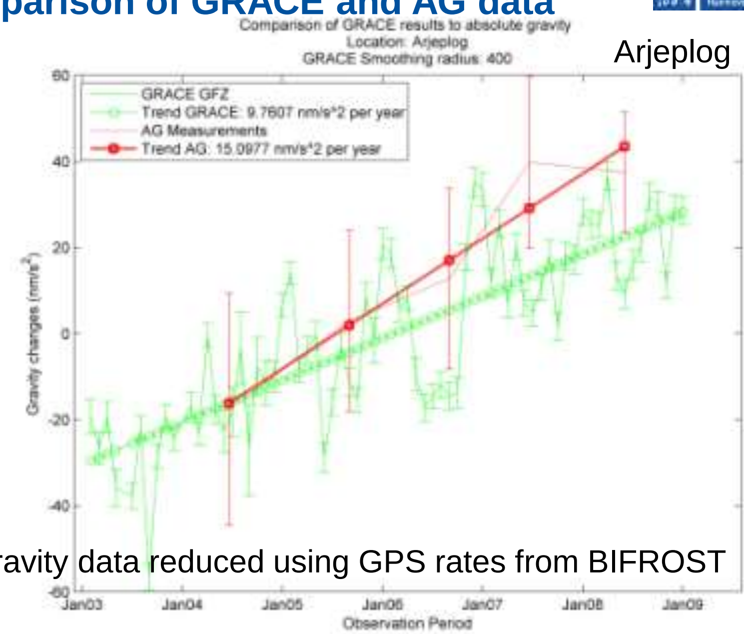
GRACE spectrum for Copenhagen



GFZ solution, Jan. 2003 – Feb. 2009

Comparison of GRACE and AG data

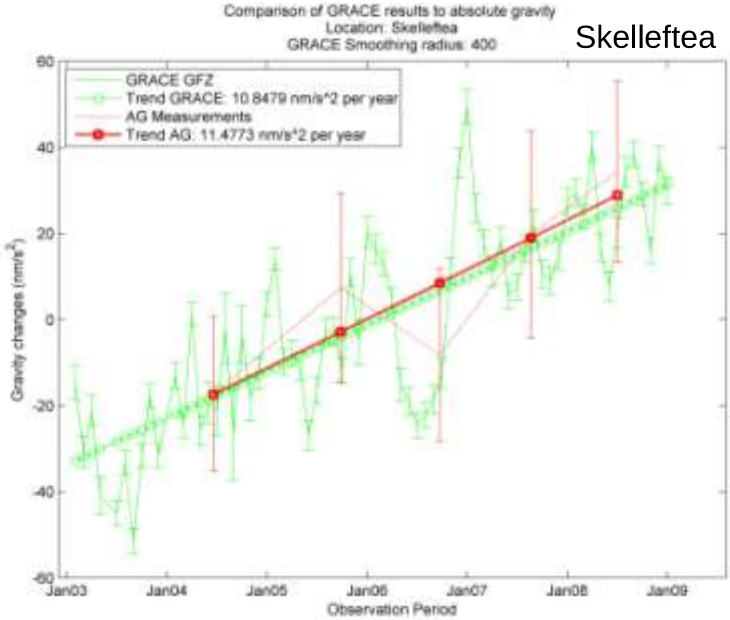
Arjeplog



AG gravity data reduced using GPS rates from BIFROST

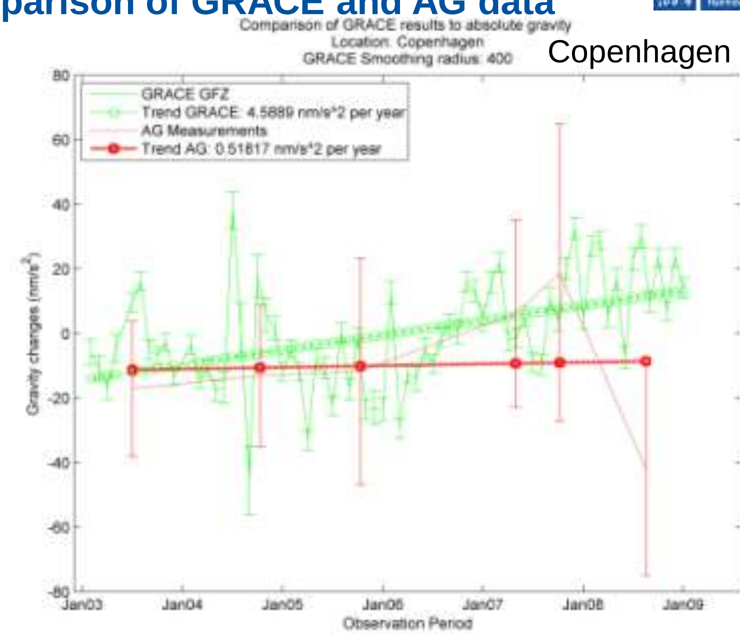
Comparison of GRACE and AG data

Skelleftea

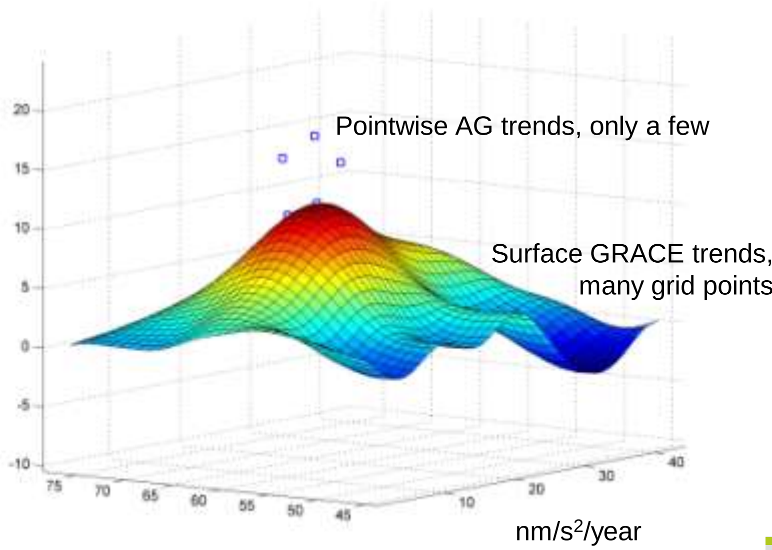


Comparison of GRACE and AG data

Copenhagen

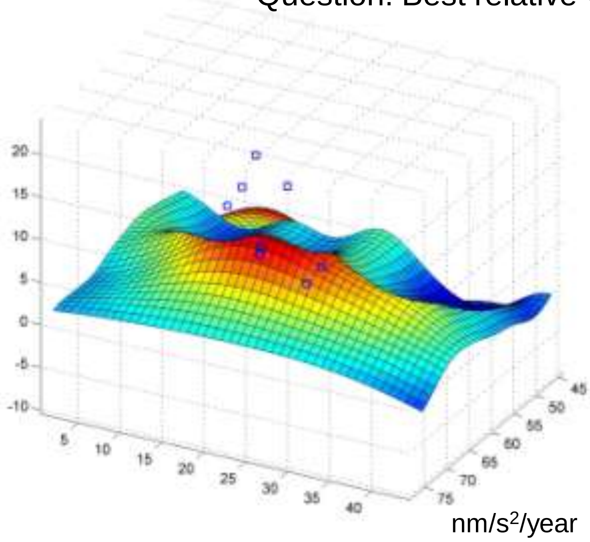


Combination of AG and GRACE, data

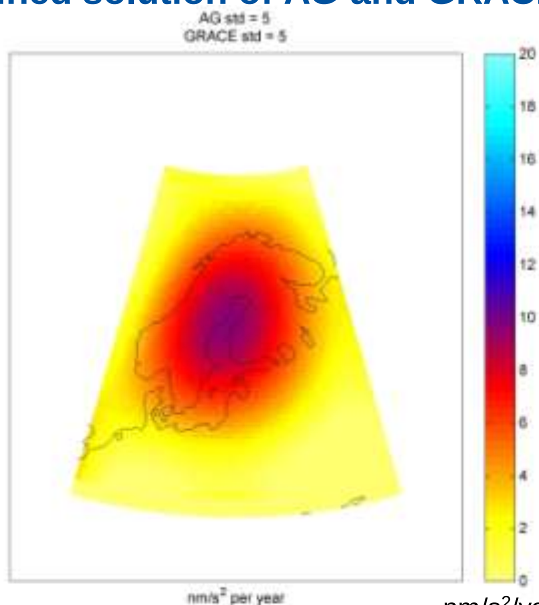


Combination of AG and GRACE, data

Question: Best relative weighting?

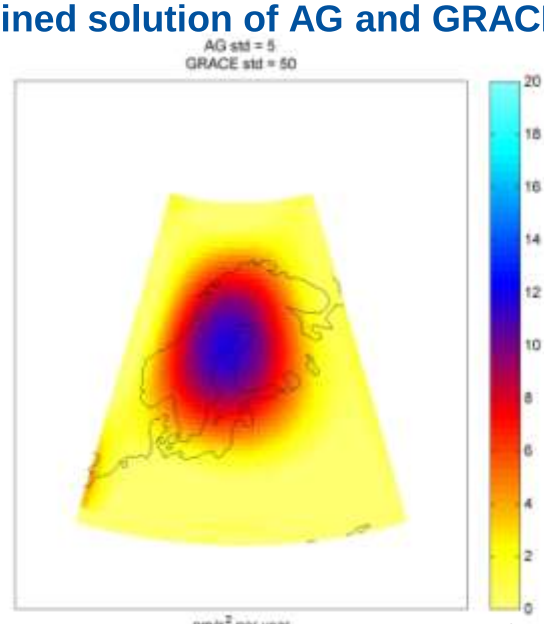


Combined solution of AG and GRACE



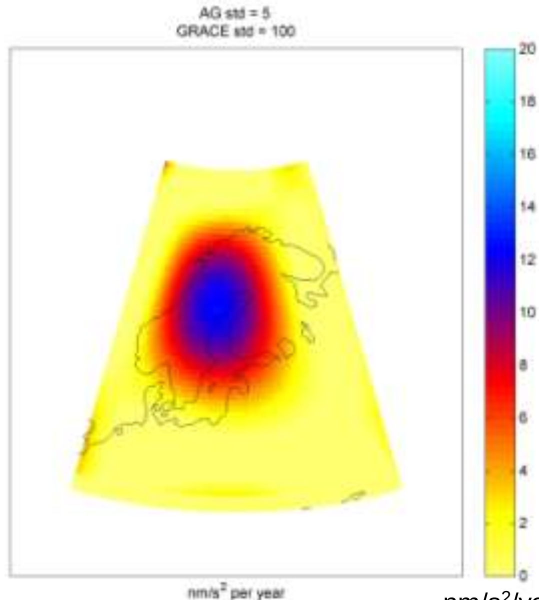
nm/s²/year

Combined solution of AG and GRACE



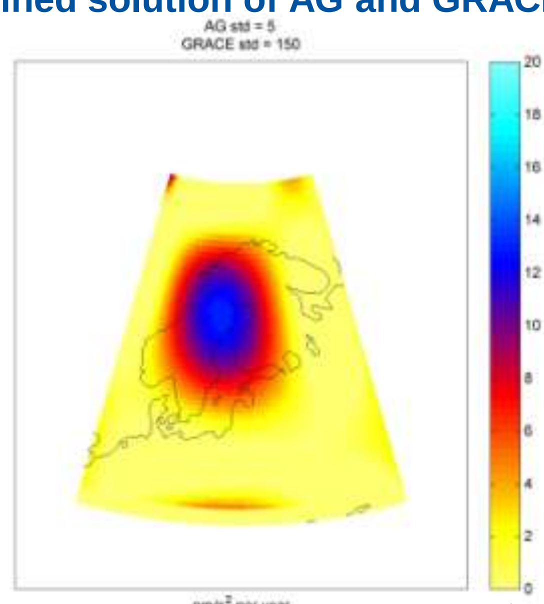
nm/s²/year

Combined solution of AG and GRACE



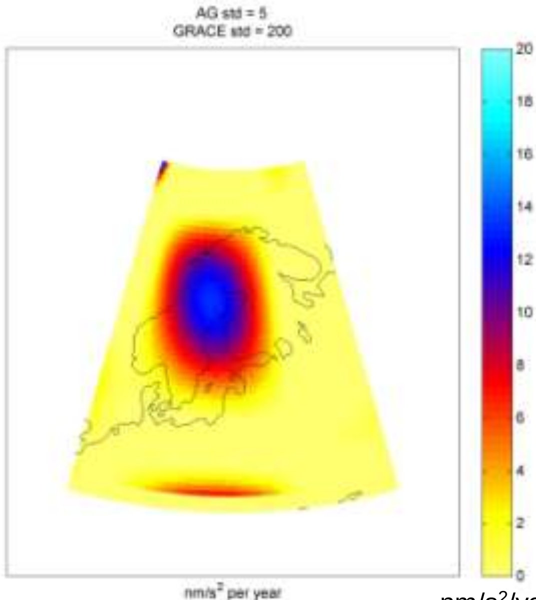
nm/s^2/year

Combined solution of AG and GRACE



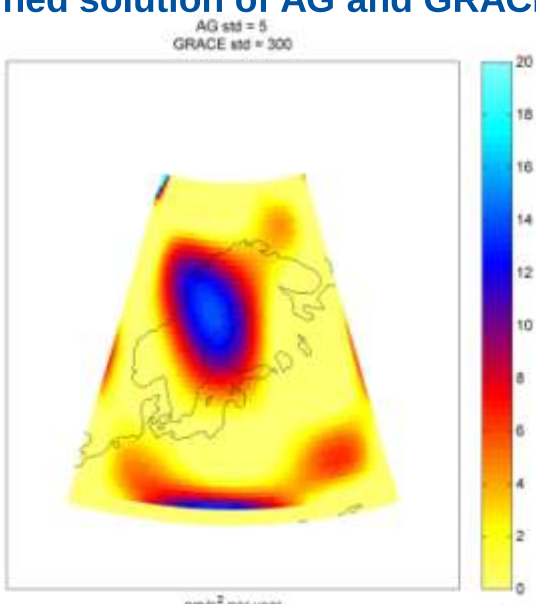
nm/s^2/year

Combined solution of AG and GRACE



nm/s²/year

Combined solution of AG and GRACE



nm/s²/year

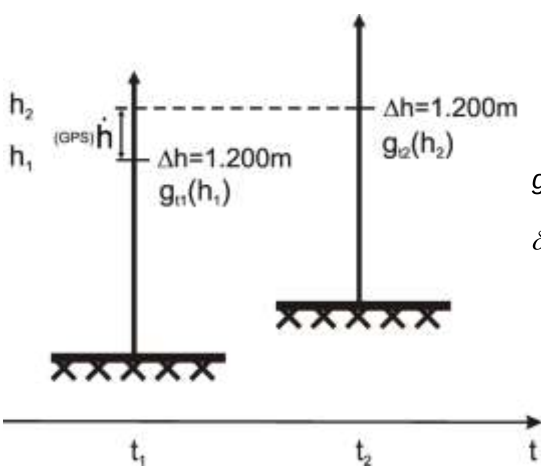
Conclusions

- GIA signature is significant in GRACE data, up to 11 nm/s^2/year for Fennoscandia
- Uplift centre and shape comparable with terrestrial measurements such as GPS and AG
- Combined solution requires
  - more AG data
  - consistent pre-processing (hydrology)
  - relative weighting to be optimised

More data and refined modelling helpful!

Conversion of gravity and height changes

Change of gravity disturbance:



Geoid change:

$$\dot{N} = \frac{R}{4\pi\gamma}\iint_{\sigma} H(\psi)\left(\dot{g} + \frac{2\gamma}{r}\dot{h}\right)d\sigma$$

gravity disturbance

$$g_{t1}(h_2) = g_{t1}(h_1) + \frac{\partial g}{\partial h}\dot{h}$$

$$\delta\dot{g} = g_{t2}(h_2) - g_{t1}(h_2)$$

Example:

$\dot{h} = 1.0$ cm

$g_{t2}(h_2) - g_{t1}(h_1) = -2.0\,\mu\text{Gal}$

$\frac{\partial g}{\partial h} = -3.0\,\frac{\mu\text{Gal}}{\text{cm}}$

$\delta\dot{g} = +1.0\,\mu\text{Gal}/\Delta t$

Comparison of GRACE and AG data

Vaasa