Globale Schwerefeldbestimmung mit GOCE

U. Meyer

Astronomical Institute, University of Bern, Switzerland

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  - First results to l_{max}=200 (84d)
- Combination with 7 years of GRACE (CMA)

GOCE Gradiometry

gradients

Eulerterm

$$\boldsymbol{a} = -\boldsymbol{V}\,\boldsymbol{r} + \dot{\boldsymbol{\omega}} \times \boldsymbol{r} + \boldsymbol{\omega} \times (\boldsymbol{\omega} \times \boldsymbol{r})$$

centrifugal acceleration

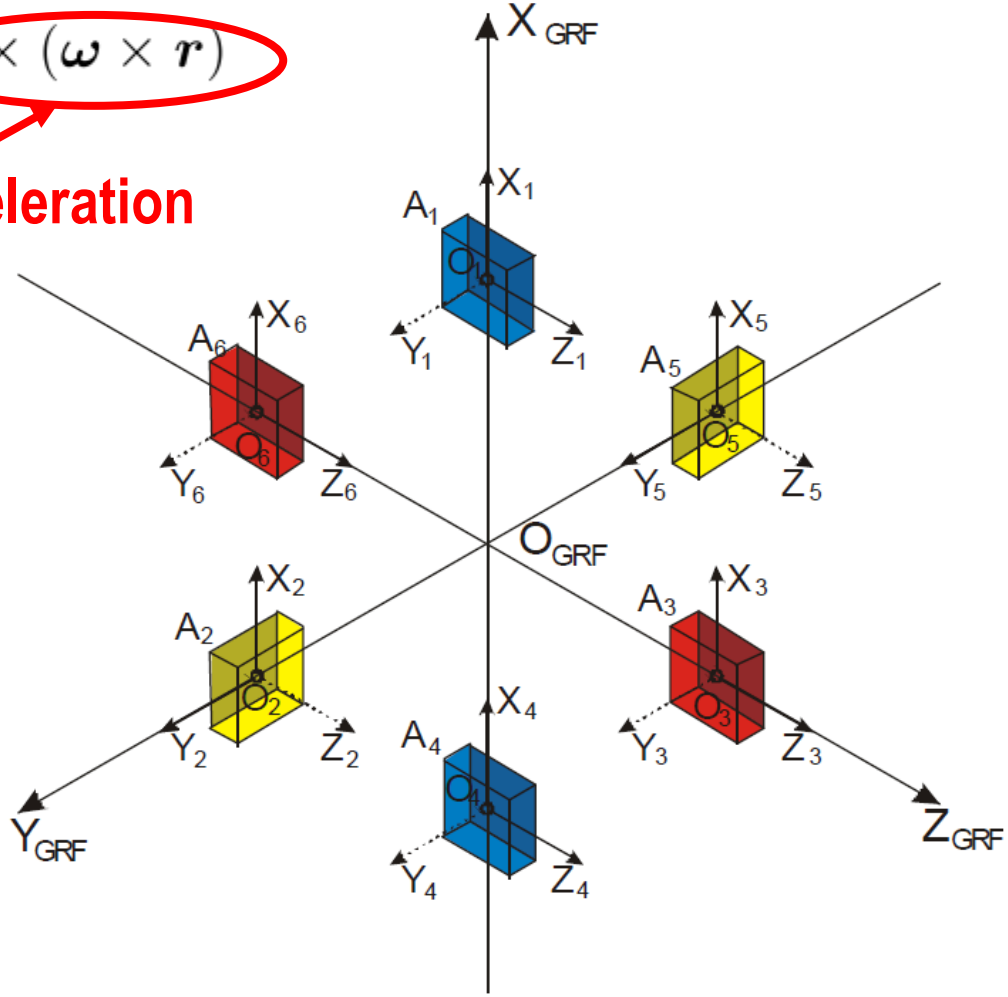
Common Mode:

$$a_{c,k,l,i} = \frac{1}{2}(a_{k,i} + a_{l,i})$$

Differential Mode:

$$a_{d,k,l,i} = \frac{1}{2}(a_{k,i} - a_{l,i})$$

$$k, l = 1, ..., 6; \quad i = x, y, z$$



Gradients and Noise

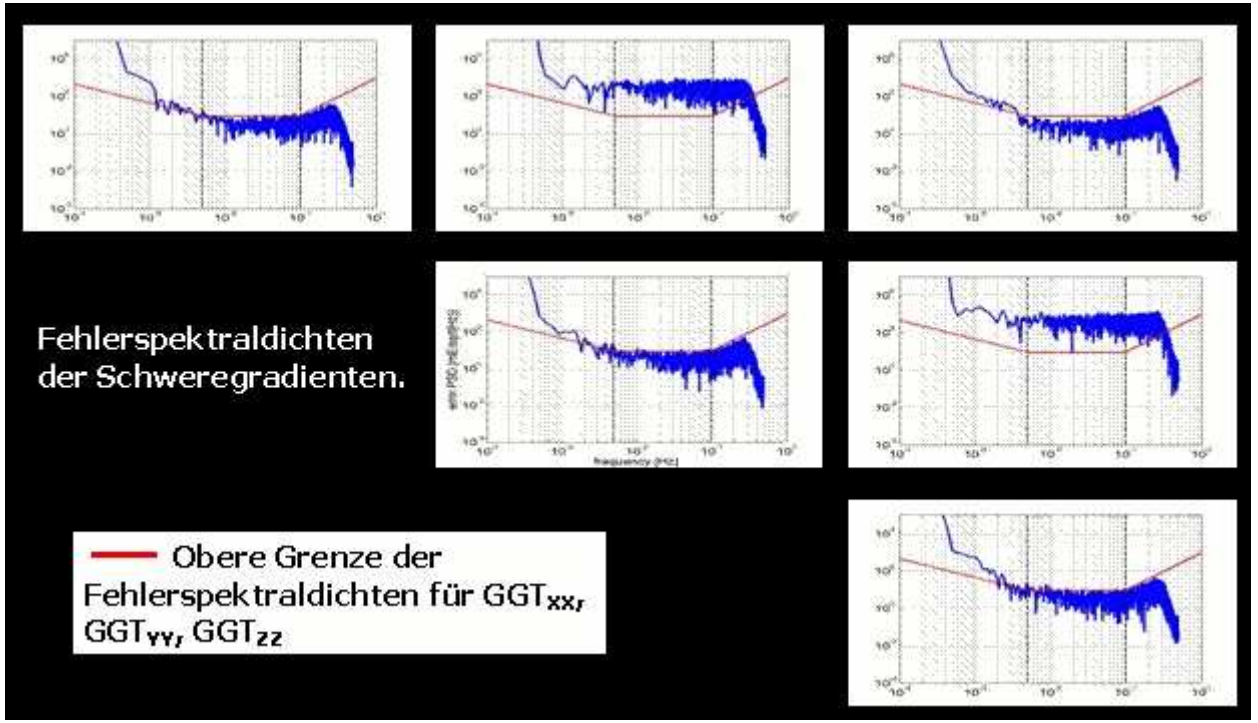
$$V_{xx} = -\frac{2 \cdot a_{d,1,4,x}}{L_x} - \omega_y^2 - \omega_z^2$$

$$V_{yy} = -\frac{2 \cdot a_{d,2,5,y}}{L_y} - \omega_x^2 - \omega_z^2$$

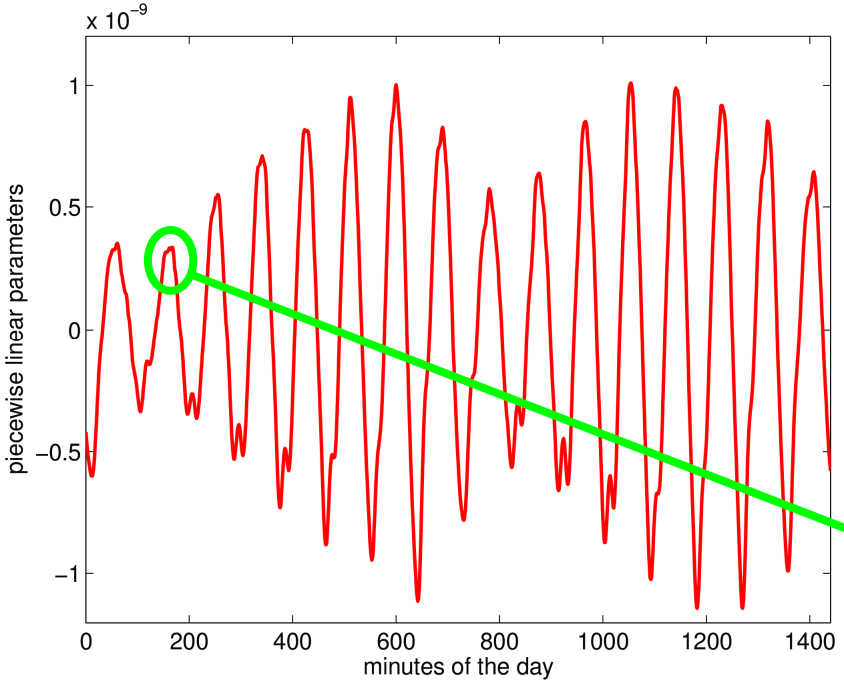
$$V_{zz} = -\frac{2 \cdot a_{d,3,6,z}}{L_z} - \omega_x^2 - \omega_y^2$$

Each type of gradients allows for a complete reconstruction of the gravity field, but sensitivities differ.

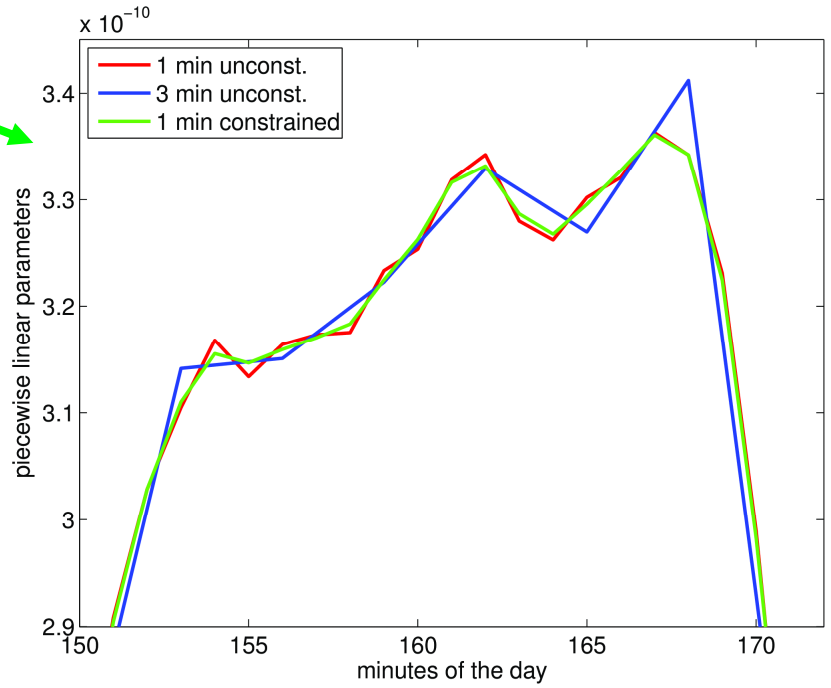
Not all gradients may be determined with equal accuracy



Gradiometer noise and PWL



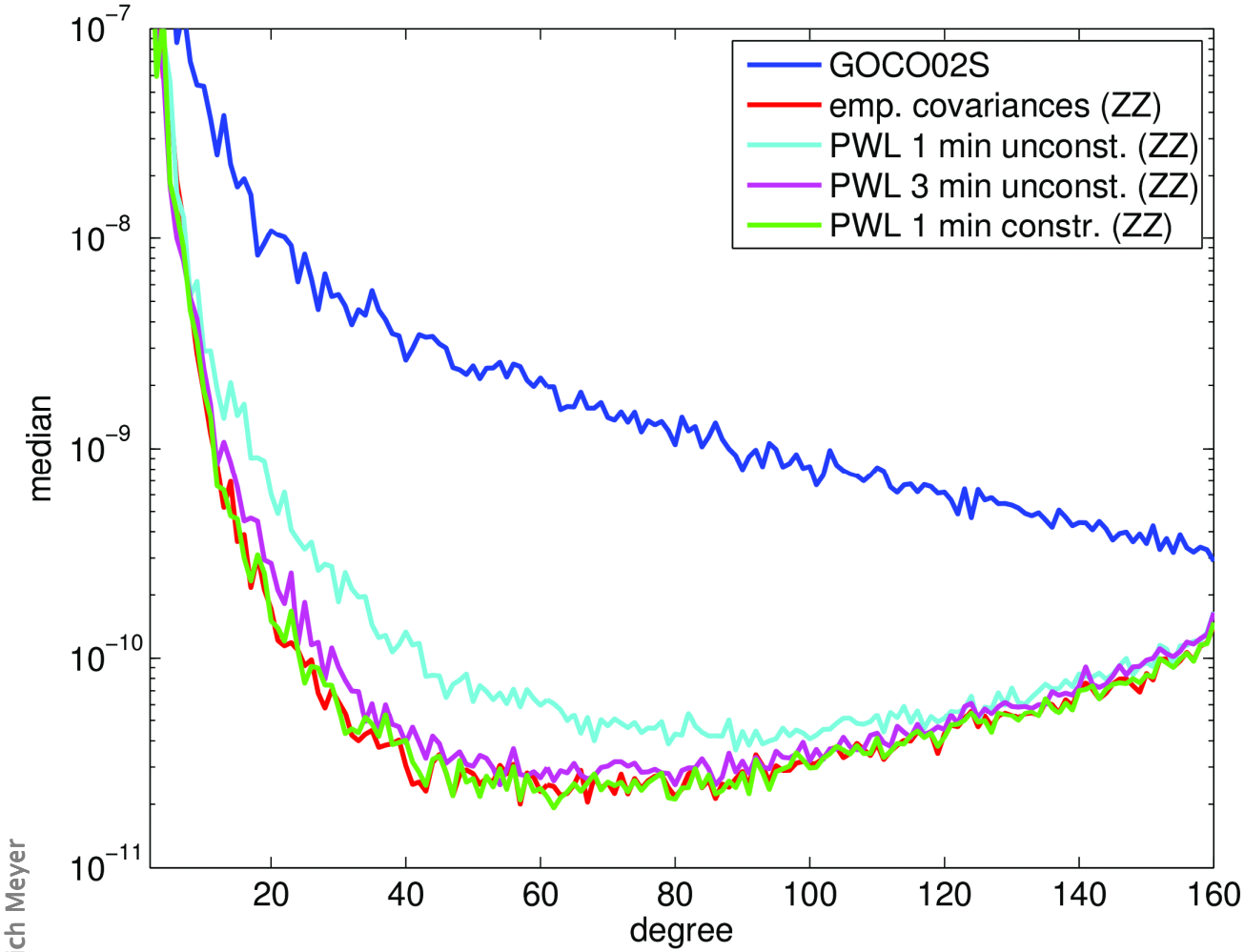
Constrained Piecewise Linear Parameters (PWL) absorb signal below measurement bandwidth of gradiometer.



Constraints on 2nd derivatives of PWL allow for:

- "hard" constraints: resampling
- "soft" constraints: smoothing

PWL contra empirical covariances



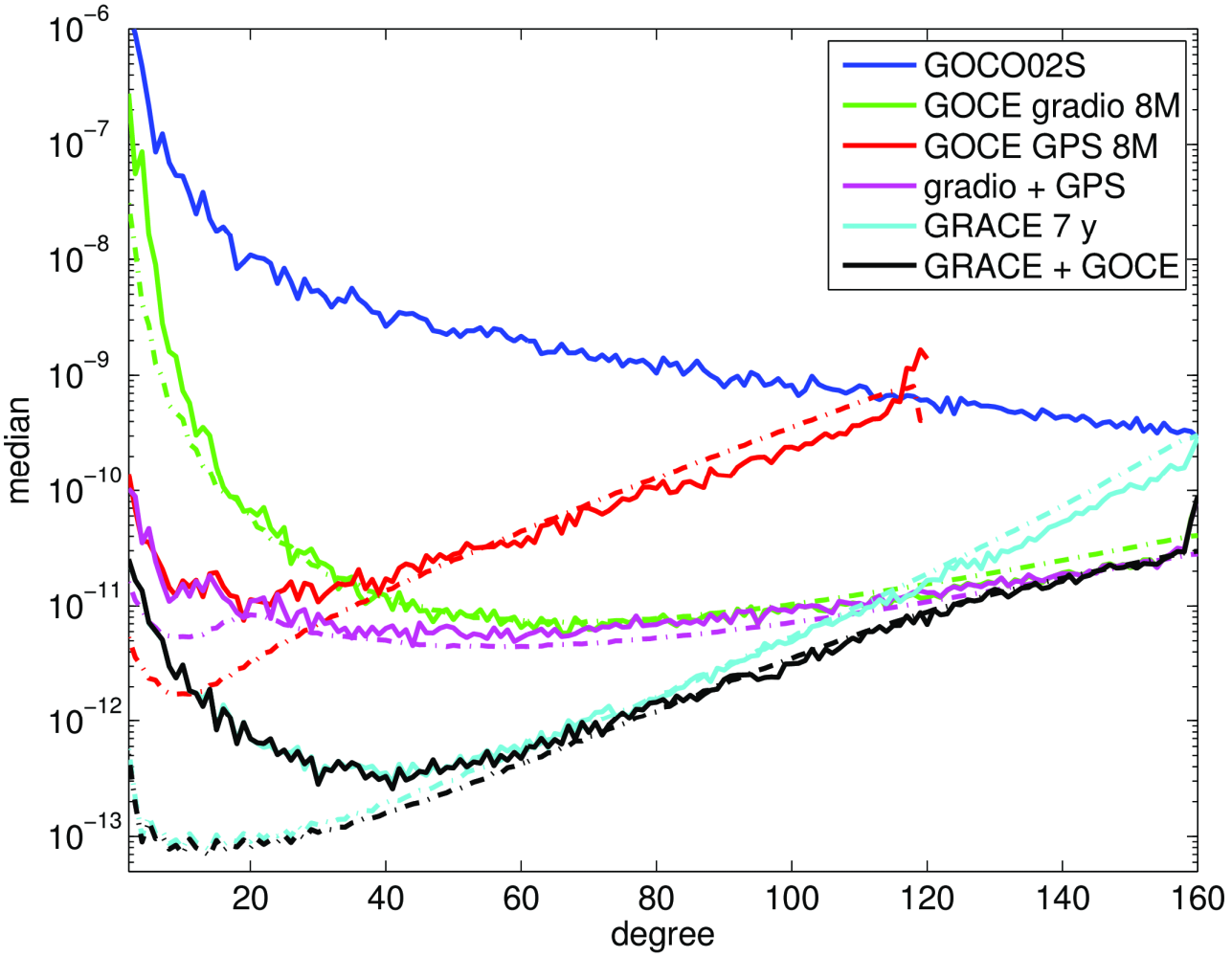
Results from 2 months of data.

smoothed 1 min PWLs

≙

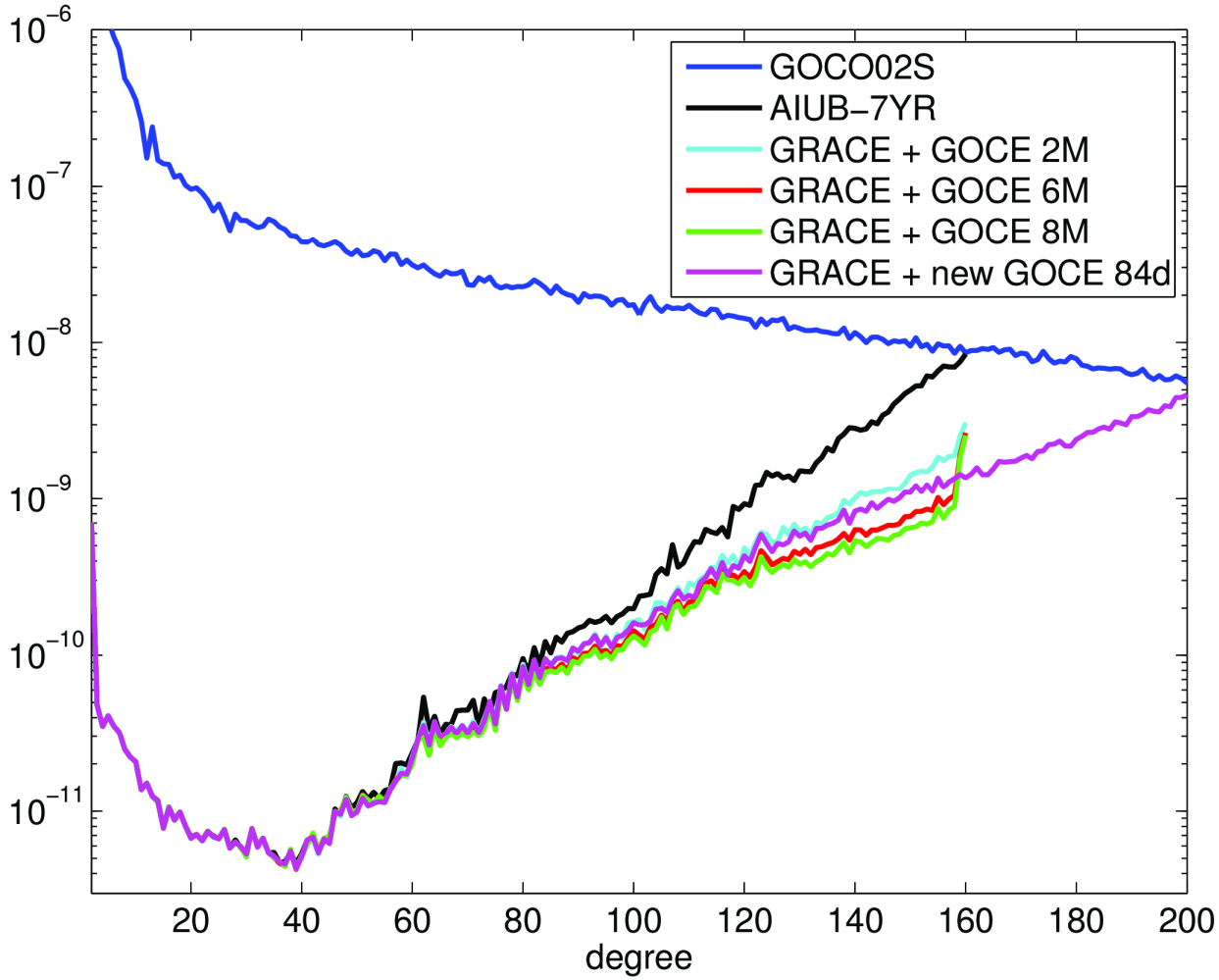
empirical covariances

Formal Errors



- relative weighting: ratio of RMS (GPS down-weighted)
- formal errors of low degrees too optimistic (GRACE), otherwise good agreement.

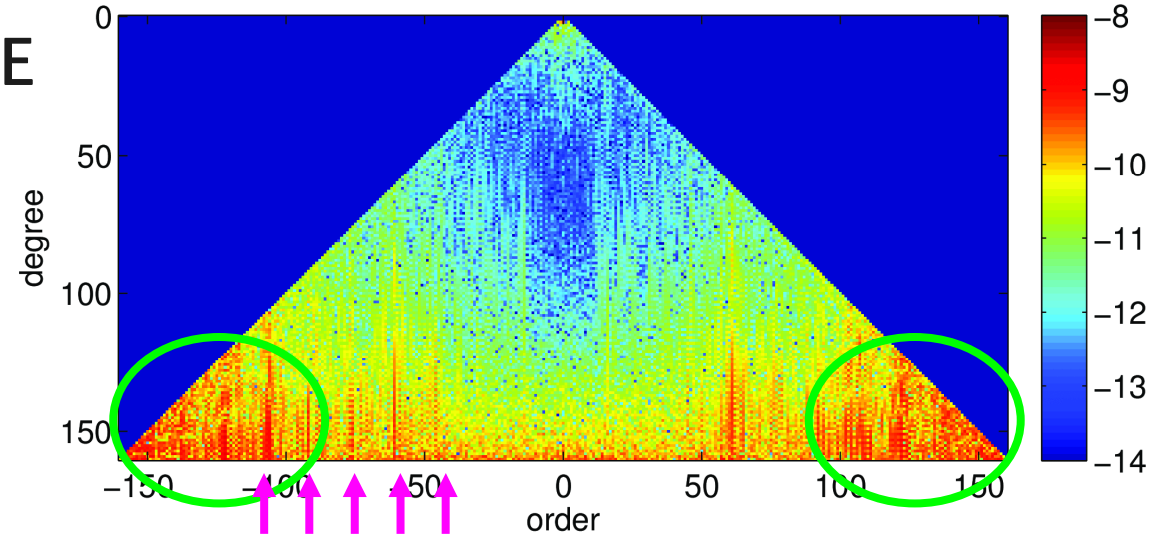
GRACE + GOCE



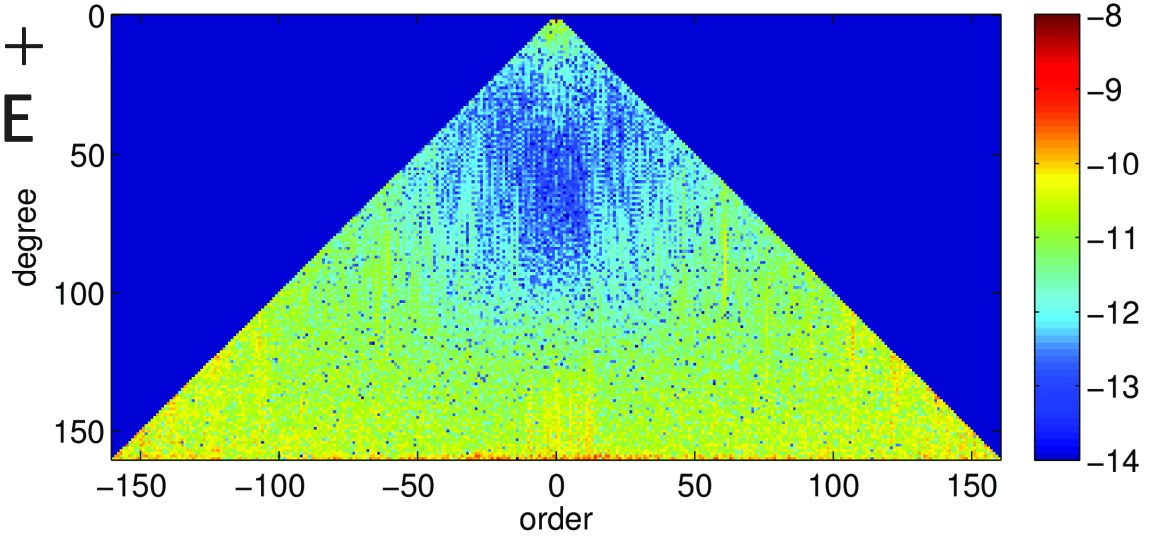
- more data => better solution
- omission error at $l_{max}=160$

A closer look

GRACE



GOCE+ GRACE

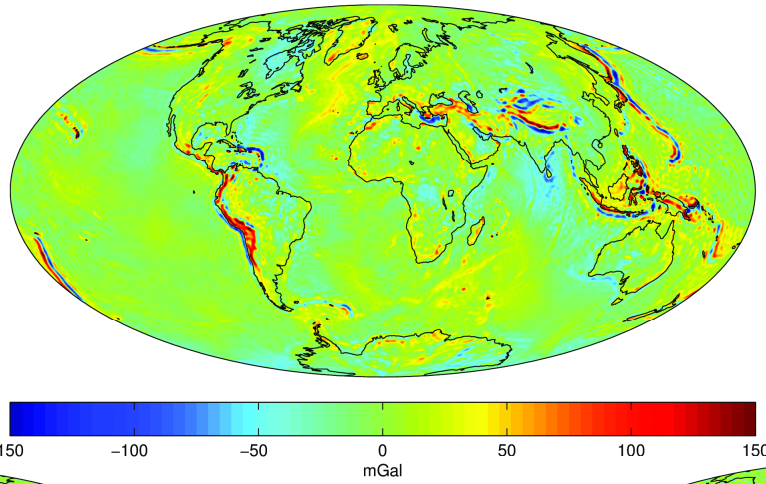


GOCE helps:

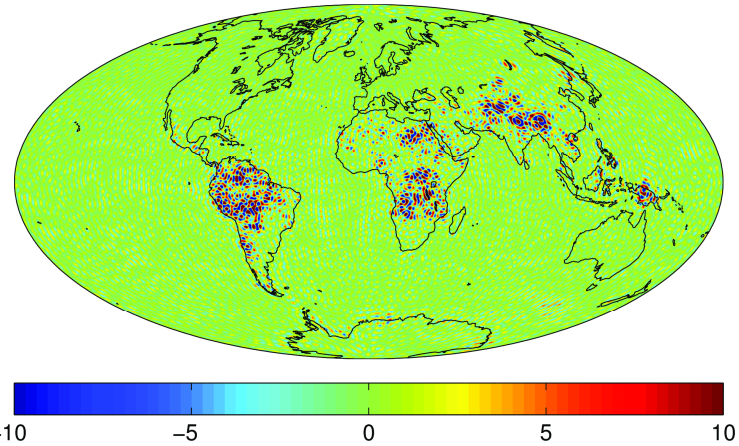
- improve sensitivity
- reduce GRACE aliasing errors on resonant orders
- Reference: GOCO02S

Comparison to EGM2008 and GOCO02S

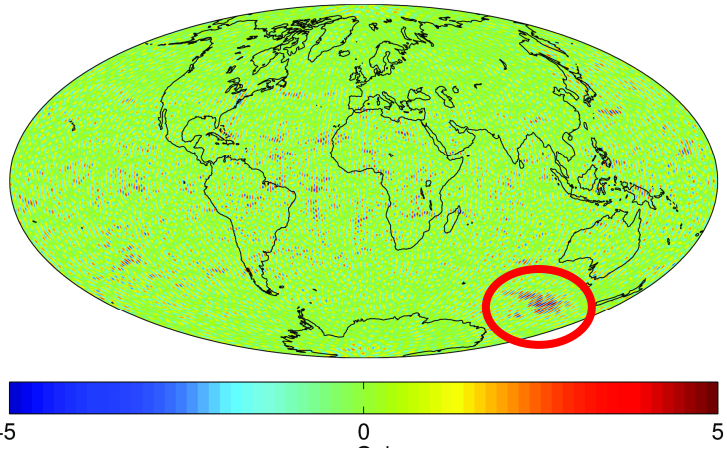
Gravity anomalies (l_{max} = 155)



Anomaly south of Australia



Diff. to EGM2008 (155)
WRMS (global): 1.39 mGal
WRMS (oceans): 0.60 mGal



Diff. to GOCO02S (155)
WRMS (global): 0.31 mGal
WRMS (oceans): 0.33 mGal

External validation

Reference	n	CMA	DIR-2	TIM-2
BRD GPS-benchmark	675 (all)	4.9 cm	5.3 cm	4.6 cm
	475 (1-σ)	2.6 cm	3.0 cm	2.4 cm
Canada GPS-benchmark	430 (all)	10.6 cm	10.3 cm	10.7 cm
	281 (1-σ)	5.7 cm	6.0 cm	6.2 cm
Japan GPS-benchmark	837 (all)	10.1 cm	10.0 cm	9.9 cm
	533 (1-σ)	5.7 cm	5.8 cm	5.6 cm

All gravity fields truncated at degree 155.

Validation performed by Thomas Gruber (only high-quality data sets shown).

Summary and Outlook

- CMA is a powerful tool for satellite gravity gradiometry, as well.
- GOCE contribution cures aliasing artifacts on resonant orders of GRACE.
- The CMA-derived gravity fields are currently expanded to even higher degrees (200).