Synergy of the GOCE and GRACE satellite missions

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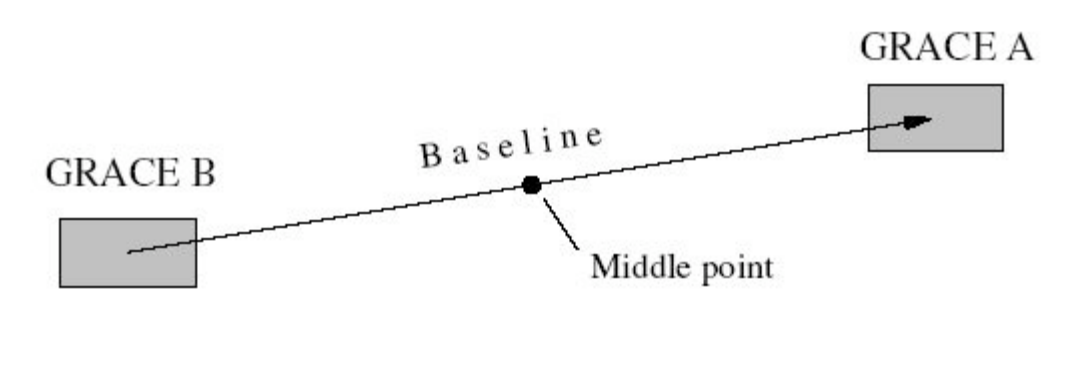
GRACE positioning



Positioning parameters not known with a high accuracy:

- Middle point position
- Cross-track and radial component of the baseline

Influence of errors in the radial component of baselines

$$V_{12} \approx |\dot{\boldsymbol{r}}_{\mathrm{mp}}|\dot{\rho} - E_{12}$$

where
- V_{12} - difference of gravitational potentials at satellite locations
- $|\dot{\boldsymbol{r}}_{\mathrm{mp}}|$ - velocity of the middle point
- $\dot{\rho}$ - observed range-rates
- E_{12} - difference in the total mechanical energy of the satellites

Influence of errors in the radial component of baselines (cont'd)

$$\epsilon(r_{12}^{(z)}) = \frac{|\dot{r}_{\mathrm{mp}}|}{g}\epsilon(\dot{\rho})$$

g $\approx$ 10 m/s^2

$|\dot{r}_{\mathrm{mp}}| \approx 7,500$ m/s

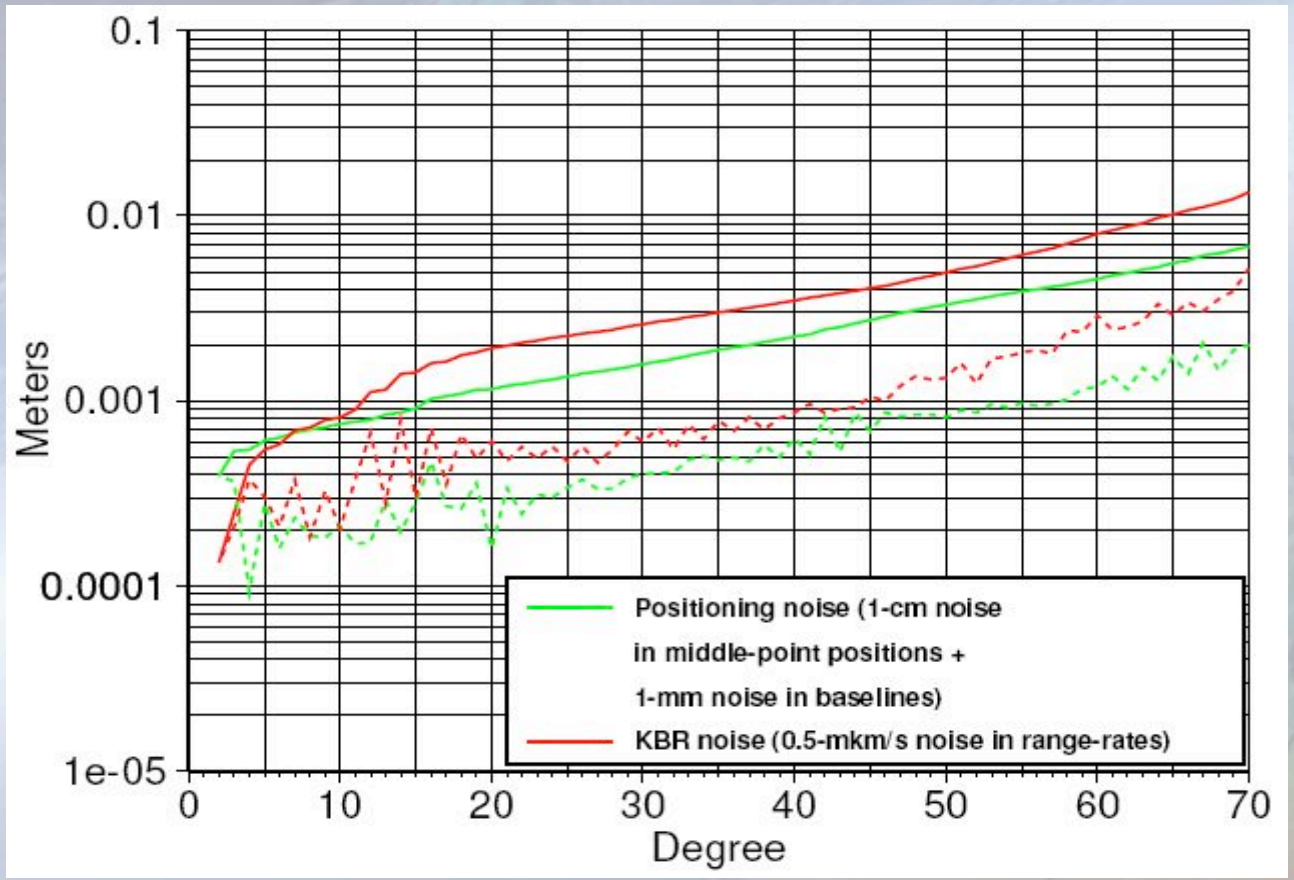
$\epsilon(\dot{\rho}) \approx$ 0.5 mkm/s

=> $\epsilon(r_{12}^{(z)})$ = 0.4 mm

Sources of positioning information

- GPS data
- A priori model of gravitational and non-gravitational forces
- KBR data at neigbouring epochs

Performance of a new functional model, in terms of geoid height errors (processing of 1-month synthetic data sets)



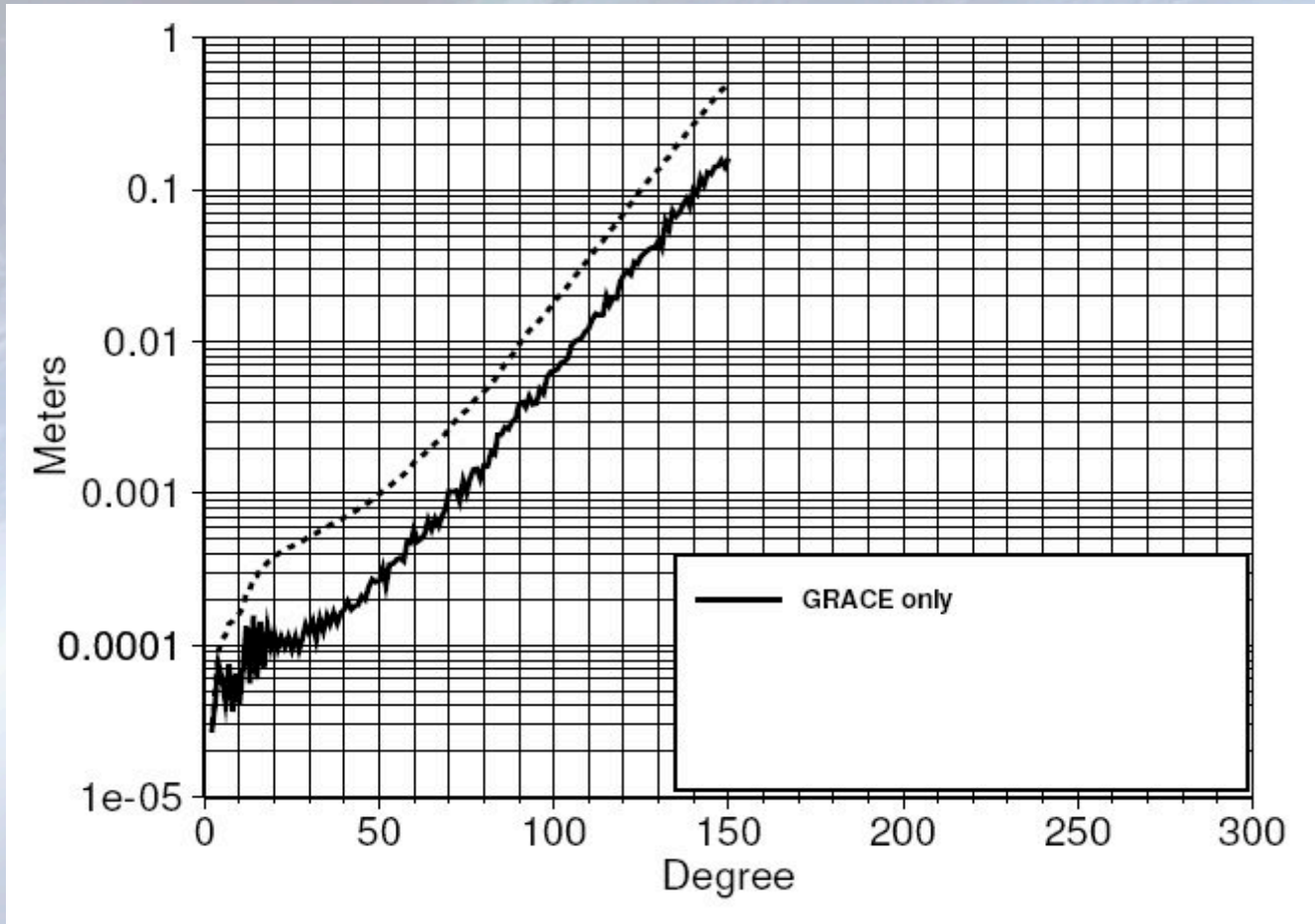
Functional models are equivalent if ...

- Tranformation of data is linear and reversible
- The data covariance matrix is transformed accordingly and used in data inversion

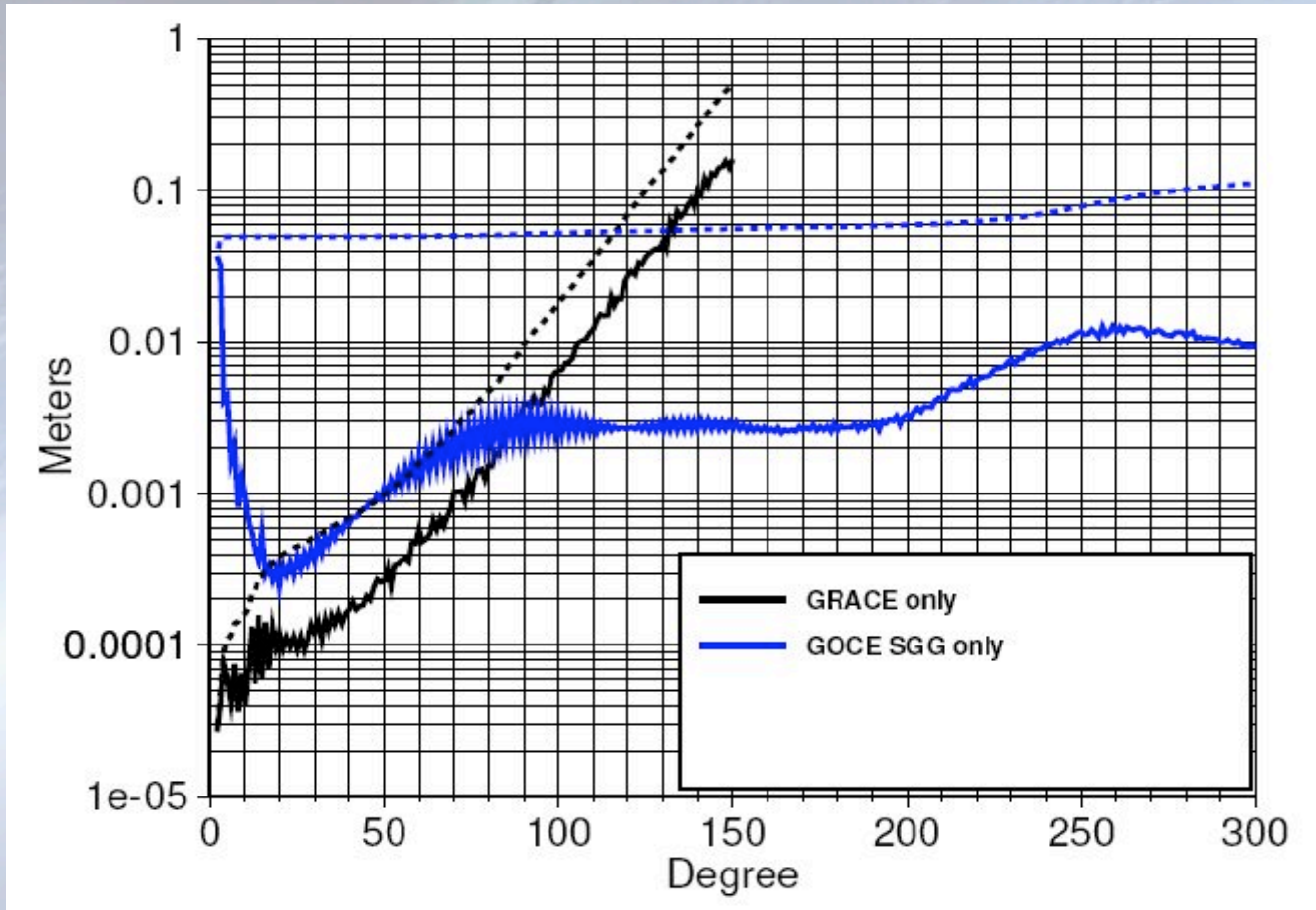
Setup of the numerical experiment

- **“True” gravity field model: EIGEN-GL04C (truncated at degree 300)**
- **Refernce gravity field model: EGM96 (truncated at degree 300)**
- **“GRACE” data: 1-month set of measurements with 5-s sampling, 0.1-mkm/s white noise in range-rates**
- **“GOCE SGG” data: 6-month set of diagonal tensor components with 1-s sampling, realistic colored noise**
- **“GOCE SST” data: 6-month set of satellite accelerations with 30-s sampling, realistic colored noise (taken over from the CHAMP mission)**

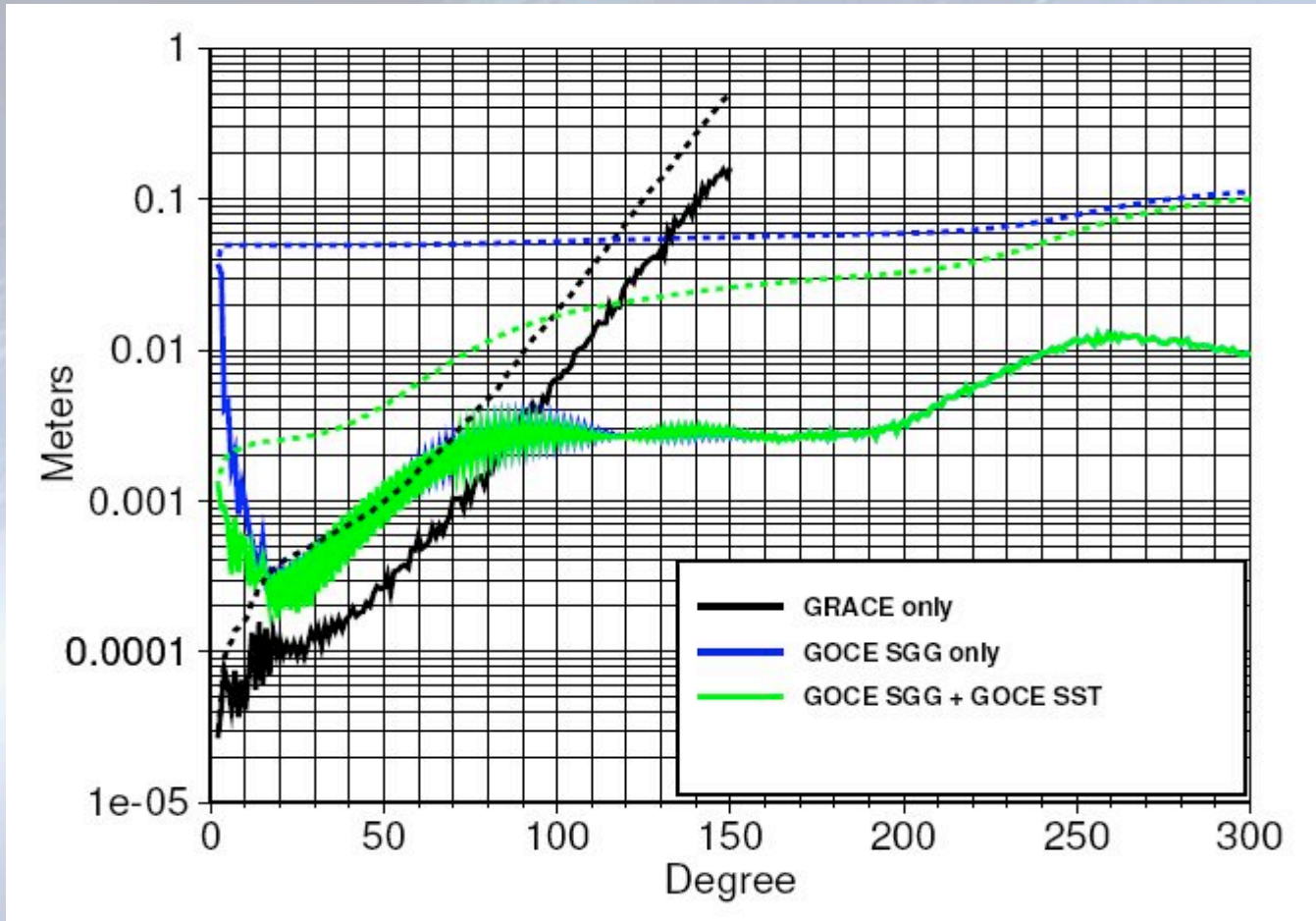
Errors in the “GRACE”-based model



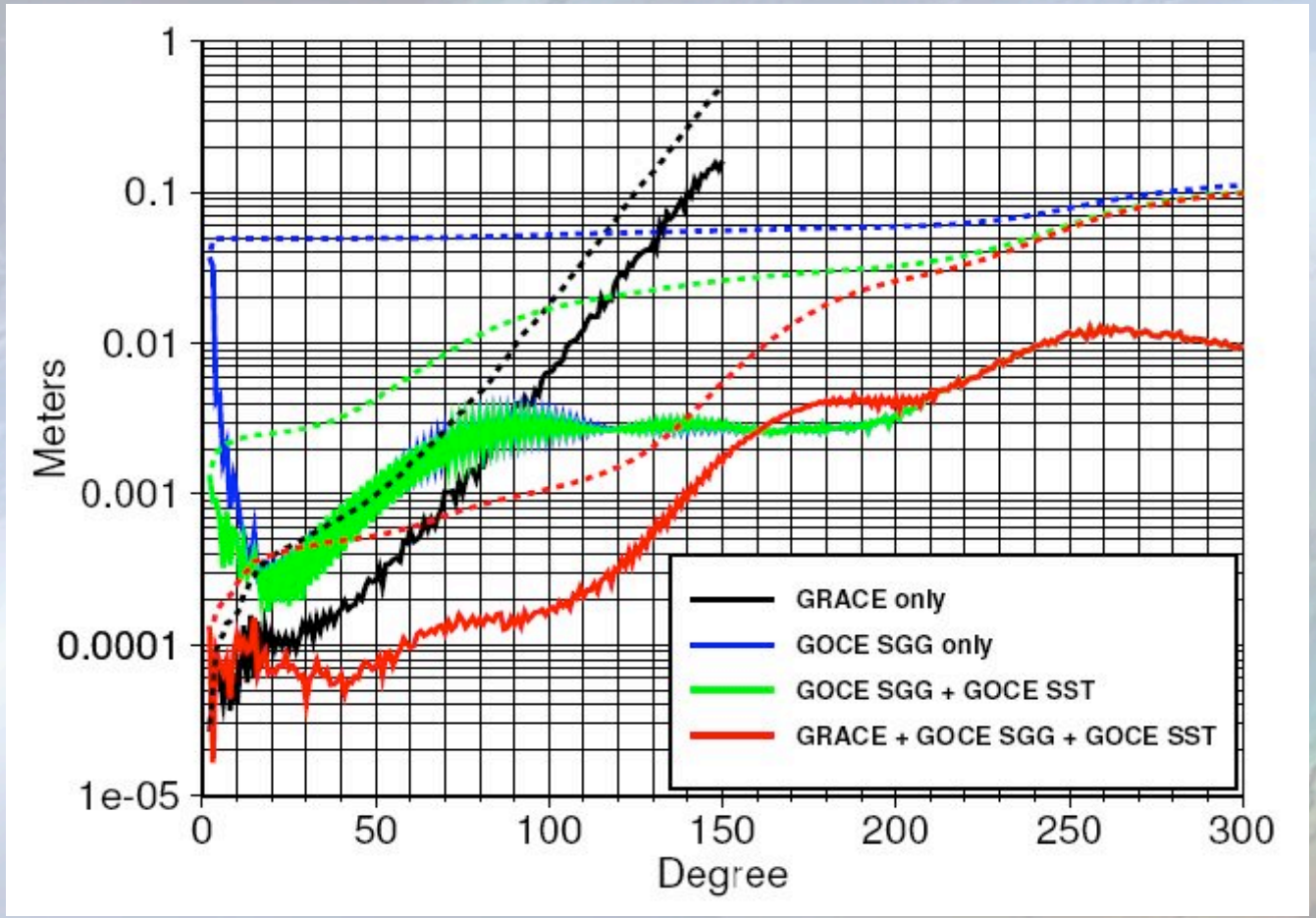
Errors in the “GOCE SGG”-based model



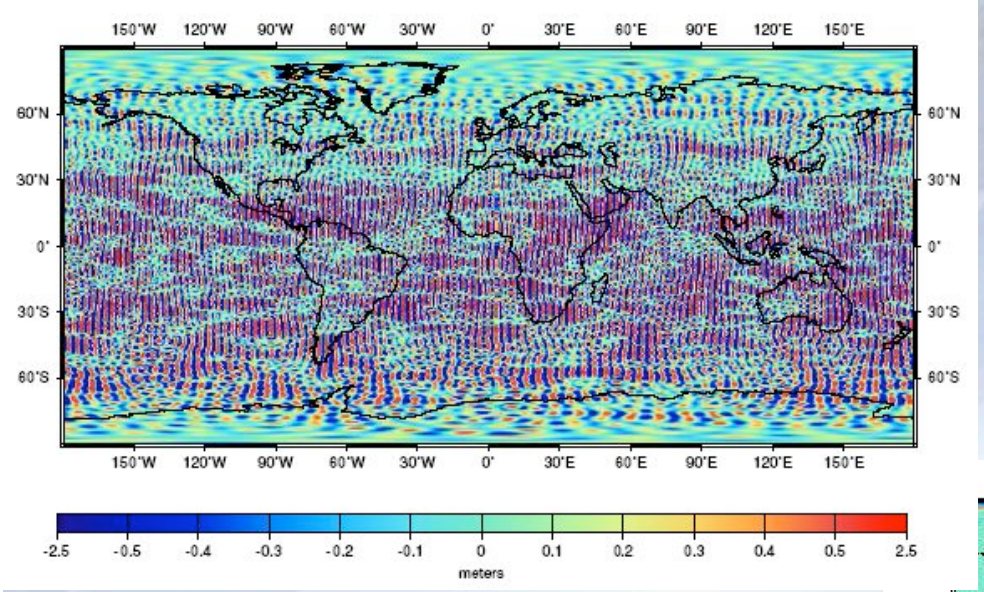
Errors in the “GOCE”-based model



Errors in the combined ("GRACE"+"GOCE") model

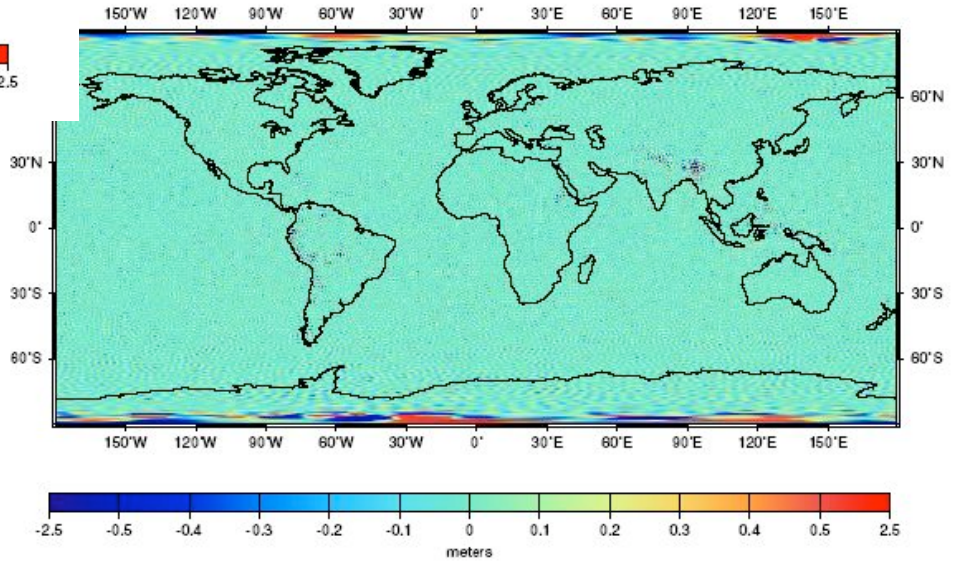


Geoid height error maps

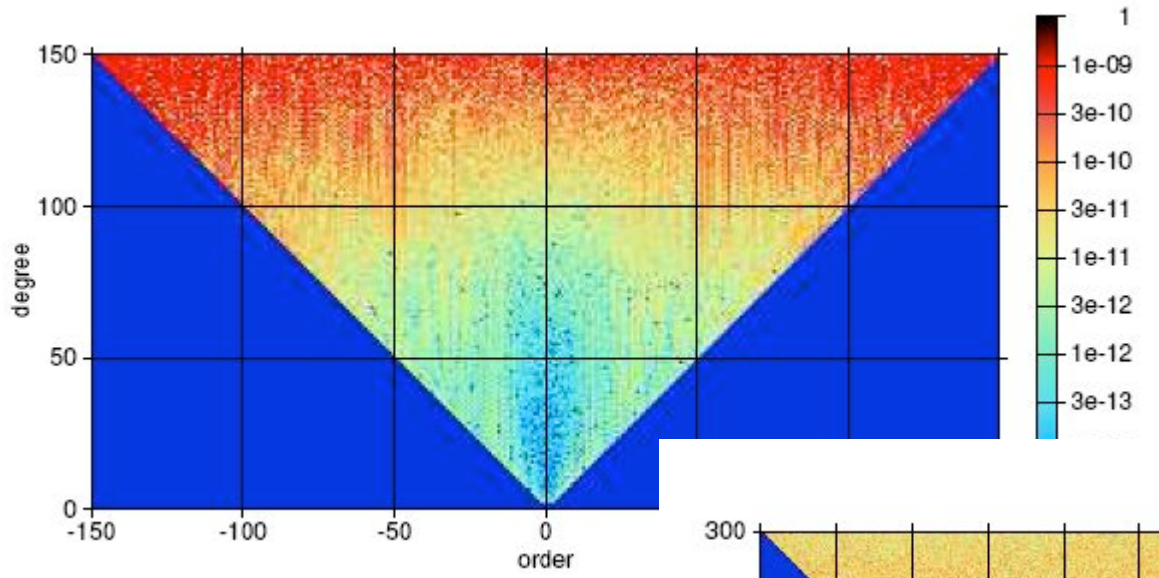


"GRACE"

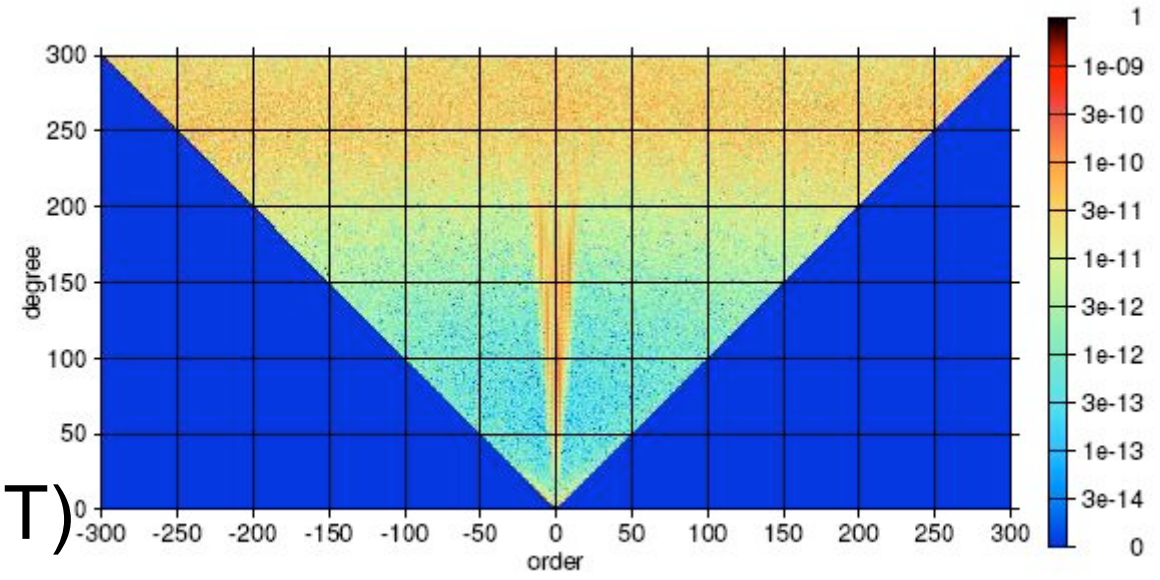
"GOCE" (SGG + SST)



Errors per coefficient

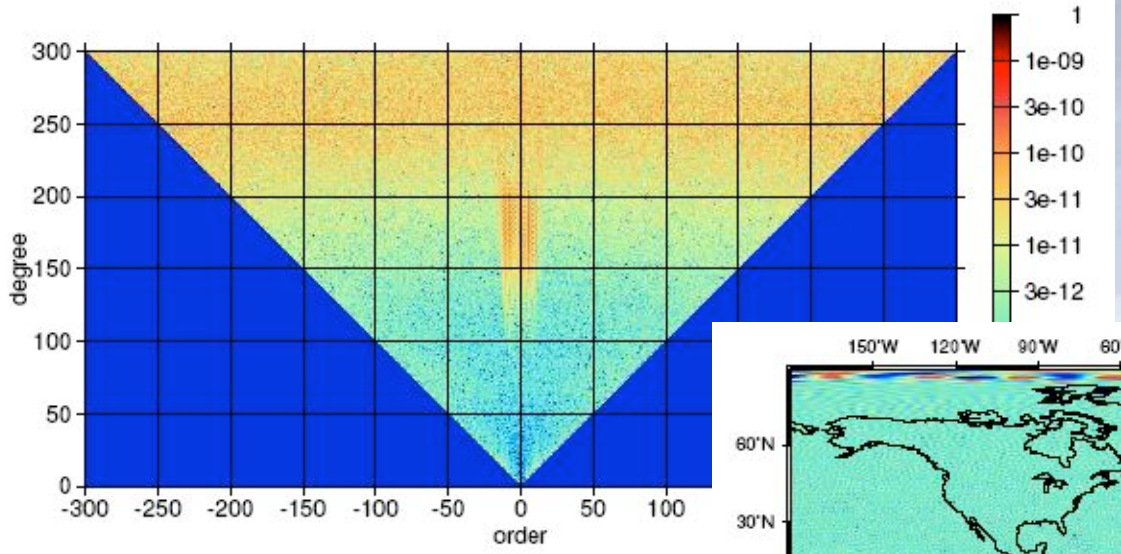


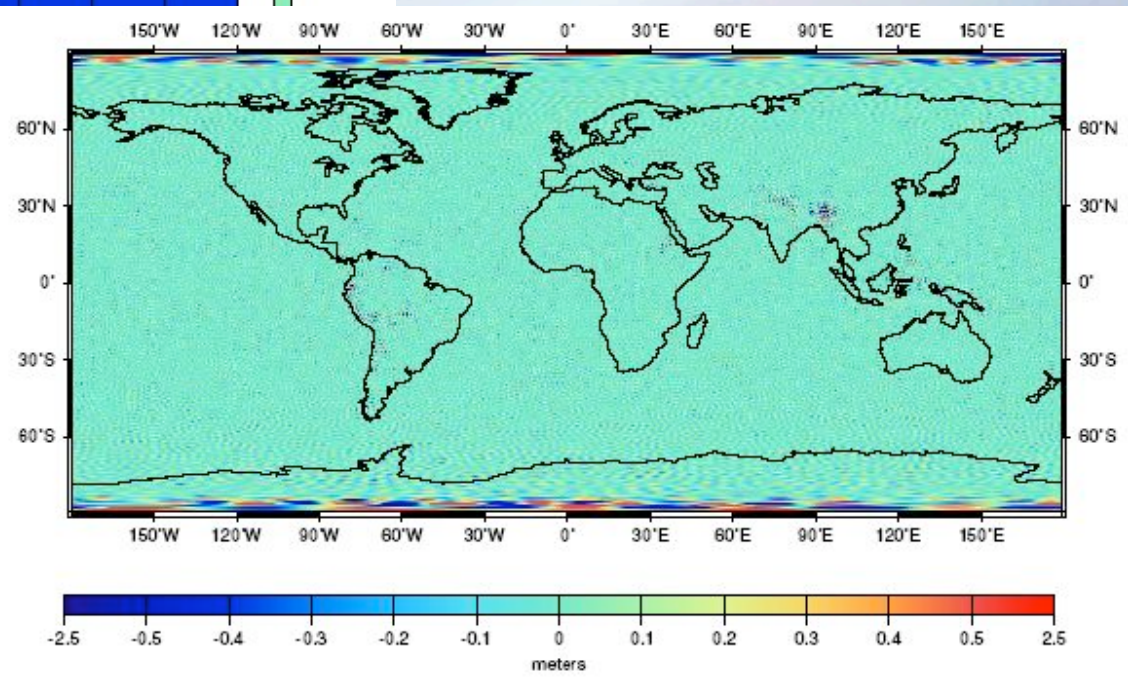
"GRACE"



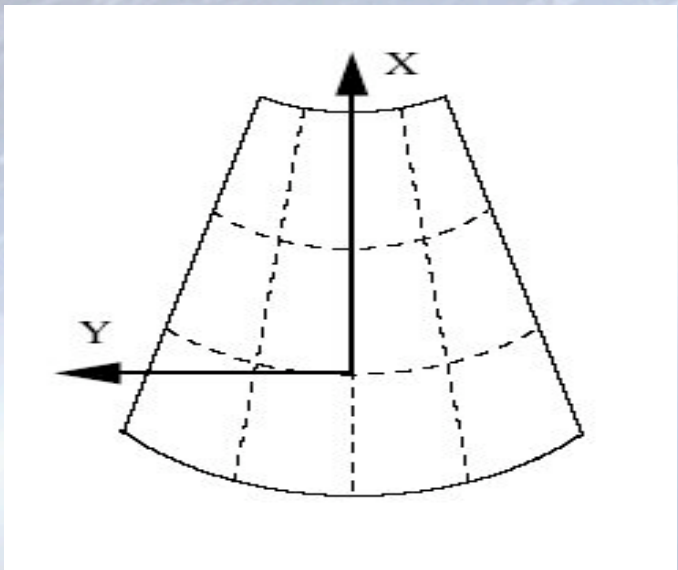
"GOCE" (SGG + SST)

Errors in the combined “GRACE”+”GOCE” model





Noisy nearly-sectorial coefficients: an intrinsic problem of GRACE KBR data



$$f_1 - f_2 \sim \frac{\partial f}{\partial x}$$

Let f =: f(y) => $\frac{\partial f}{\partial x} = 0$

Conclusions

- **High-quality processing of GRACE KBR data requires an accurate satellite positioning (relative satellite altitudes are especially imortant)**
- **The relative satellite altitudes can be determined with a sufficeint accuracy from GRACE KBR data themselves**
- **A joint GRACE + GOCE gravity field modeling may improve the quality of results dramatically (an order or magnitude at degree 100)**
- **Poor quality of GRACE solutions in the East-West direction is (most probably) an intrinsic feature of GRACE KBR data**

Utilized model of SGG data noise