Institut für Erdmessung

Mass Variations in Fennoscandia from GRACE

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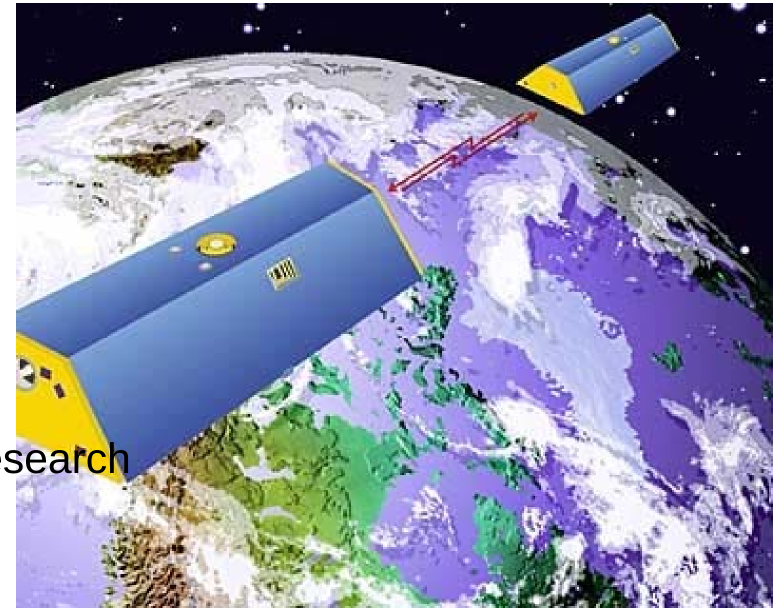
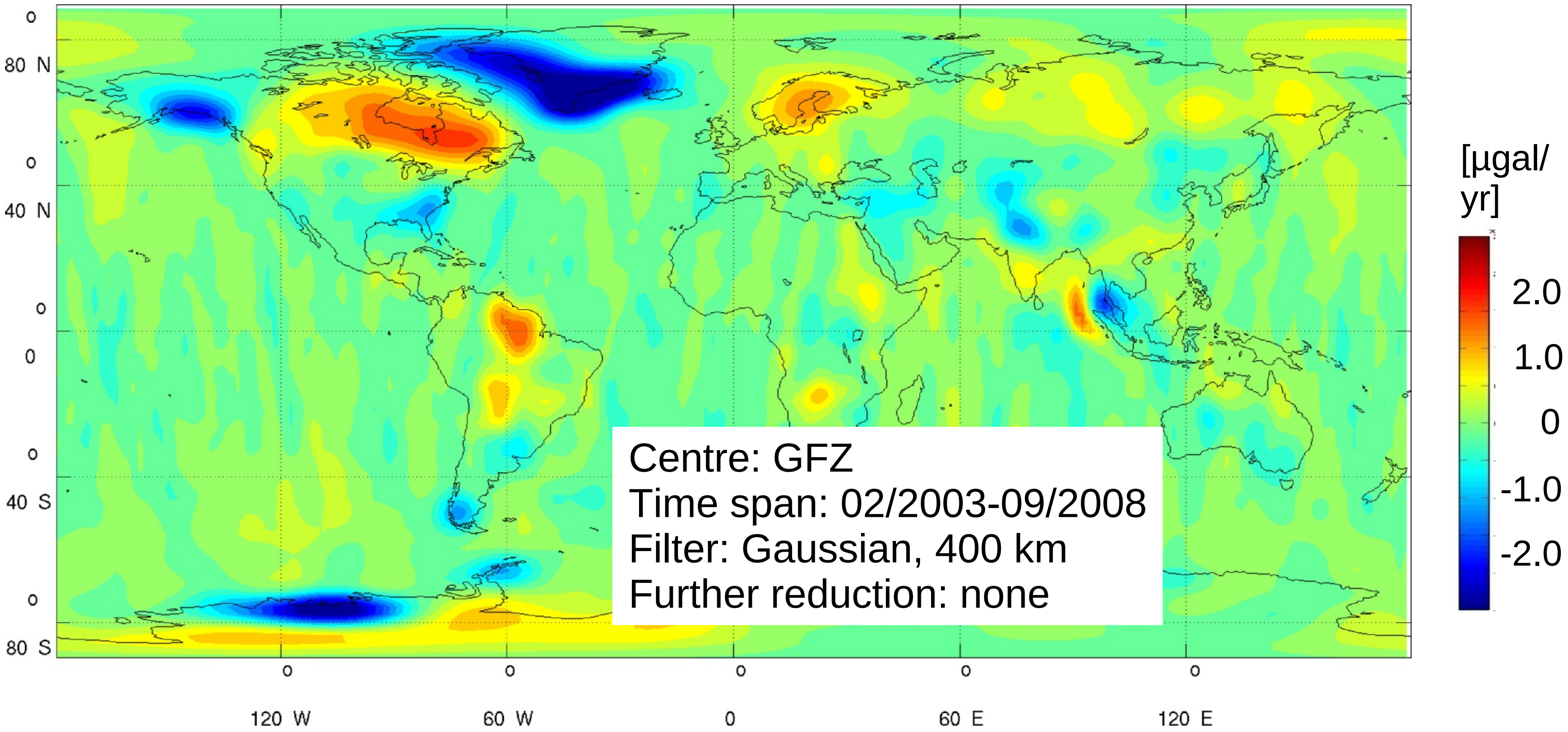
DFG Priority program SPP 1257:
Mass distribution and mass transport
in the Earth system

Centre of excellence:
Quantum Engineering and Space Time-Research



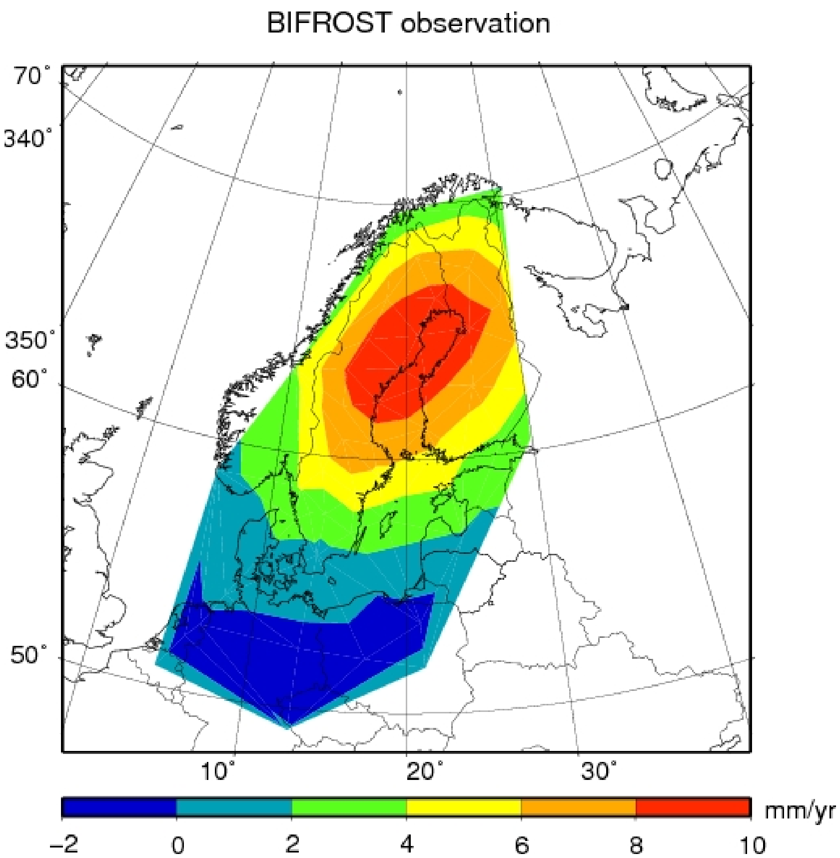
Secular trend of GFZ monthly solutions



Land uplift in Fennoscandia

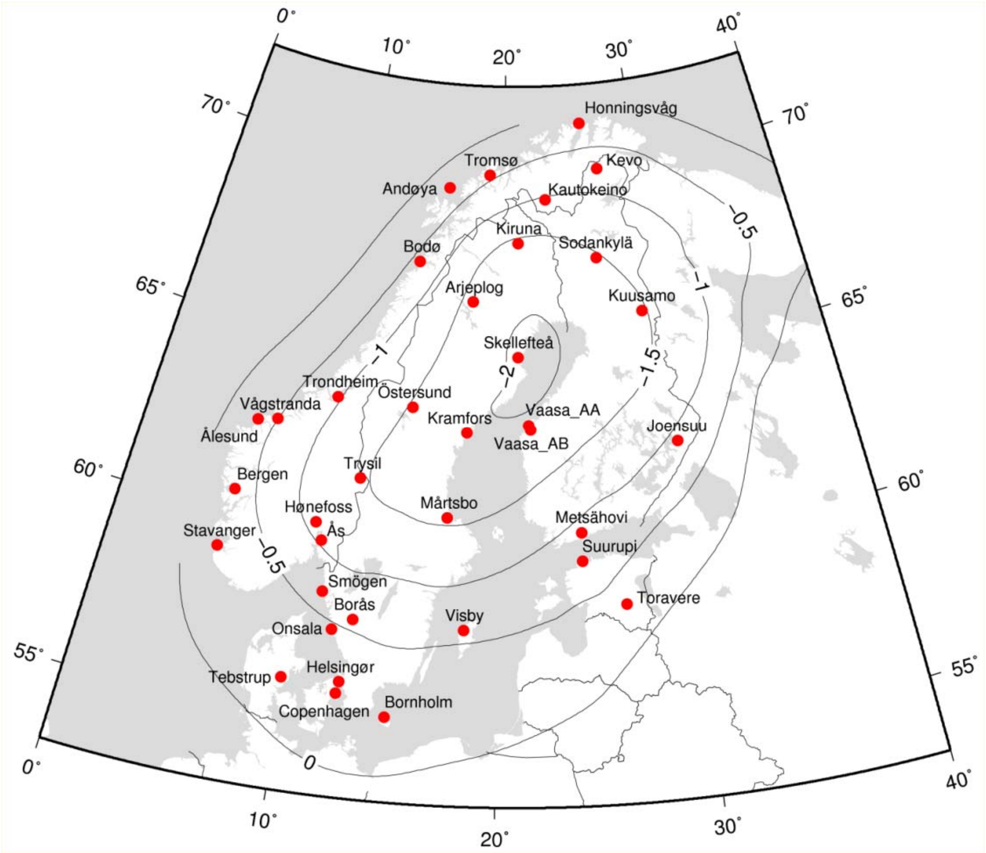
Leibniz Universität Hannover

BIFROST GPS network



max. measured uplift rate:
10.06 mm/year (at Umeå)
Lidberg et al. (2007)

Absolute gravity network

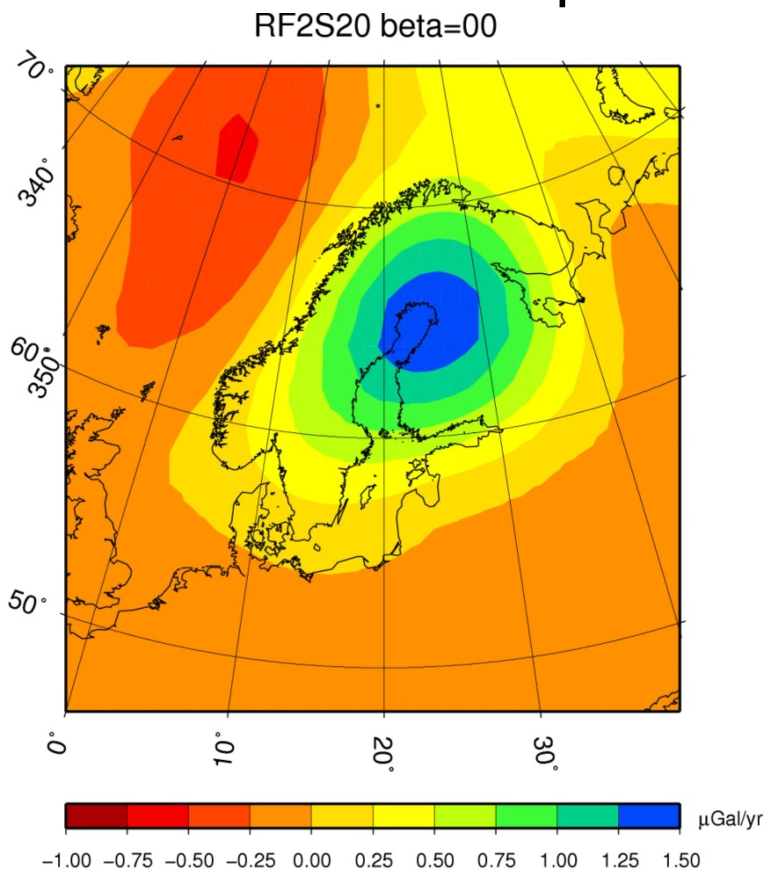


Gravity change
Ekman and Mäkinen (1996)

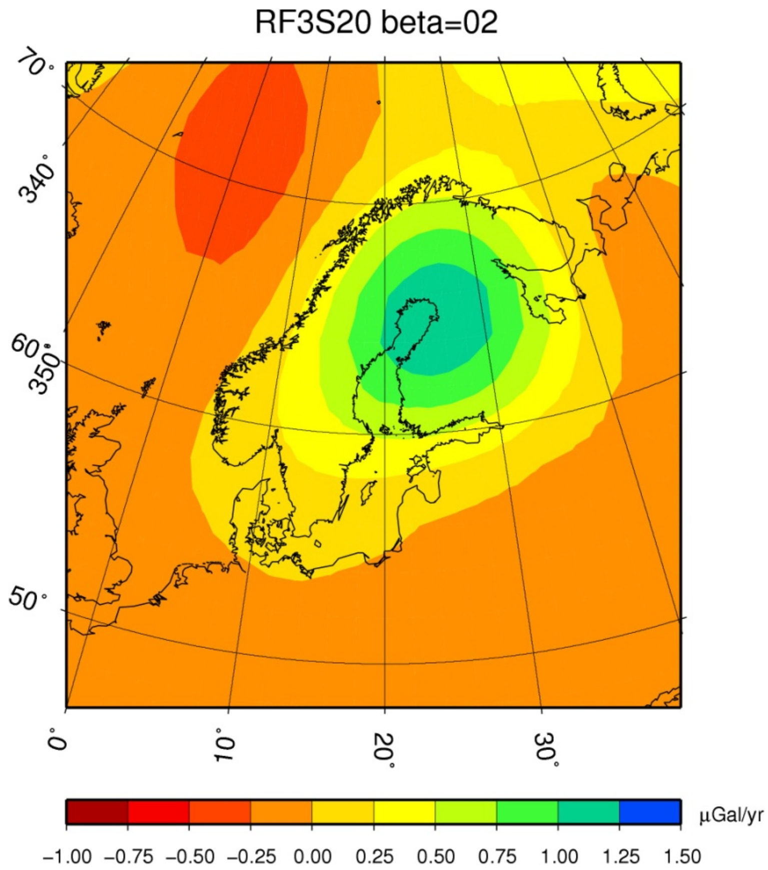
ife

Land uplift in Fennoscandia

3D Earth model output



Gravity change
Wu (pers. comm.)



Gravity change
Wang et al. (2008)

Introduction

- GRACE monthly solutions reflect mass variations in the atmosphere, hydrosphere and geosphere

- Different periodic signatures (e.g. seasonal, short and medium-term), but also long-periodic mass variations and secular trends

- Since 2002 solutions from 3 main analysis centres (CSR, GFZ, JPL)
- Other solutions: ITG (l_{max},m_{max}=40), CNES (l_{max},m_{max}=50)

- Time-variable atmospheric and oceanic effects and tides already reduced using background models

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

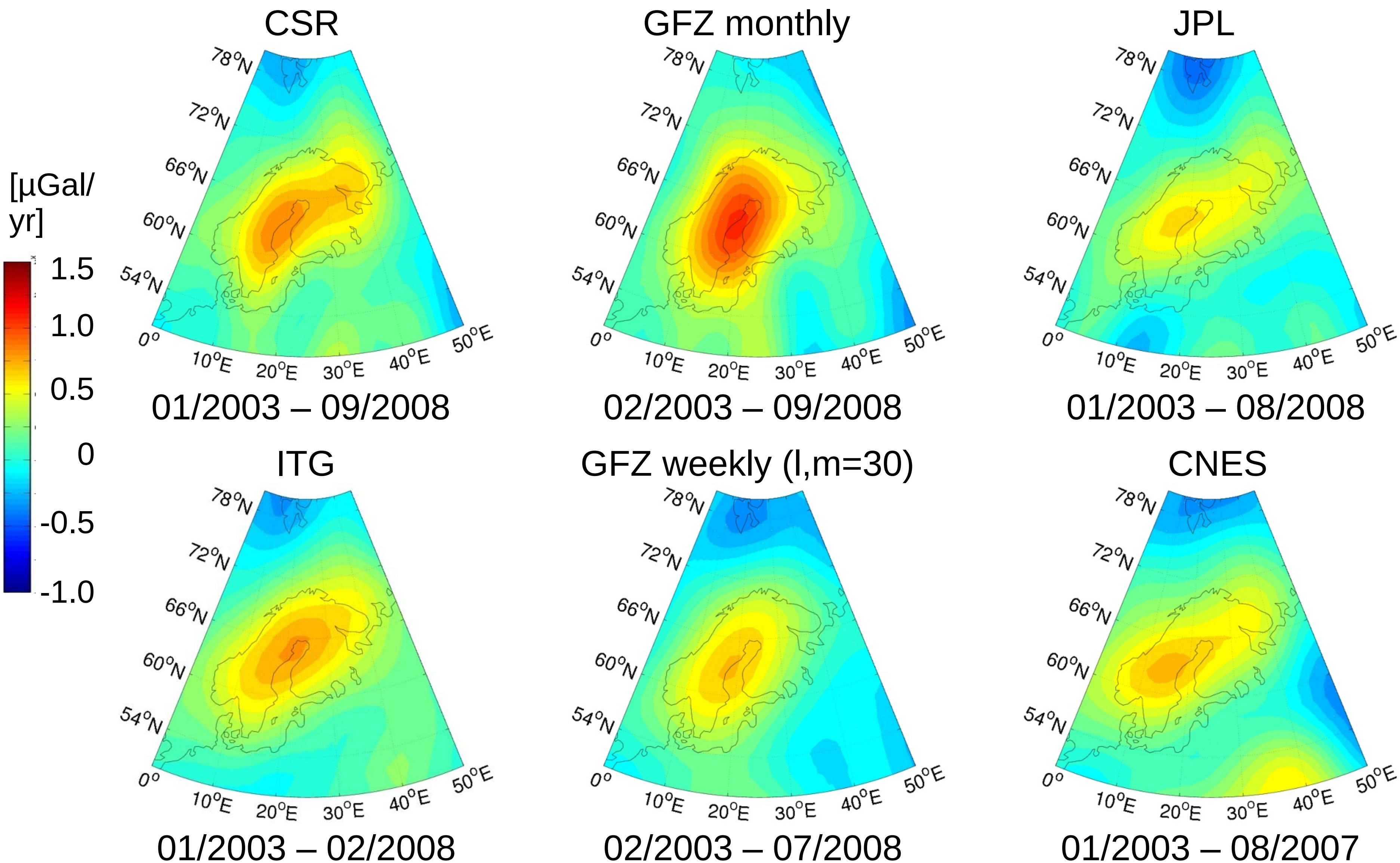
c) Pixel-wise least-squares adjustment

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

trend periodic variations

Which periods should be considered?

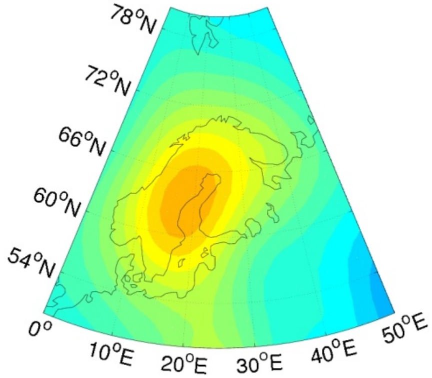
Secular trend of monthly solutions



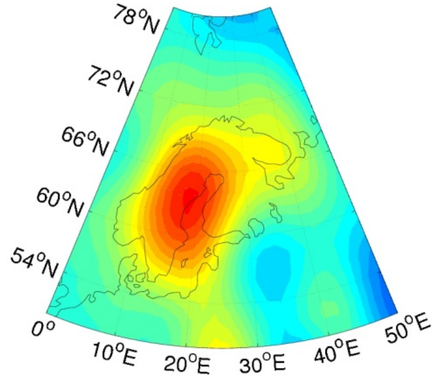
Gauss filter: 400 km

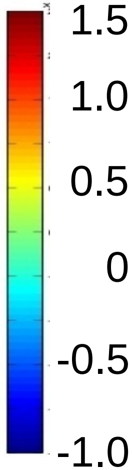
Comparison of filter techniques

isotropic Gaussian
530 km

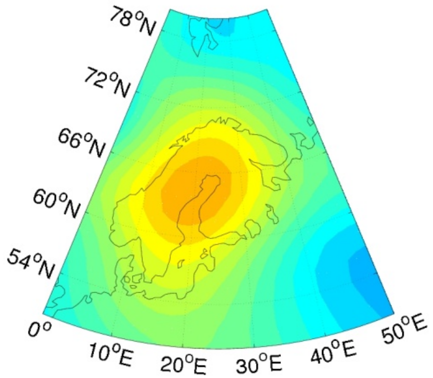


isotropic Pellinen
530 km

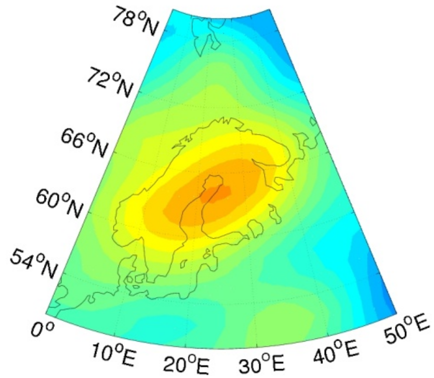




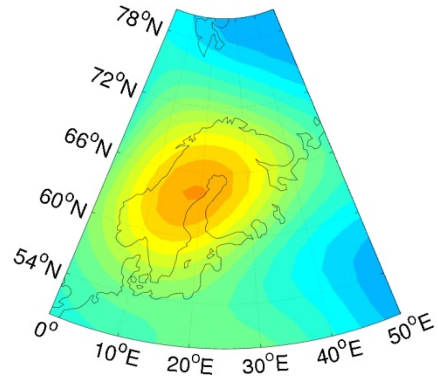
non-isotropic Gaussian
340/680 km, m1=15
(Han et al. 2005)



correlated
error filter
(Swenson & Wahr 2006)

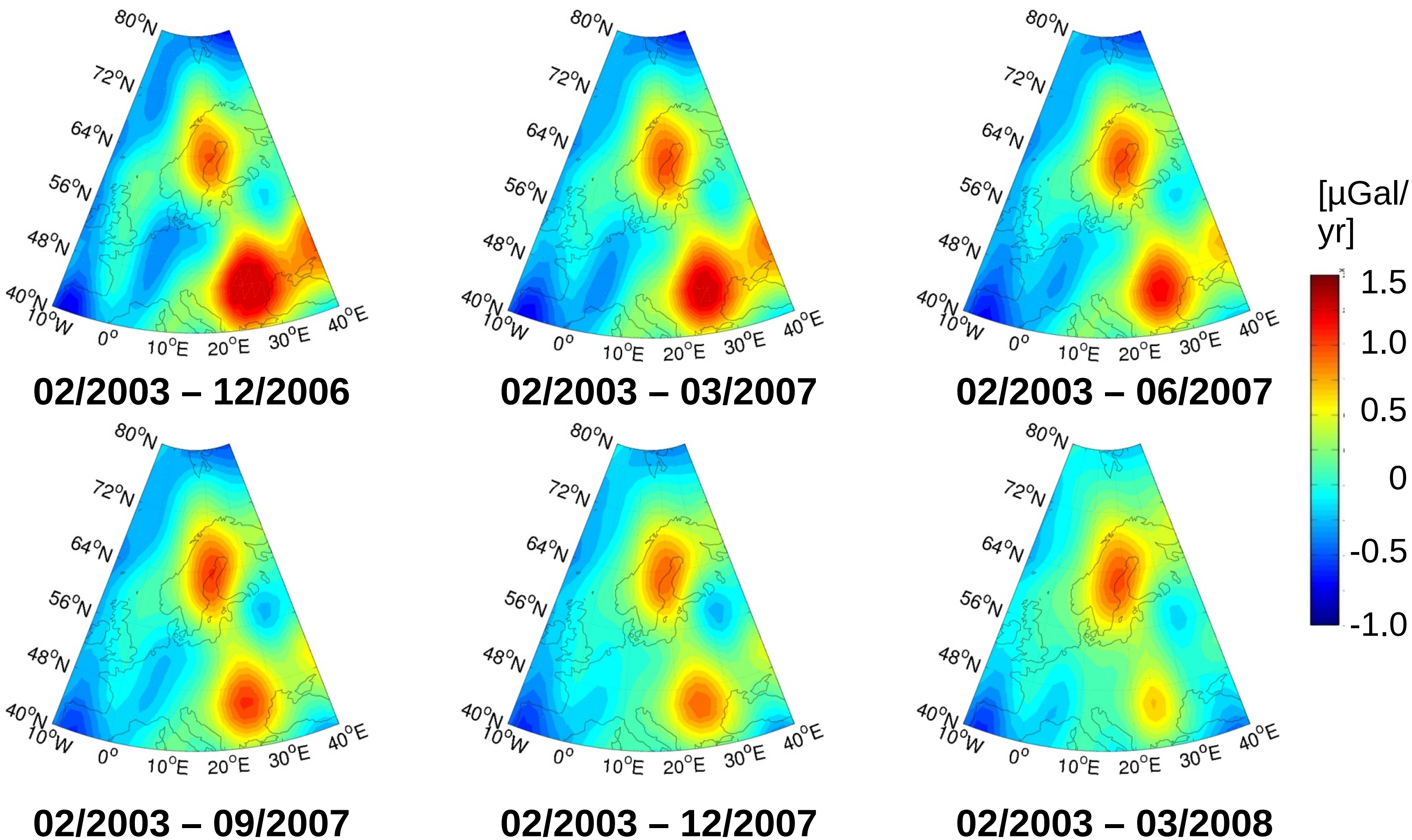


non-isotropic decorrelation
filter DDK1
(Kusche et al., 2008)



GFZ solution (02/2003 - 05/2008)

Effect of different time spans



GFZ solution, Gauss filter: 400 km

Spectral analysis – Chandler period?

Results of the frequency analysis

	Gauss 500	DDK1	DDK2	DDK3
1.	annual (57%)	annual (68%)	annual (65%)	annual (49%)
2.	424 d (5.6%)	424 d (5.2%)	2.7 a (4.5%)	431 d (3.9%)
3.	2.3 a (4.7%)	2.2 a (4.7%)	433 d (3.9%)	2.7 a (3.0%)

DDK – Filters of Kusche based on full covariance information

Found in all 4 cases: significant periodic variation with a period in range 424-434 days - ... also in the SH-coefficient C_{21} as well!

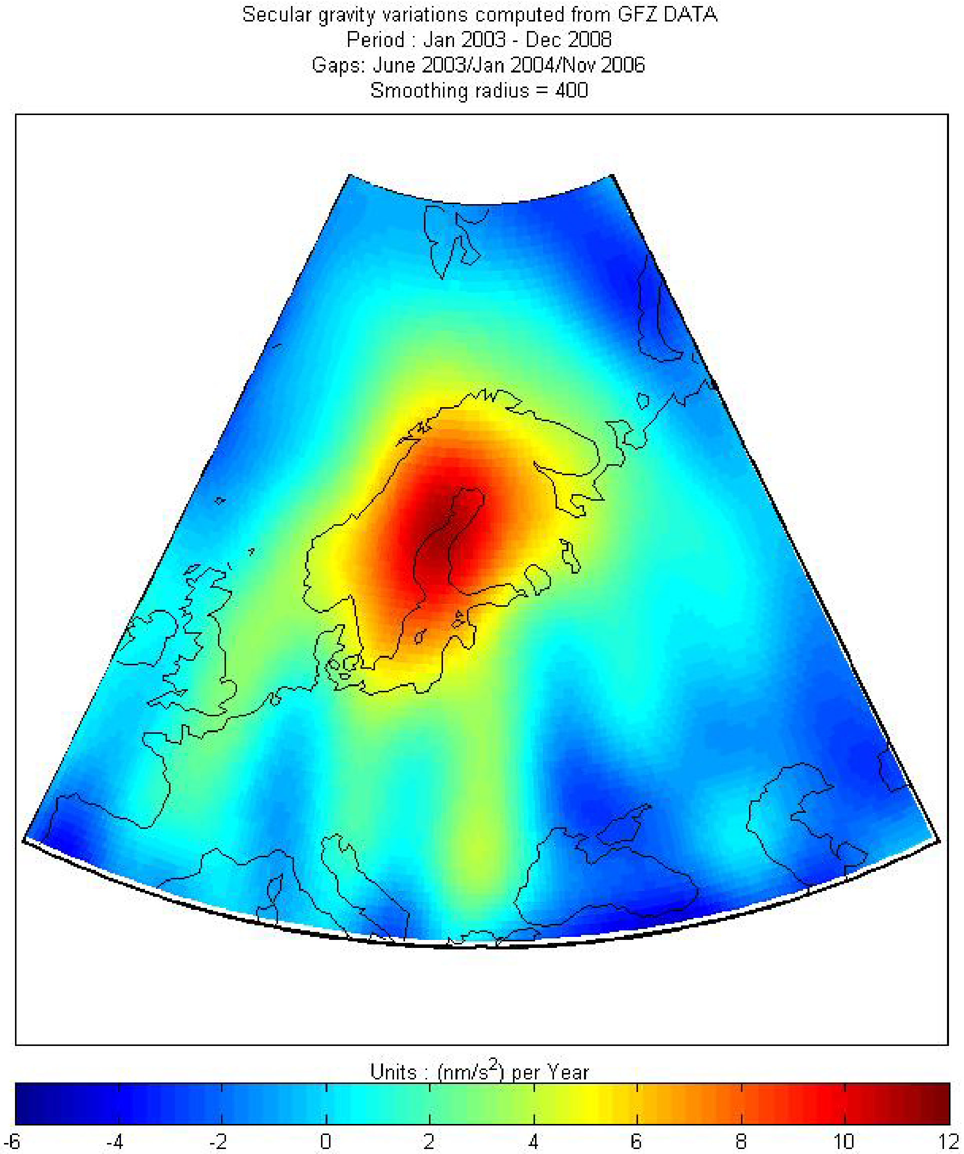
Coincidence of mass redistributions with a Quasi-Chandler period?

Can this period be considered as characteristic for considered region and interpreted physically?

Could also be a consequence of an imperfect realisation of the reference frame!

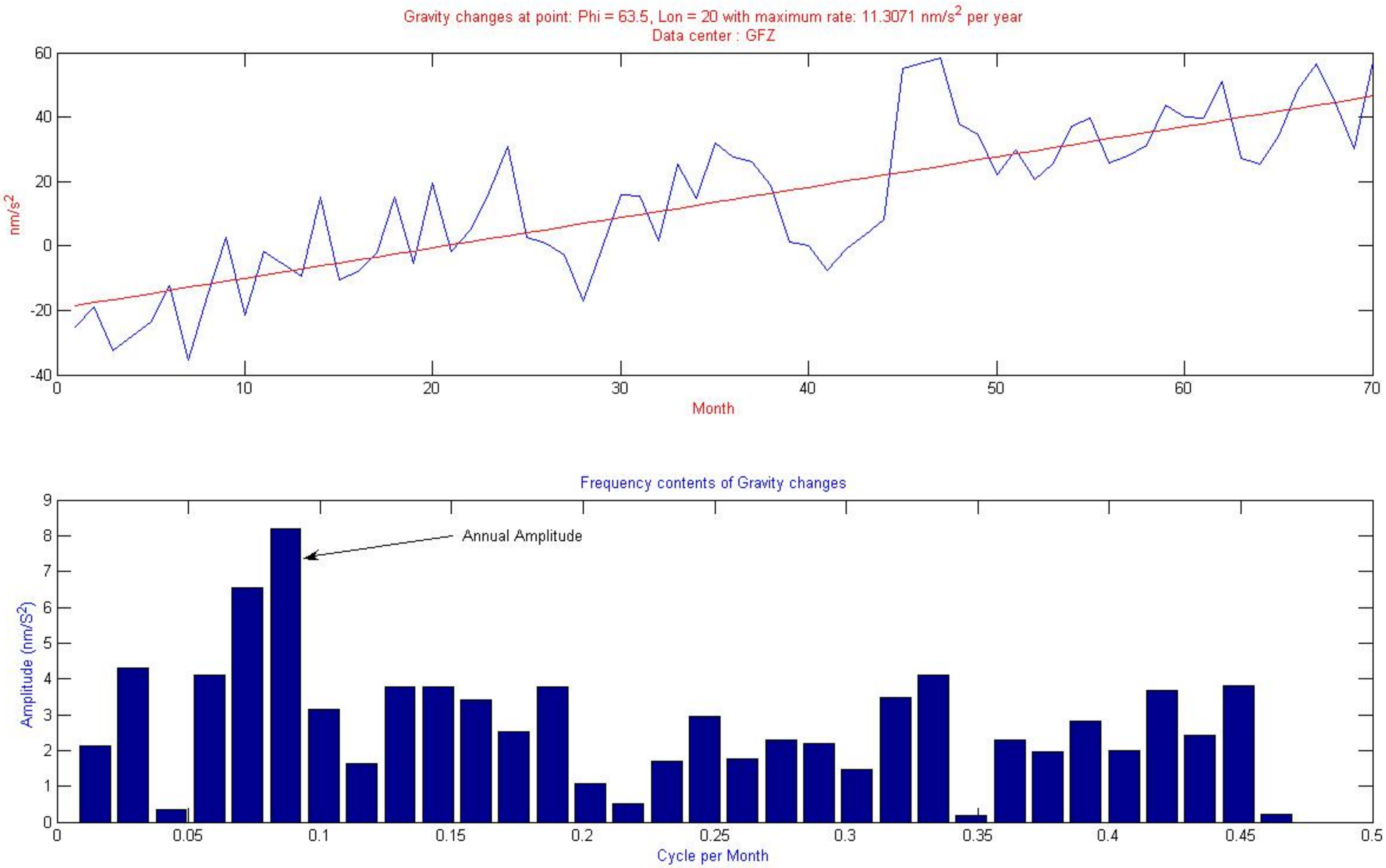
Study by GFZ: Petrovic/Kusche et al. 2008

Gravity change from GRACE soluti



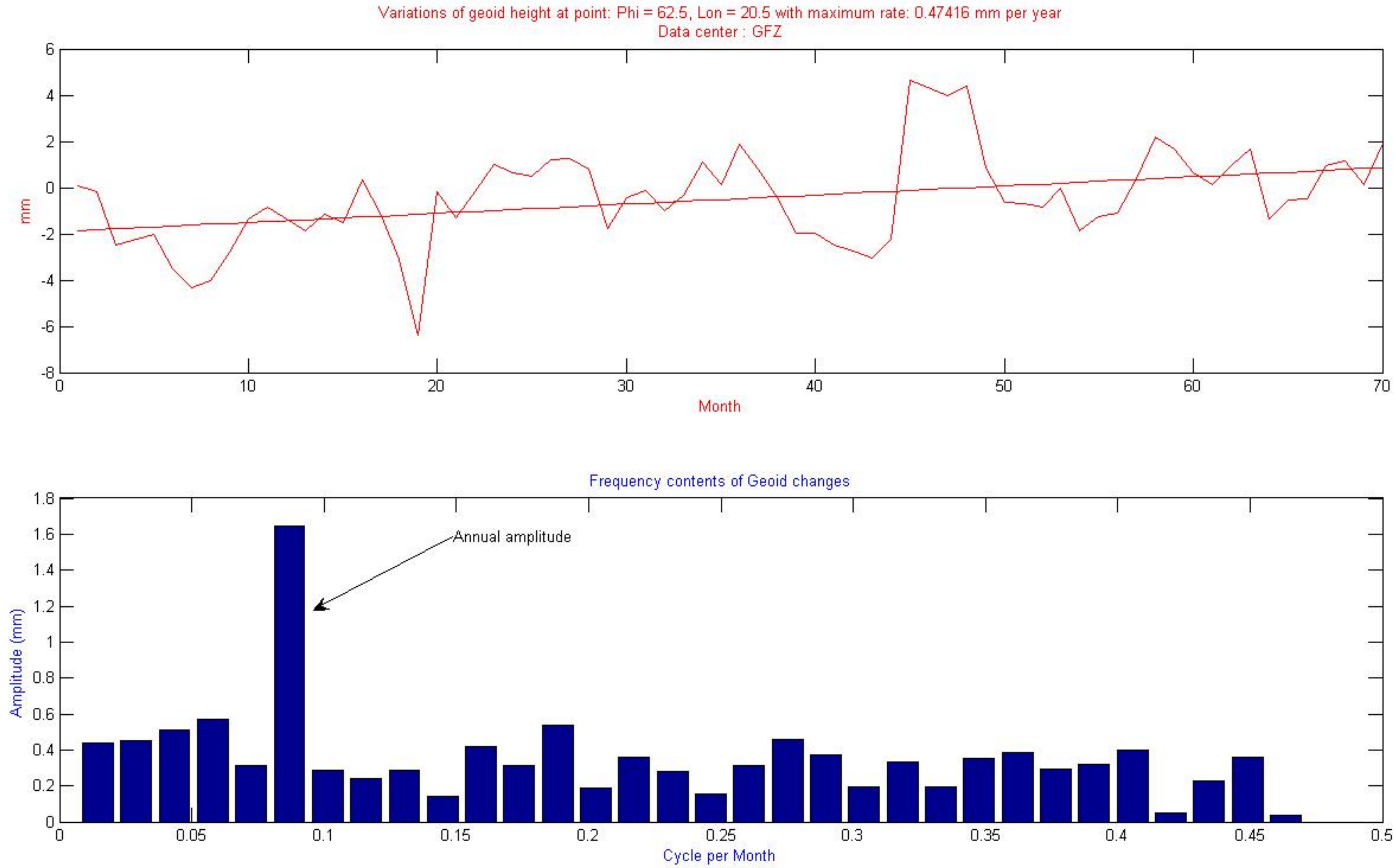
GFZ solution, Jan. 2003 – Dec. 2008, Gauss 400 km

Spectral analysis of GRACE



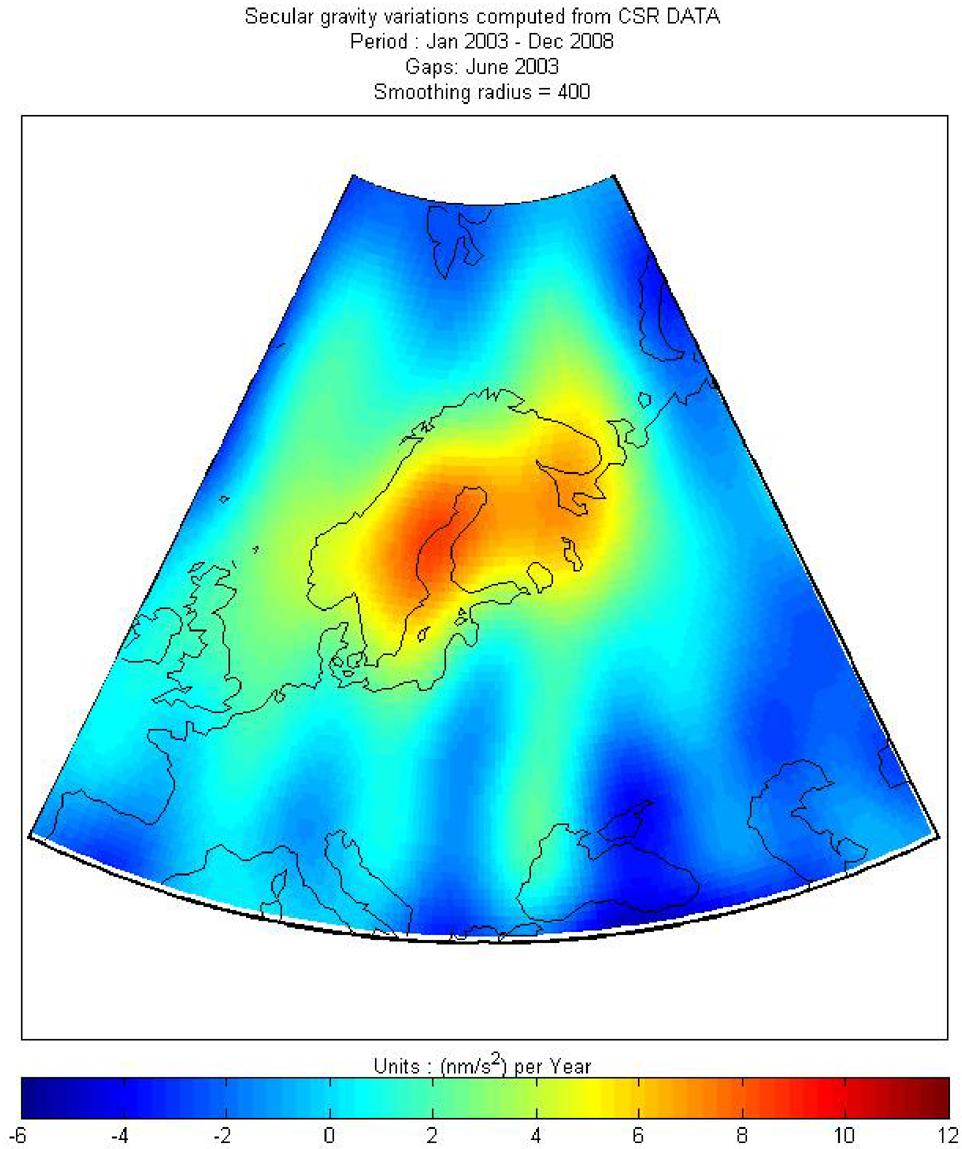
Gravity change at uplift center

Spectral analysis of GRACE



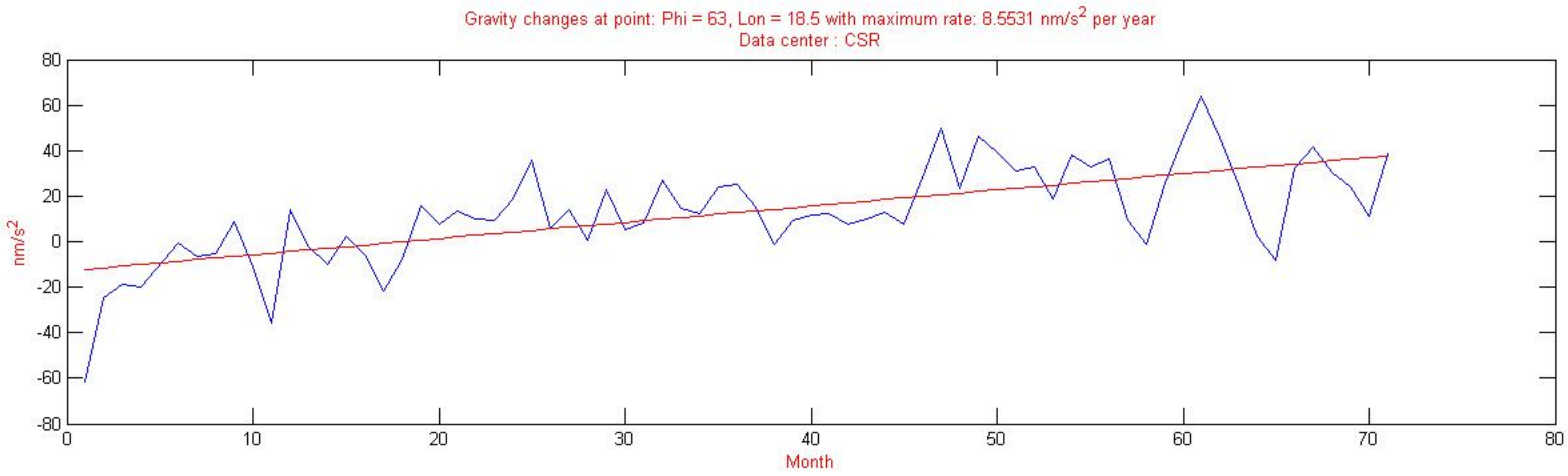
Geoid change at uplift center

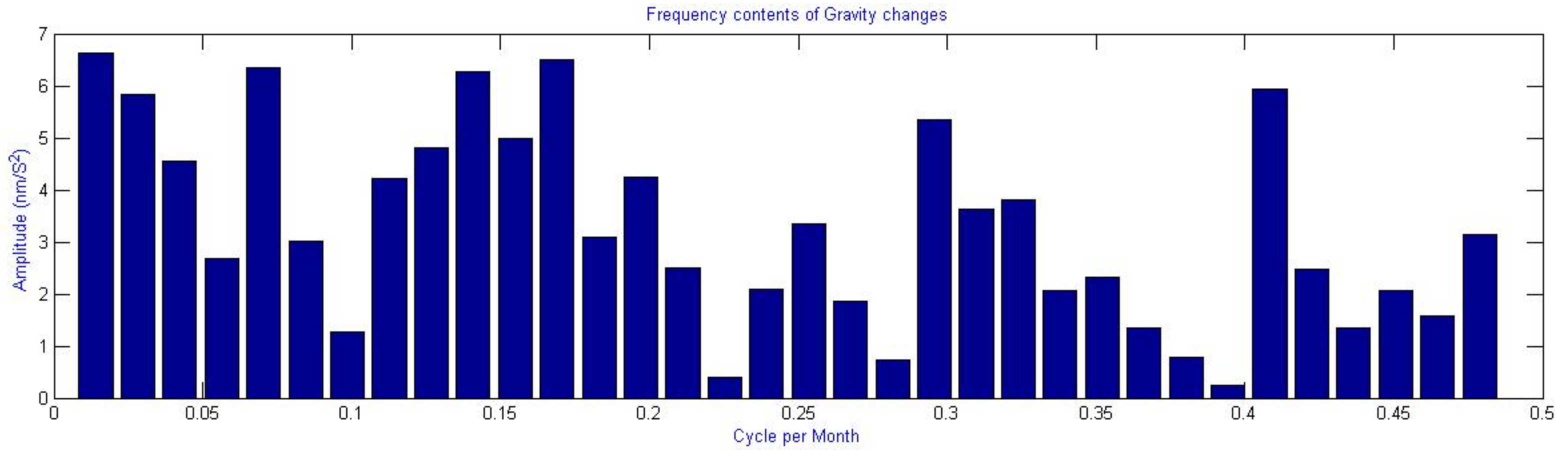
Gravity change from GRACE so



CSR solution, Jan. 2003 – Dec. 2008, Gauss 400 km

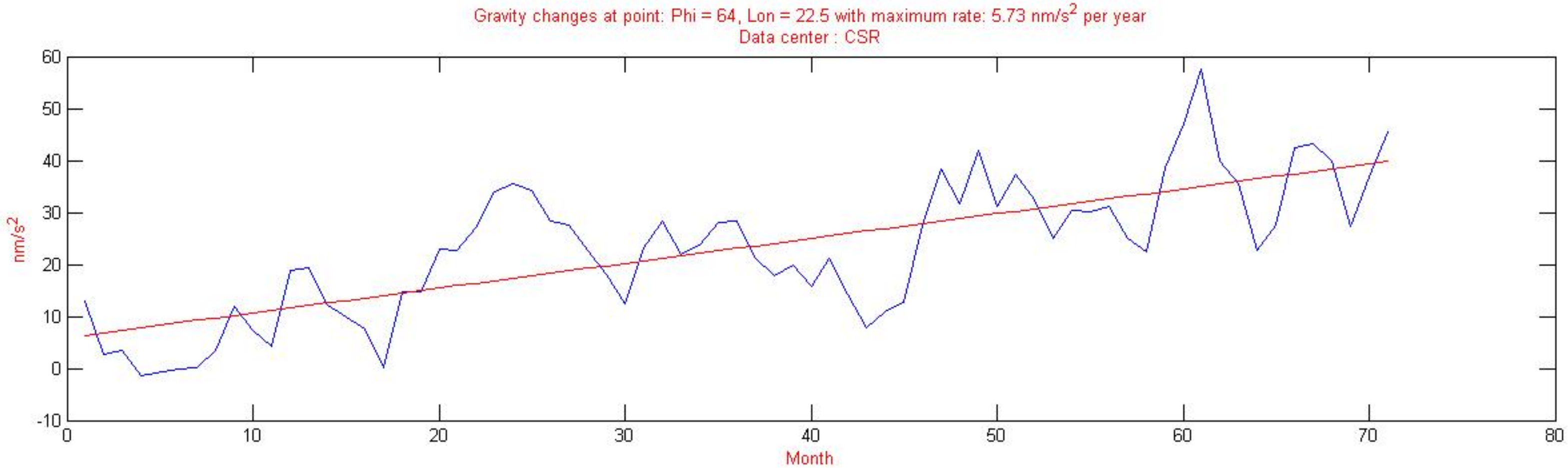
Spectral analysis of GRACE

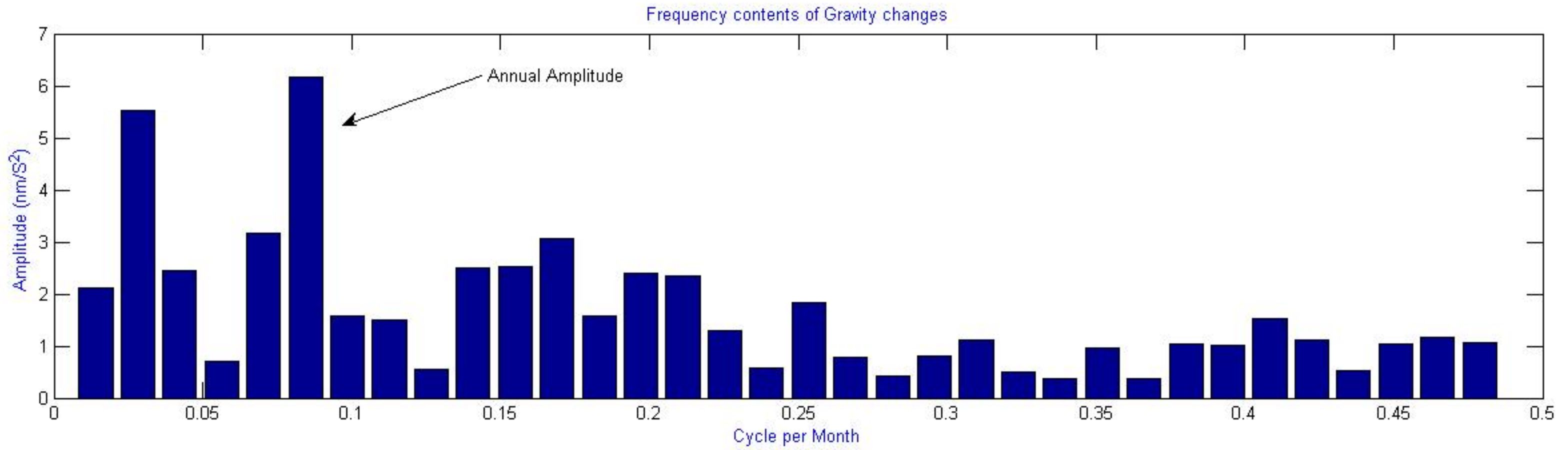




Gravity change at uplift center

Spectral analysis of GRACE

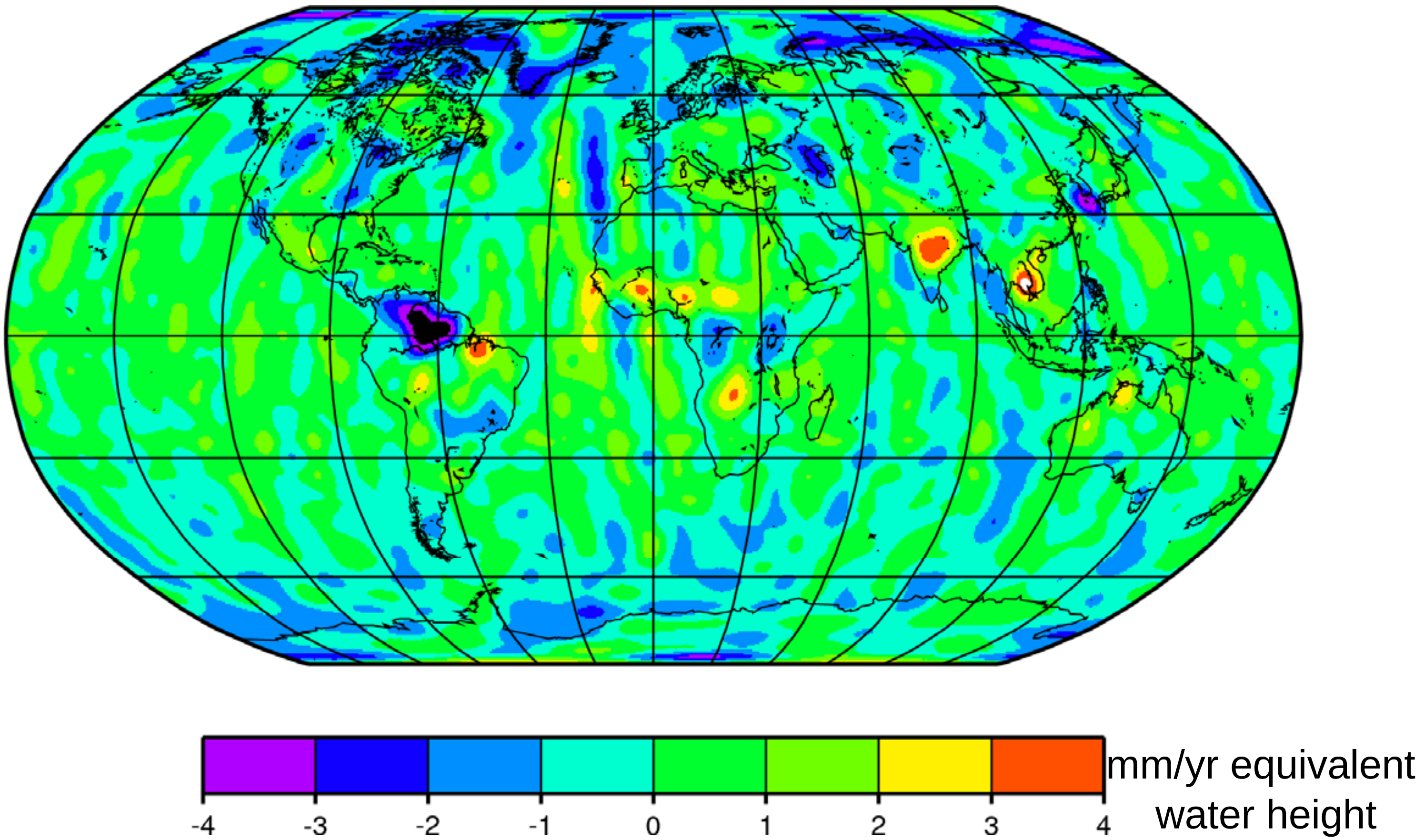




Gravity change at uplift center

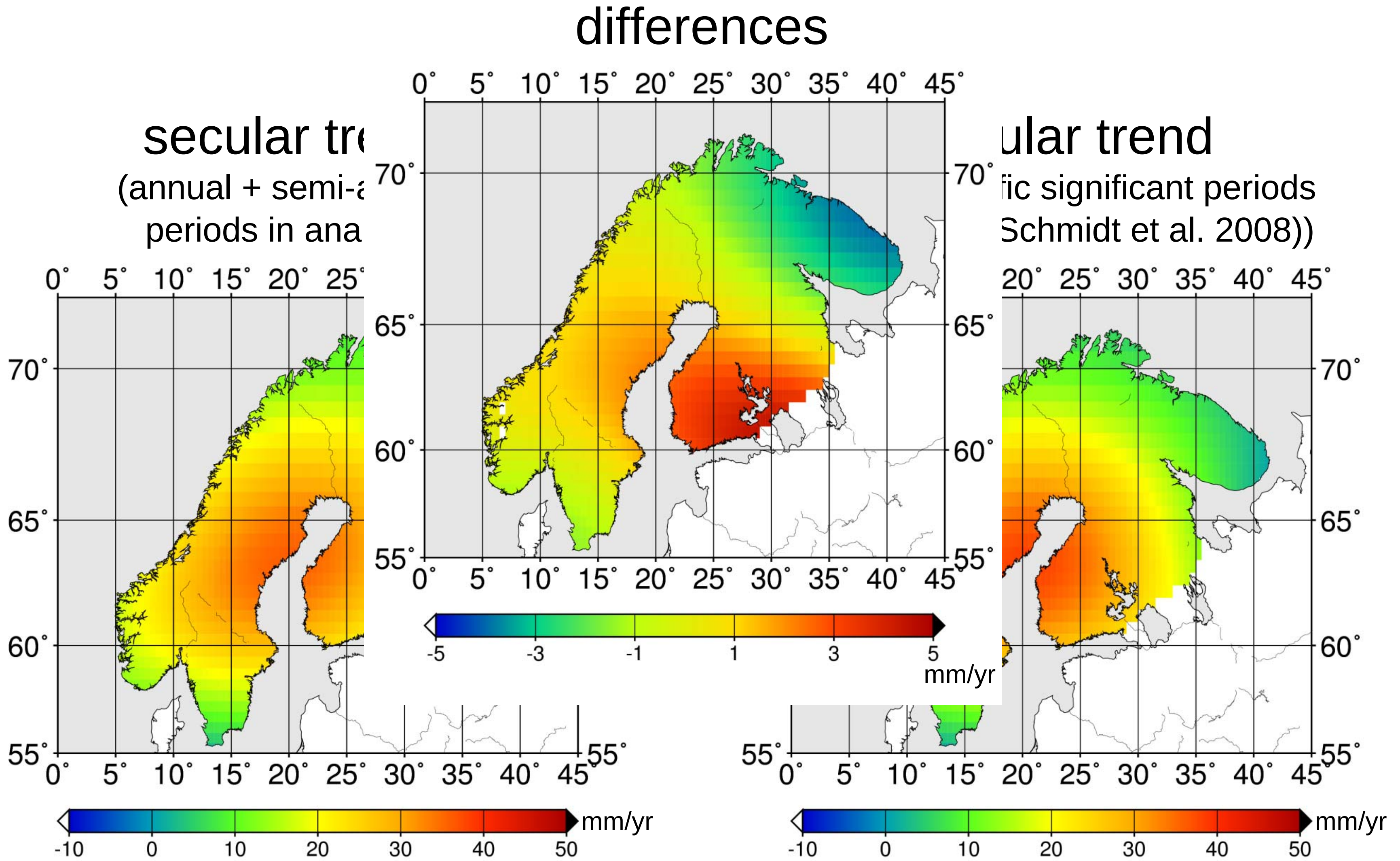
Analysis of GRACE monthly solutions

Differences in resulting secular trend when simultaneously considering annual + semi-annual periods or annual only



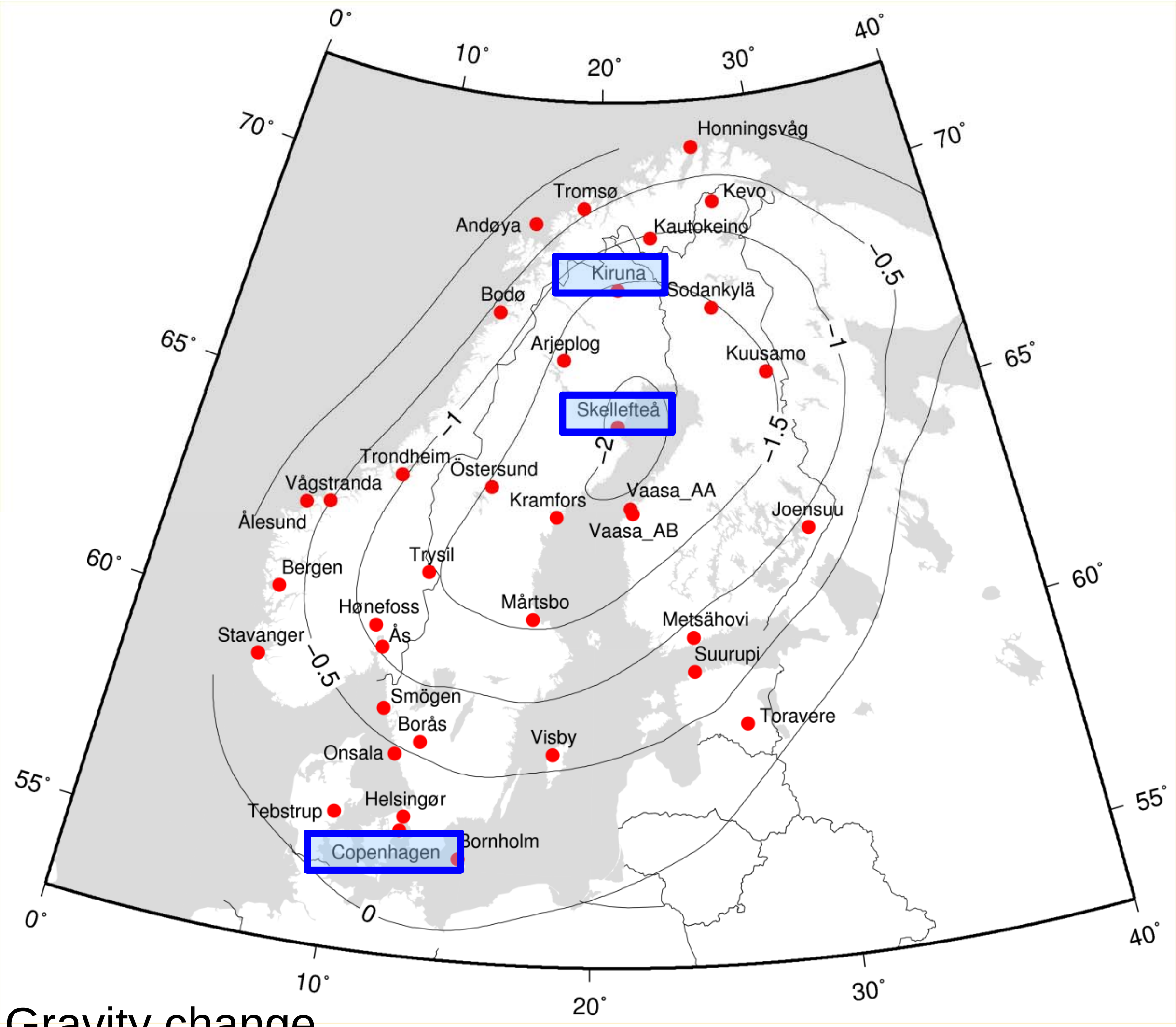
GFZ solution, DDK3 filter

Analysis of GRACE monthly solutions



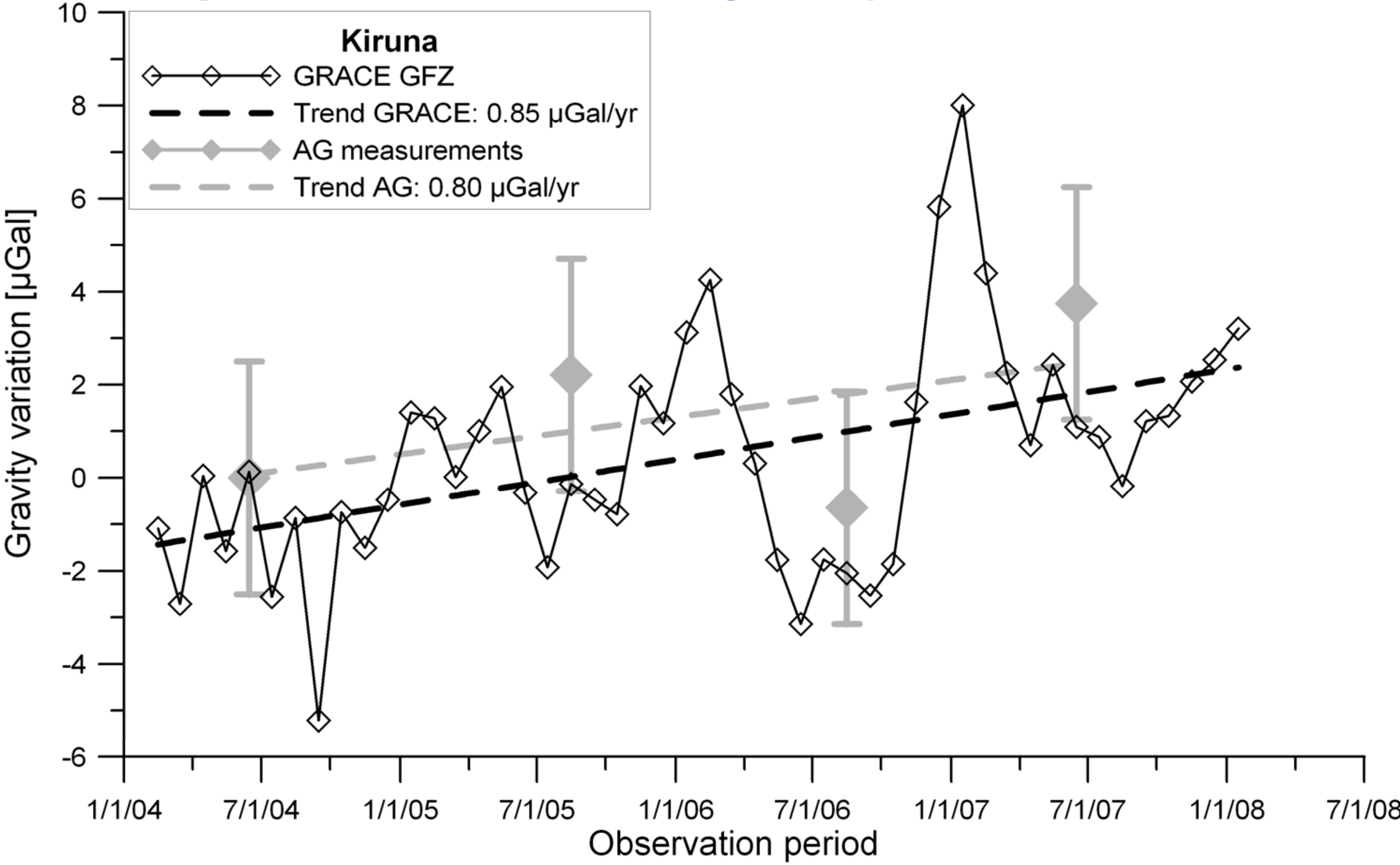
Absolute gravity network

FG5-220 from IfE (Photo: Gitlein)

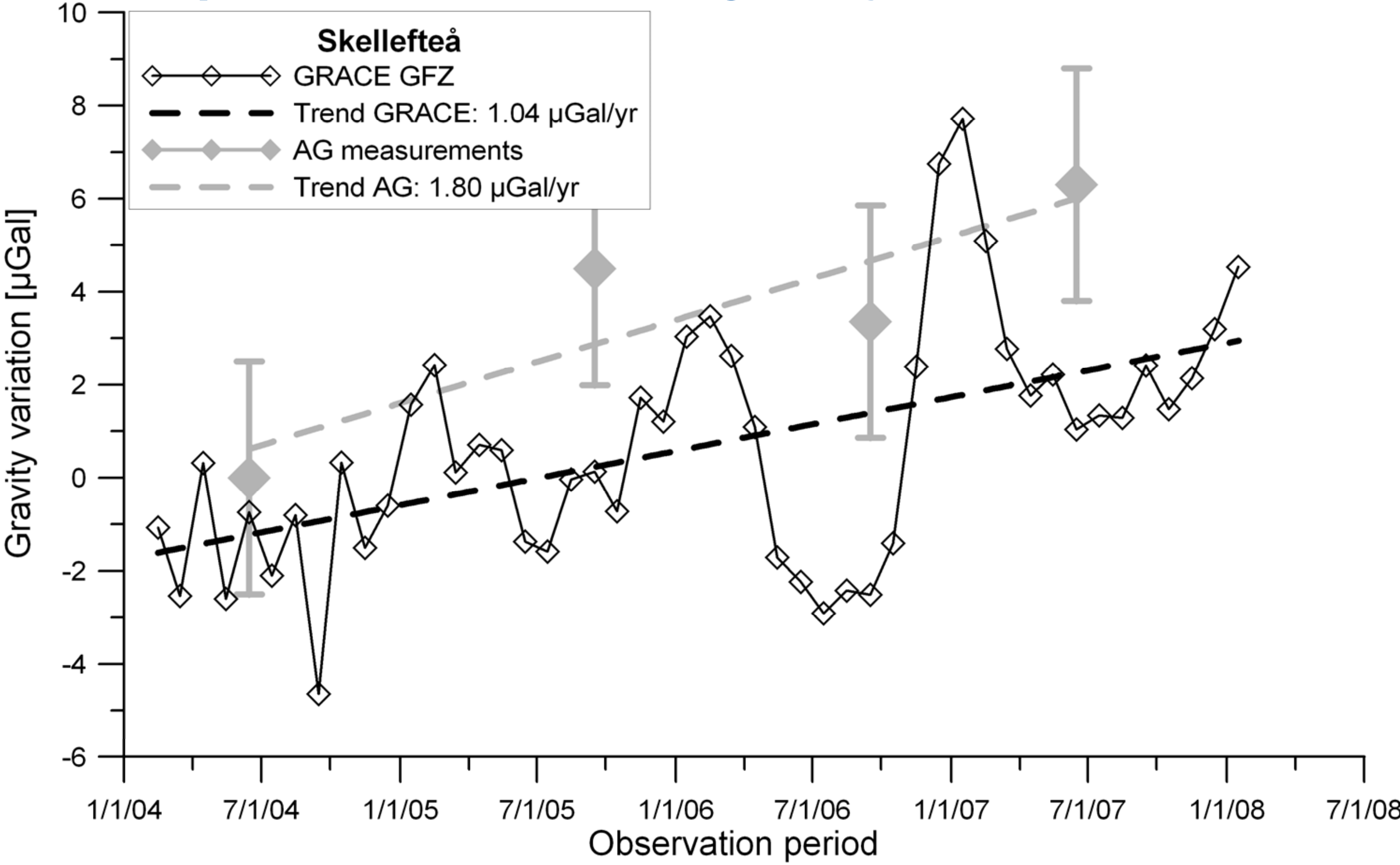


Gravity change
after Ekman and Mäkinen (1996)

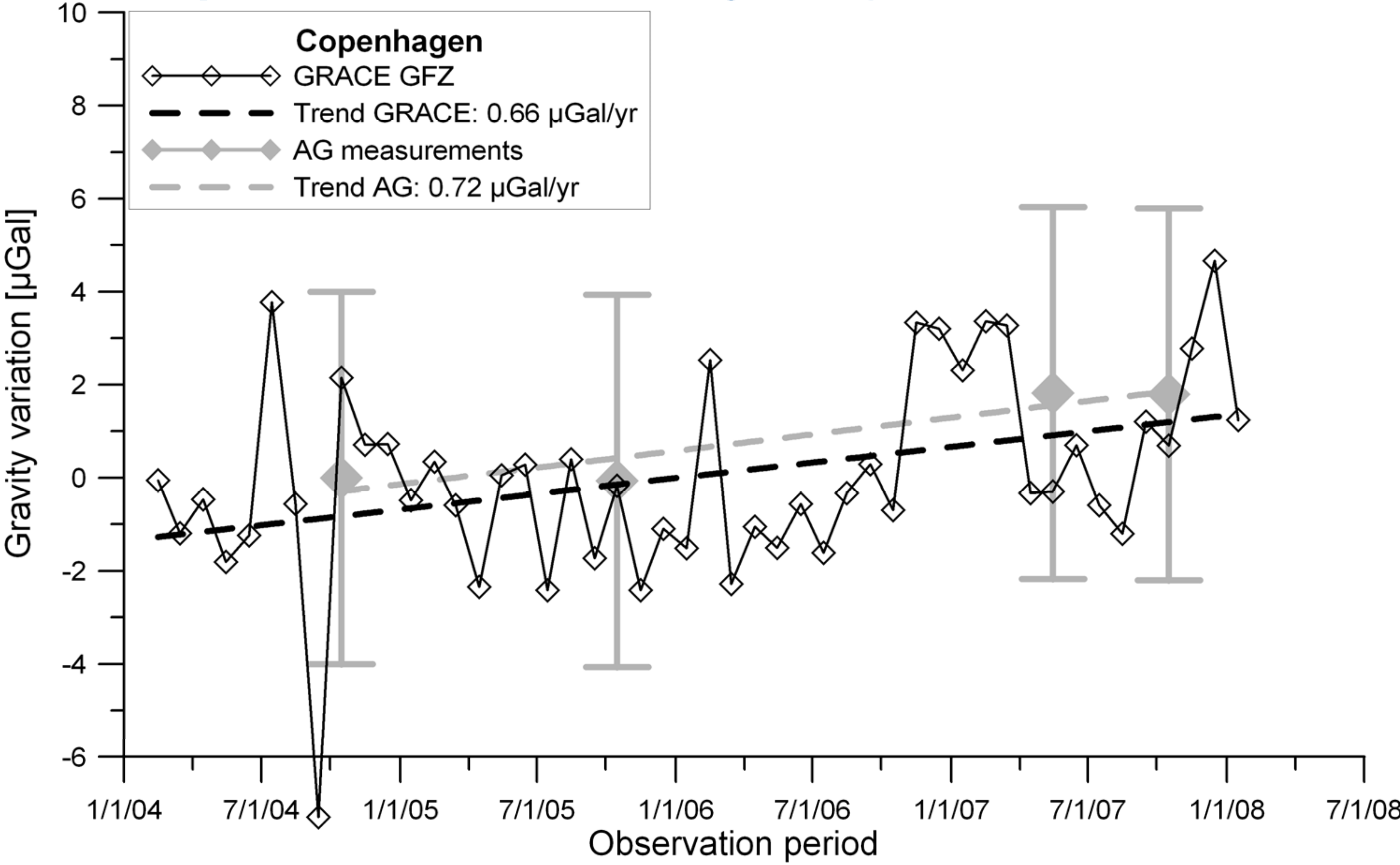
Comparison to absolute gravity



Comparison to absolute gravity



Comparison to absolute gravity



Conclusions

- Results depend on chosen analysis centre, filter technique, time span and reduction (models)
- GIA signature is significant, values of about 0.8-1.3 µGal for Fennoscandia
- Uplift centre and shape comparable with terrestrial measurements such as GPS and AG (and geophysical models)
- Secular trend of recent hydrology models not usable, better hydrology models helpful

Be careful when interpreting GRACE data!

Acknowledgements

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Thank you for your attention!