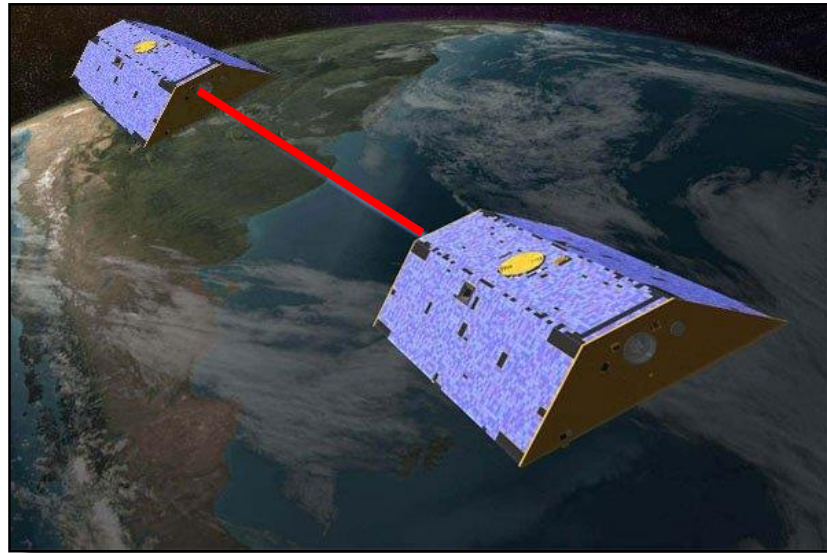


# ITSG-Grace2014



Institute of Theoretical Geodesy and Satellite Geodesy  
Graz University of Technology

Torsten Mayer-Gürr, Norbert Zehentner, Beate Klinger, Andreas Kvas

# ITSG-Grace2014

## High resolution static field

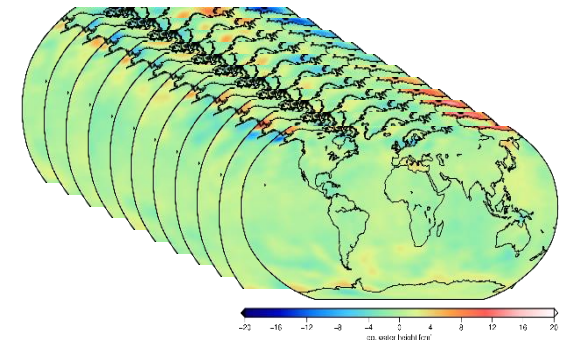
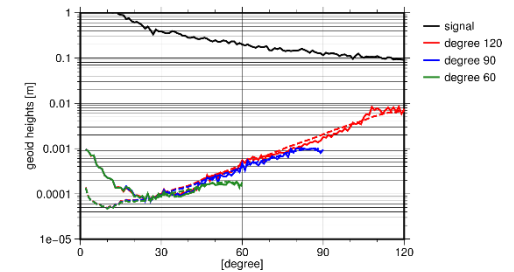
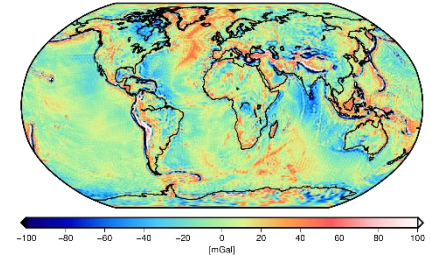
- Degree 200
- Unconstrained ITSG-Grace2014s
- Kaula regularized ITSG-Grace2014k
- Combined estimation of Mean, Trend, Annual, Daily variations
- Full variance-covariance matrix is published

## Unconstrained monthly solutions

- Degree 60, 90, 120
- Full variance-covariances matrices are published

## Daily Kalman smoothed solutions

- Degree 40



[itsg.tugraz.at/research/ITSG-Grace2014](http://itsg.tugraz.at/research/ITSG-Grace2014)

# Content

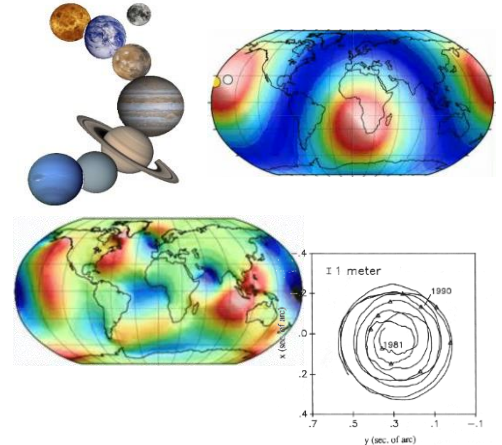
- ➔ • Processing details
  - High resolution static field
  - Unconstrained monthly solutions
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  - Summary

# State of the art background models

## Background models:

- Third body forces:
- Solid earth tides:
- Ocean tides:
- Pole tides:
- Ocean pole tides:
- Atmospheric tides (S1, S2)
- Dealiasing:

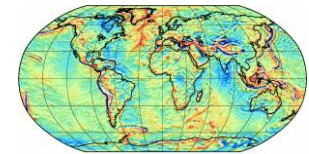
JPL DE421  
 IERS 2003  
 EOT11a  
 IERS 2003  
 Desai 2004  
 Bode-Biancale 2003  
 AOD1B RL05



## Restored models

- Static field:
- Trend, Annual:

GOCO03s  
 ITG-Grace2010



## Parametrization:

- Per day: satellite state vector
- Per day: accelerometer polynomial bias (degree=3) per axis in SRF
- Per day: accelerometer scale factors
- Per month: KBR antenna center

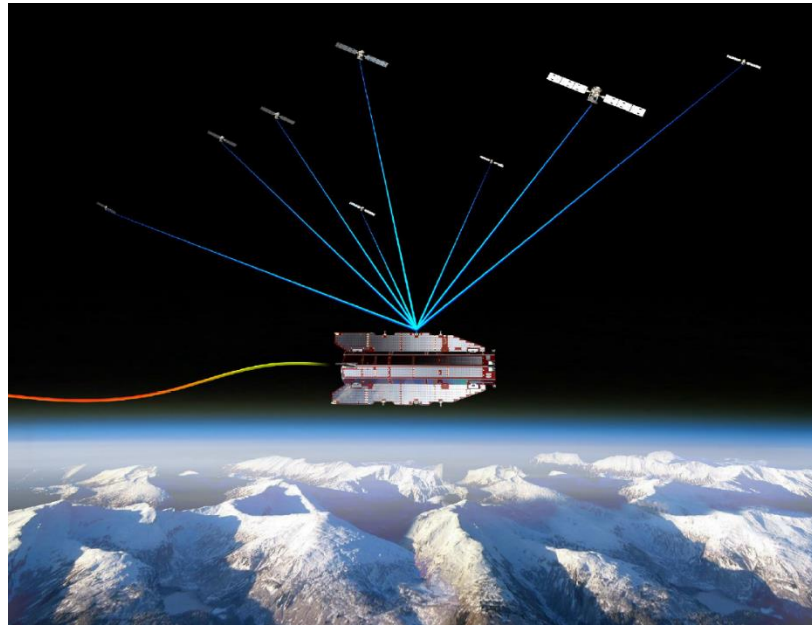


Arc length: 1 day

# GPS observations - Kinematic Orbits

Sampling 5 min.

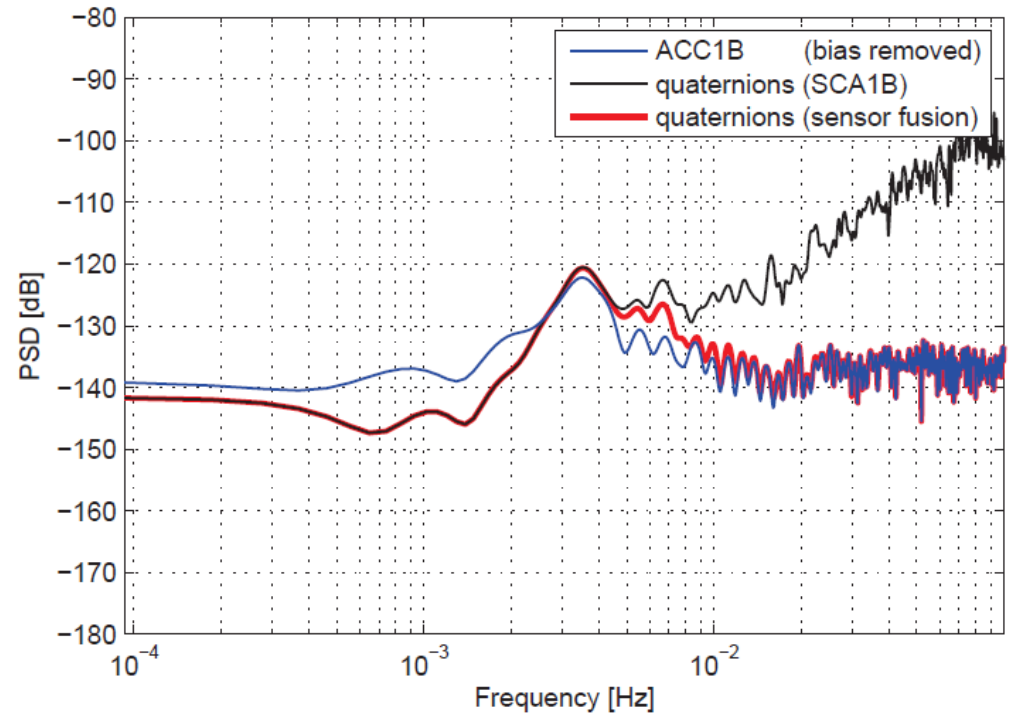
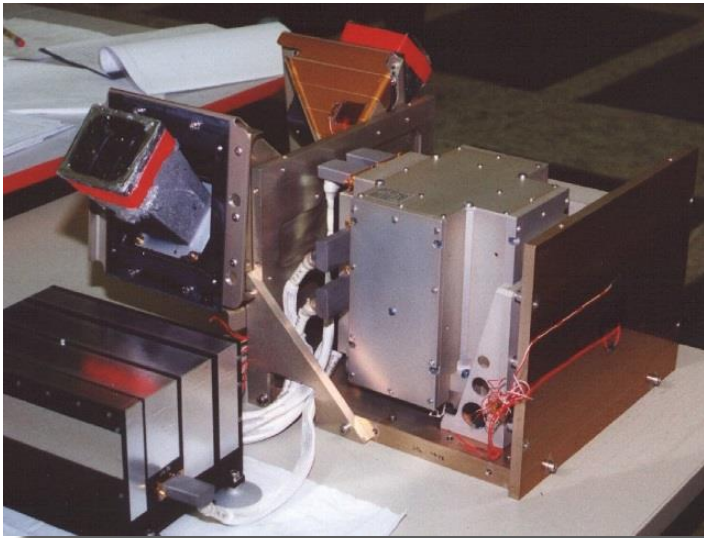
- Kinematic orbits for GRACE A and GRACE B
- Epoch wise (3x3) covariance matrix



**Tuesday, 14:30:** *Non-dedicated satellite missions for time variable gravity field estimation*  
Norbert Zehentner, Torsten Mayer-Gürr, Matthias Weigelt, Adrian Jäggi

# Star camera/Accelerometer Fusion (1/2)

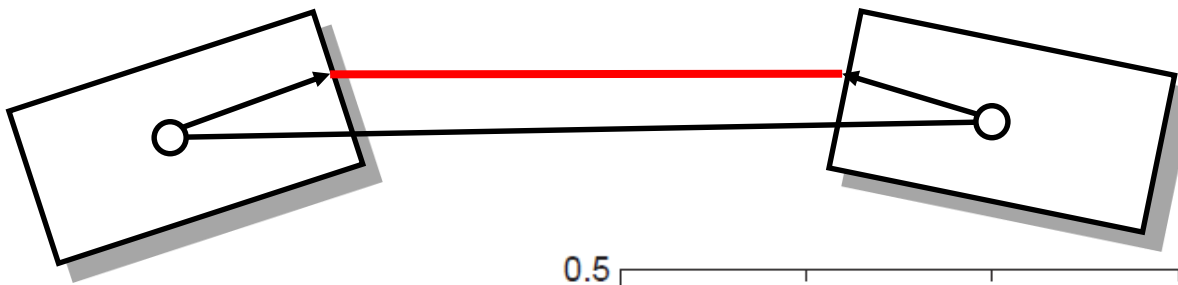
Smoothed quaternions by combination of star camera data and angular accelerations



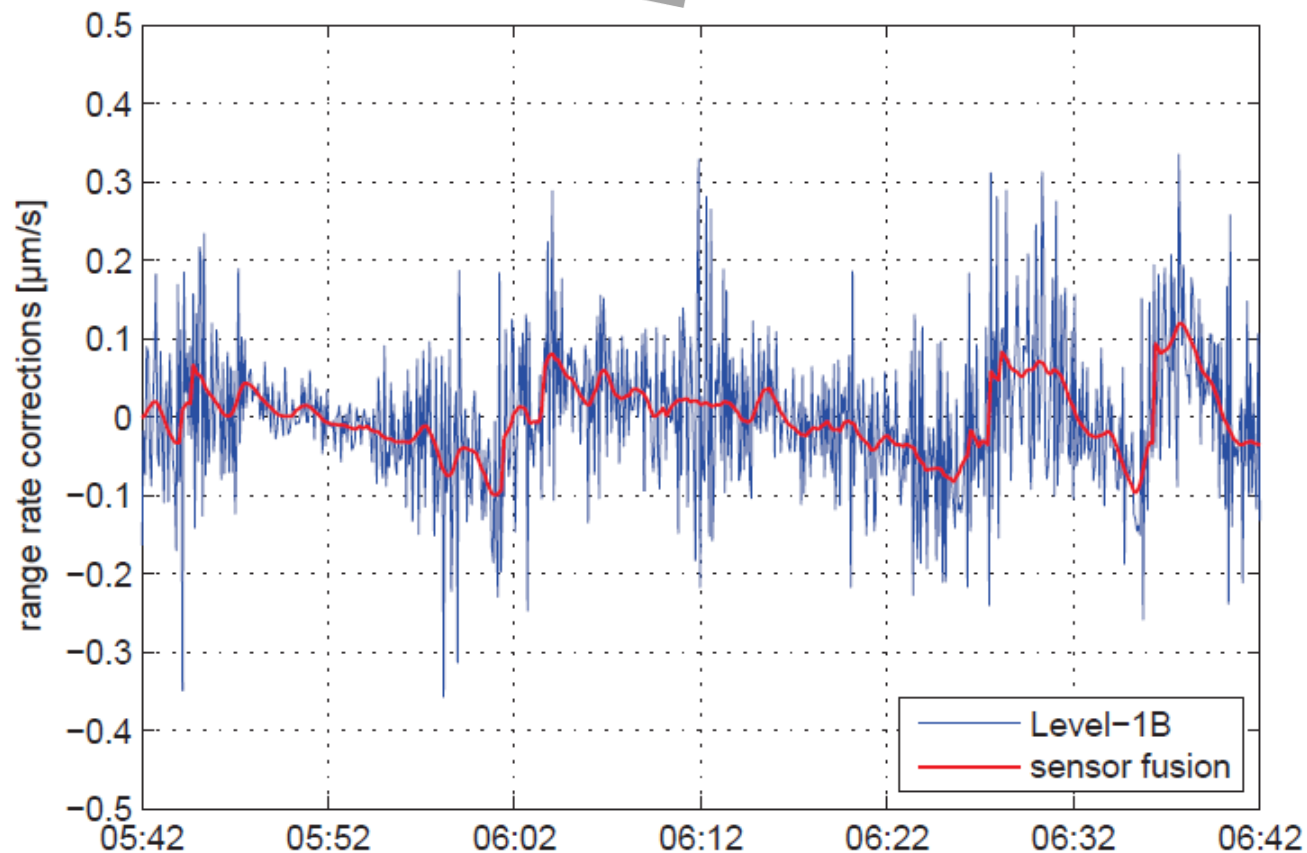
**Tuesday, 9:30:** *Combination of GRACE star camera and angular acceleration data: impact on monthly gravity field models*

Beate Klinger and Torsten Mayer-Gürr

# Star camera/Accelerometer Fusion (2/2)

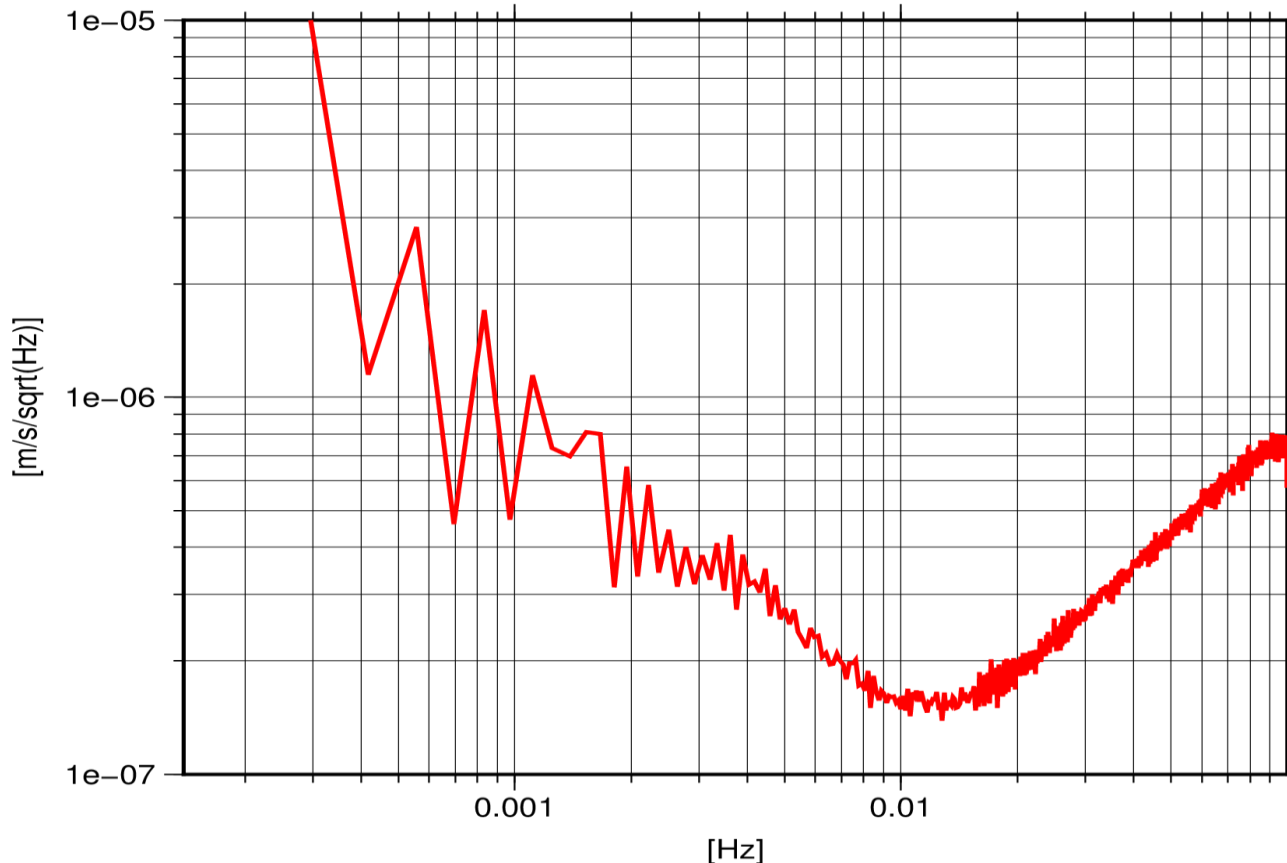


Improved quaternions are used to estimate KBR antenna center corrections



# Noise modelling

KBR Range Rate Power spectrum 2012-01



**Noise covariance function computed by Variance Component Estimation (VCE):**

T. Mayer-Gürr (2013): *Estimation of error covariance functions in satellite gravimetry*,  
IAG General Assembly, Potsdam

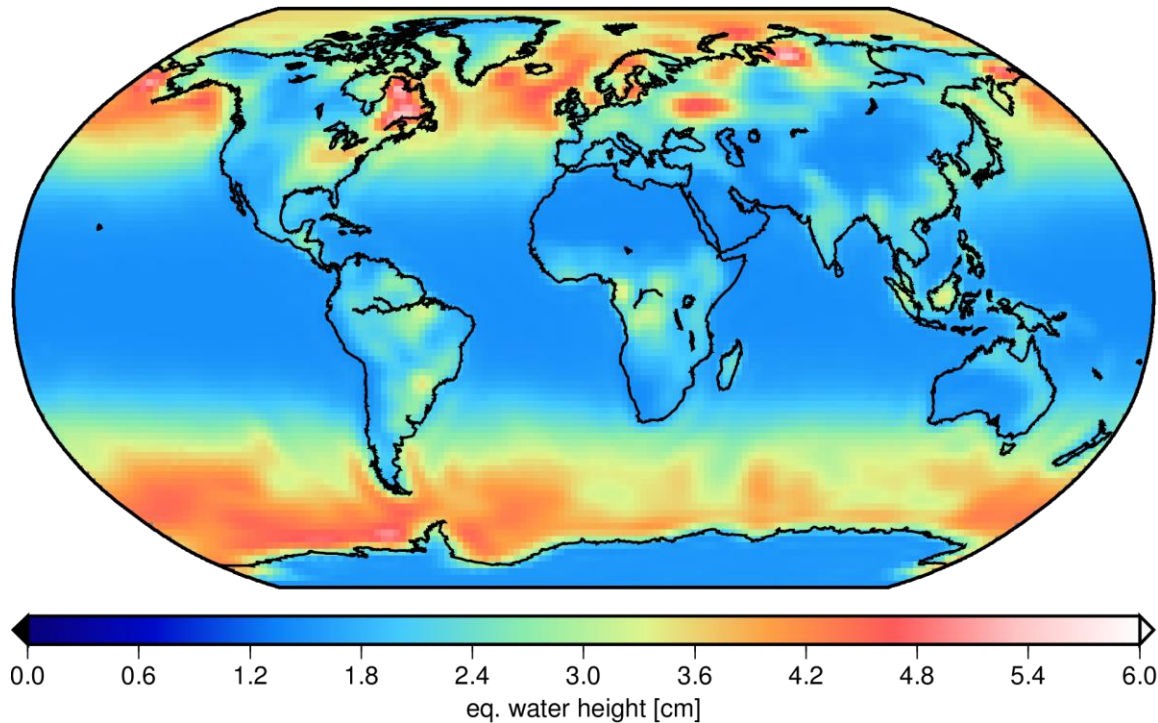


# Co-estimation of daily variations

- Co-Estimation of daily variations (degree  $n=40$ )
- Eliminated from the normal equations
- Regularized according to expected signal

Assumptions about the accuracy of the AOD1B model are needed:  
25 years of models are analyzed to estimate an empirical covariance matrix.

covariance 1976–2000



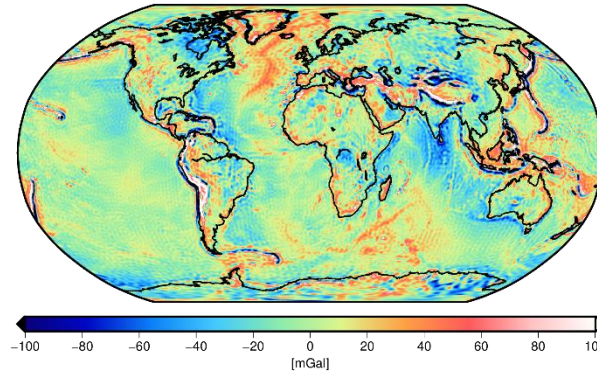
# Content

- ➔ • Processing details
  
- ➔ • High resolution static field
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# ITSG-Grace2014s and ITSG-Grace2014k

## Combined Estimation of

- Static field up to degree 200

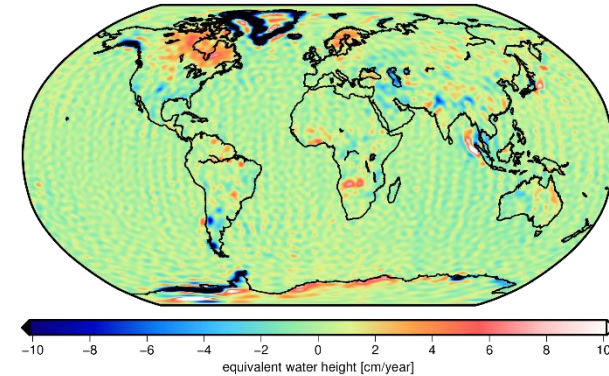
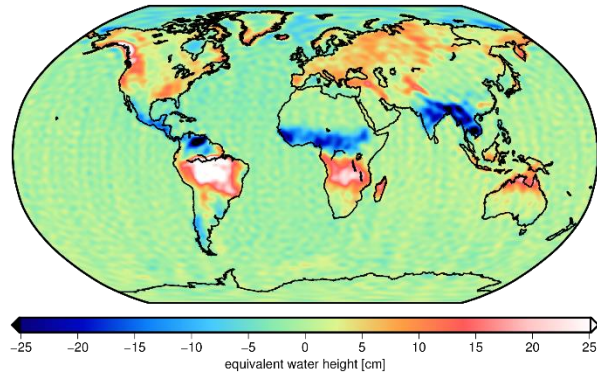
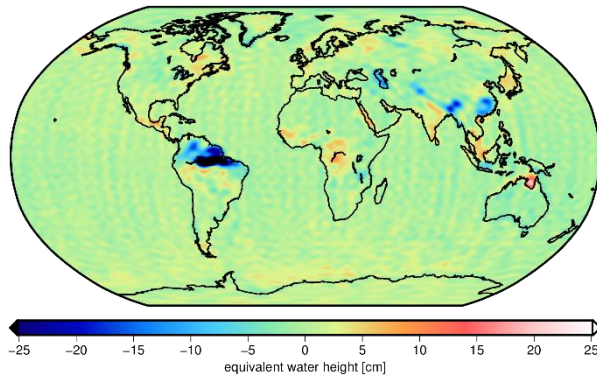


- Temporal variations (degree 100, Kaula type regularized)

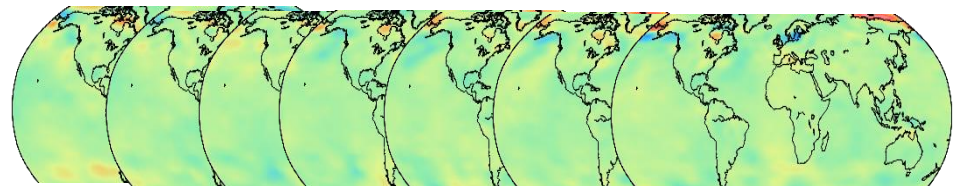
Annual sin

Annual cos

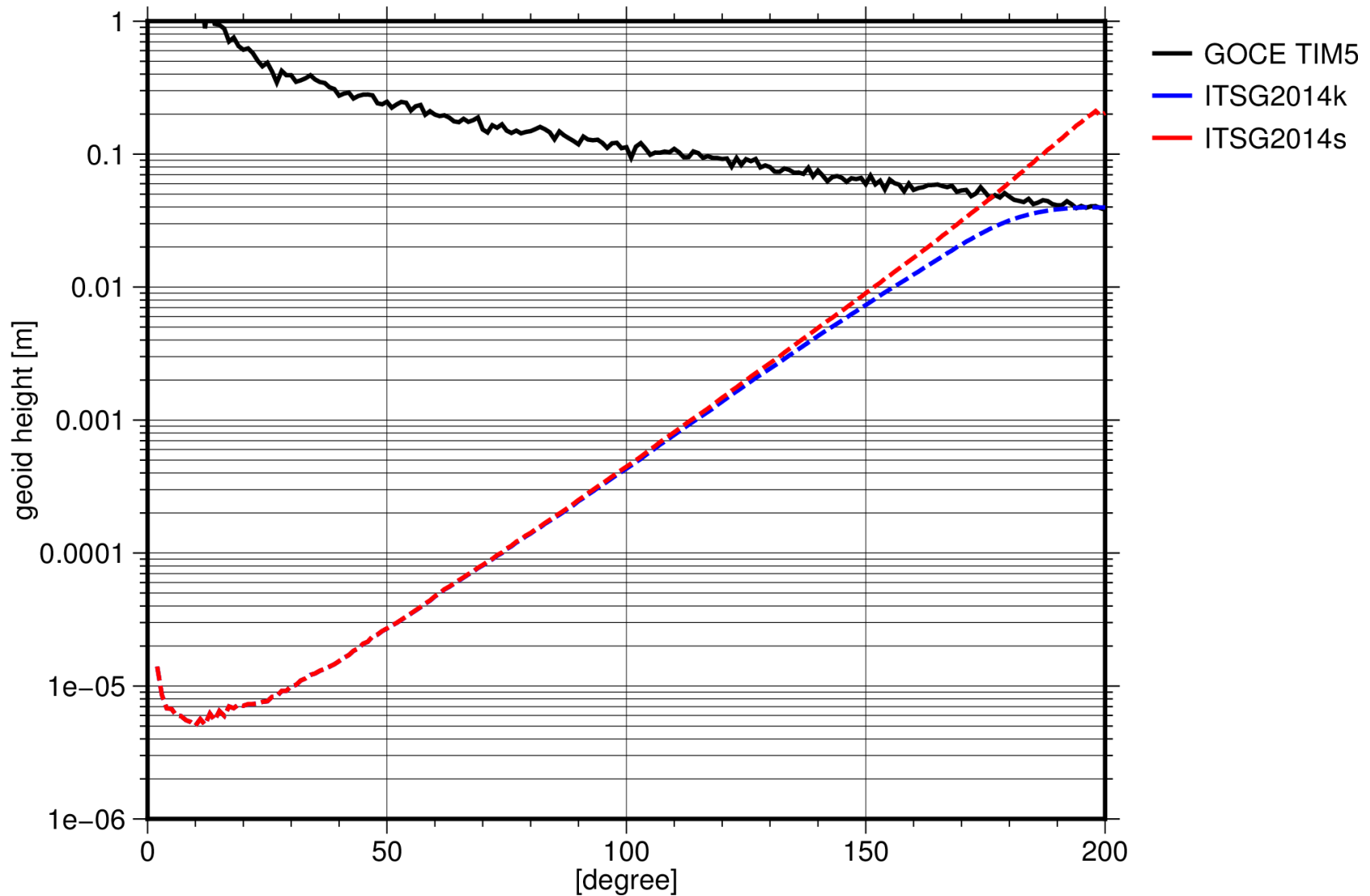
Trend



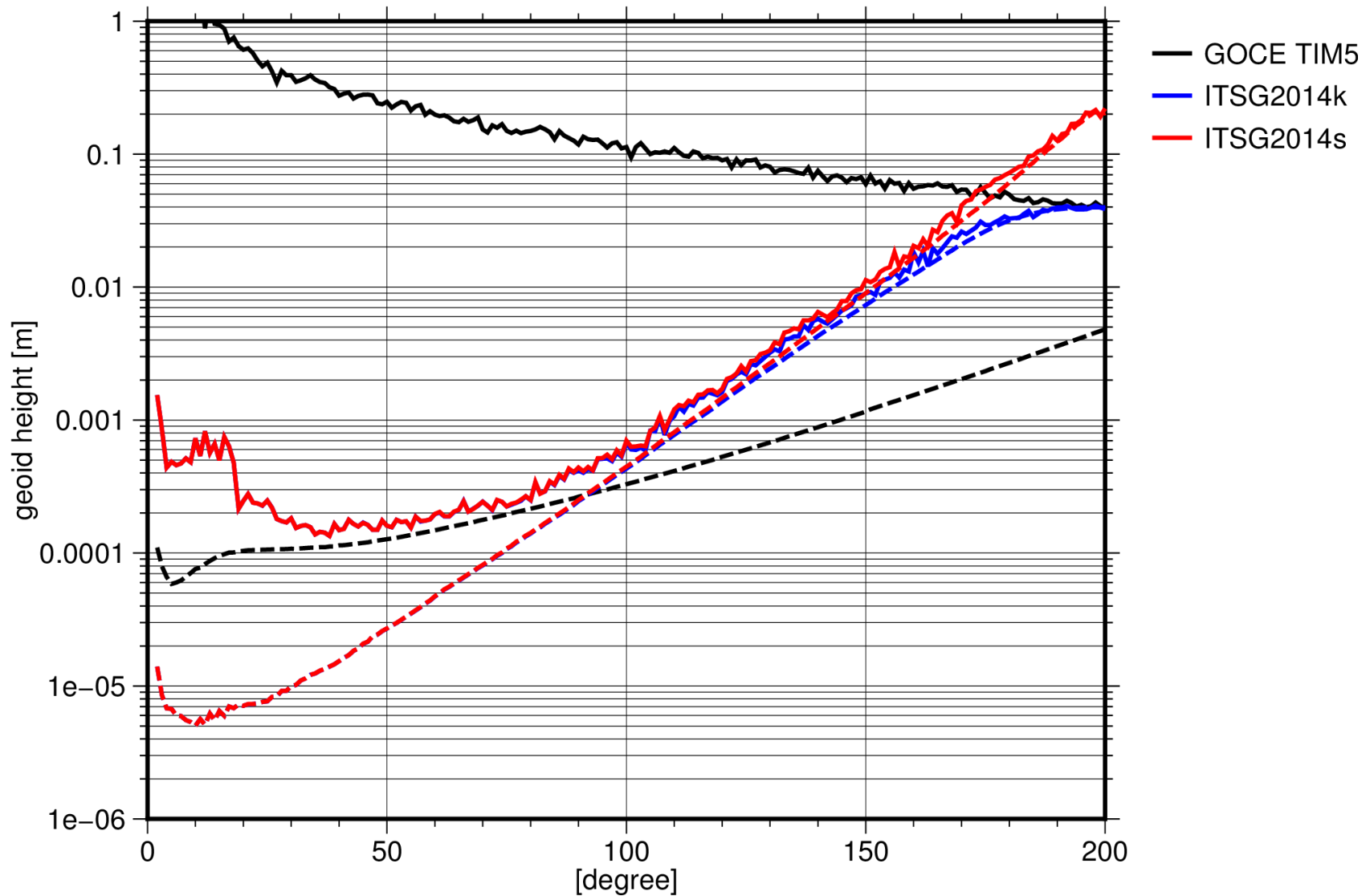
- Daily variations (degree 40, regularized)



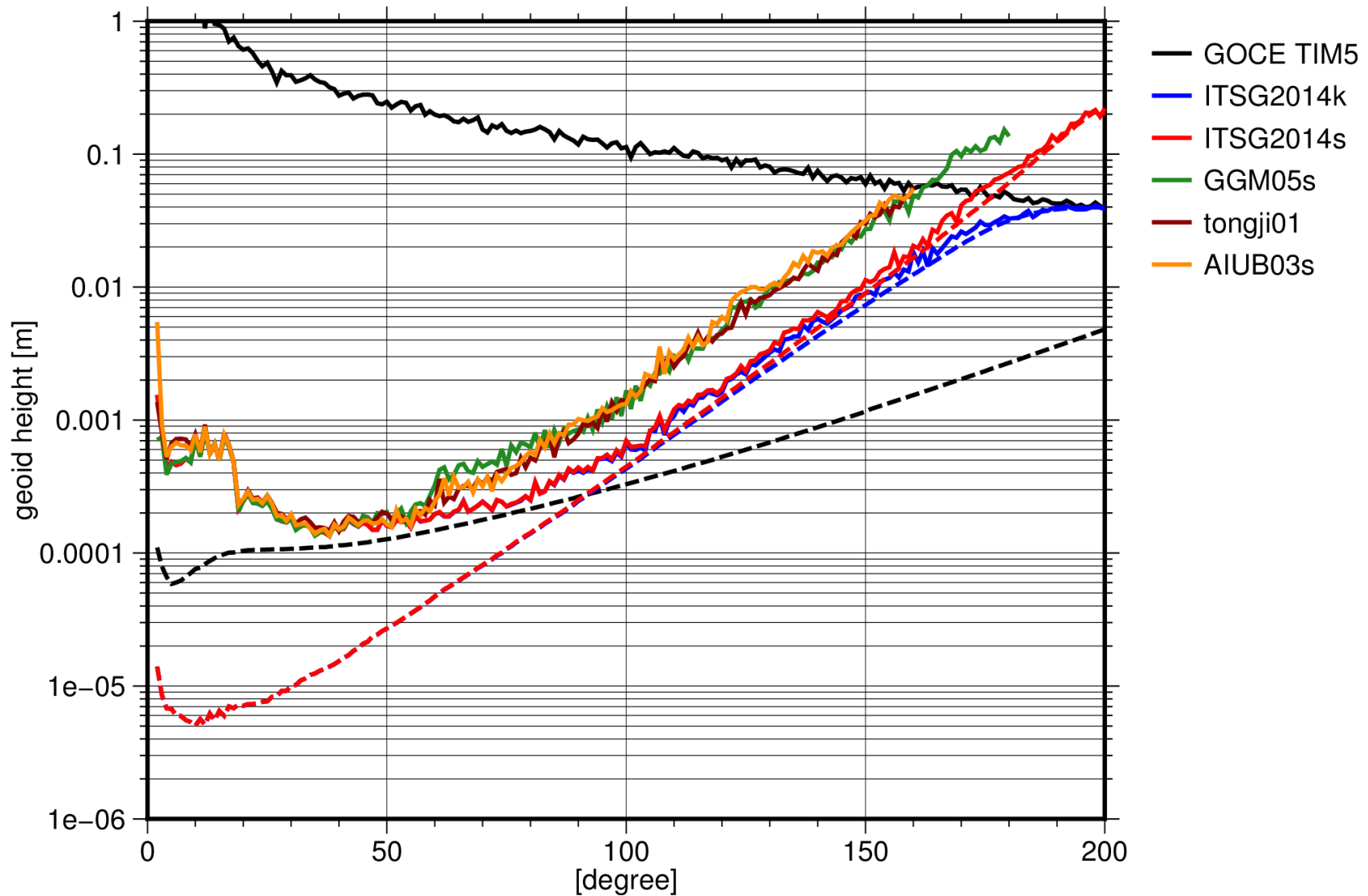
# ITSG-Grace2014s and ITSG-Grace2014k





# ITSG-Grace2014s and ITSG-Grace2014k



# ITSG-Grace2014s and ITSG-Grace2014k

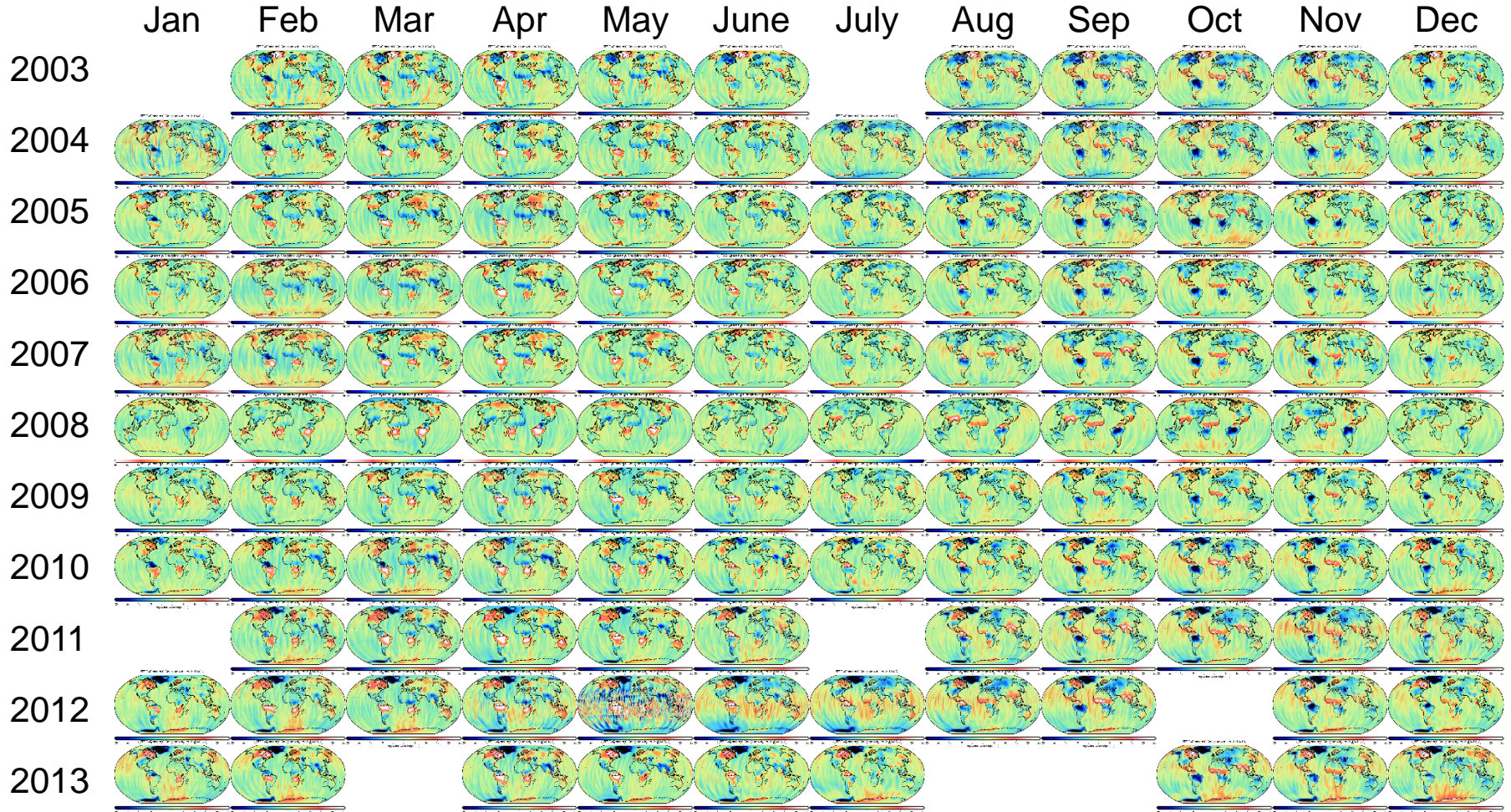


# Content

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# ITSG-Grace2014 Monthly solutions

Unconstrained solutions  
provided with degree  $n=60$ ,  $n=90$ ,  $n=120$

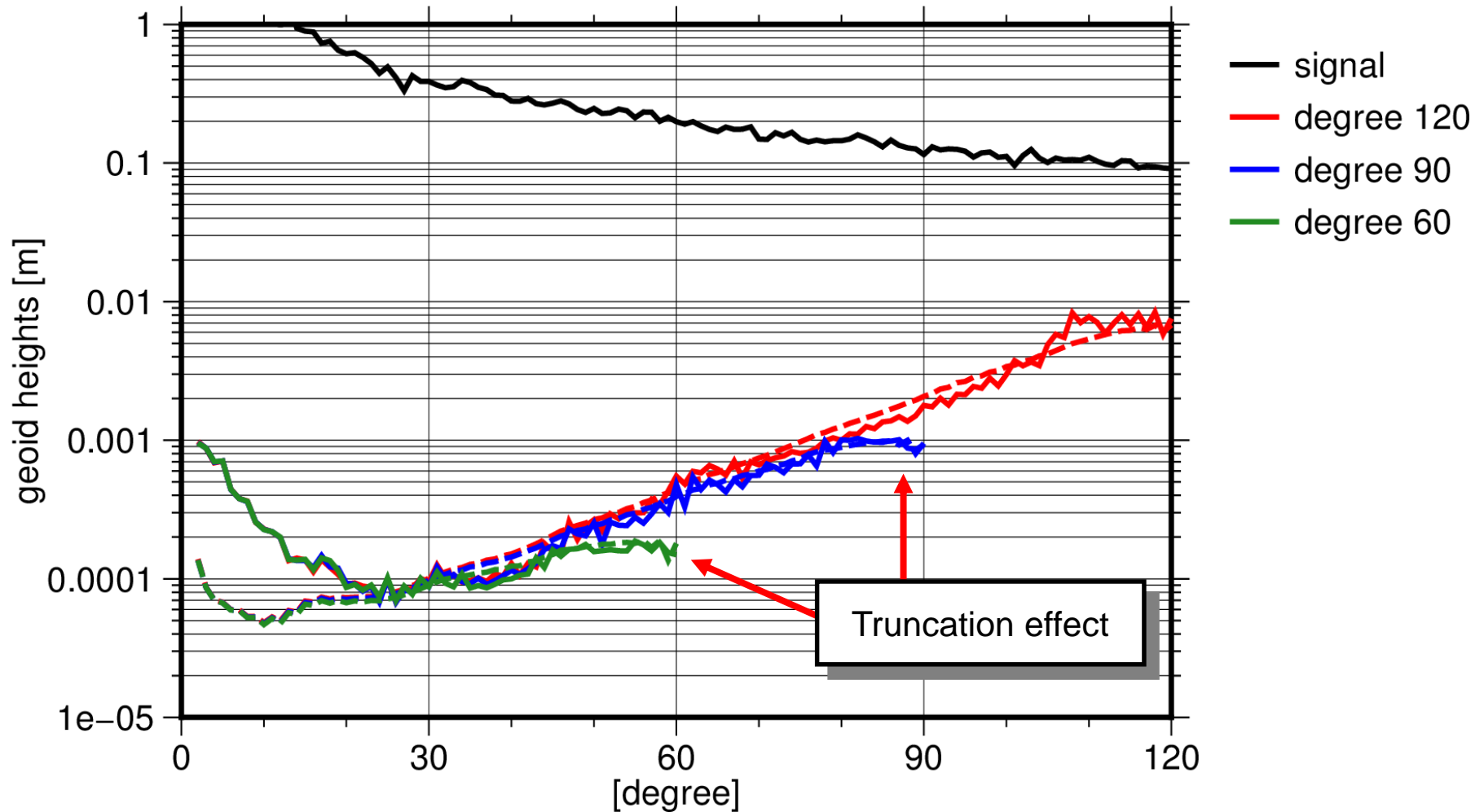




# ITSG-Grace2014 Monthly solutions

Unconstrained solutions  
provided with degree  $n=60$ ,  $n=90$ ,  $n=120$

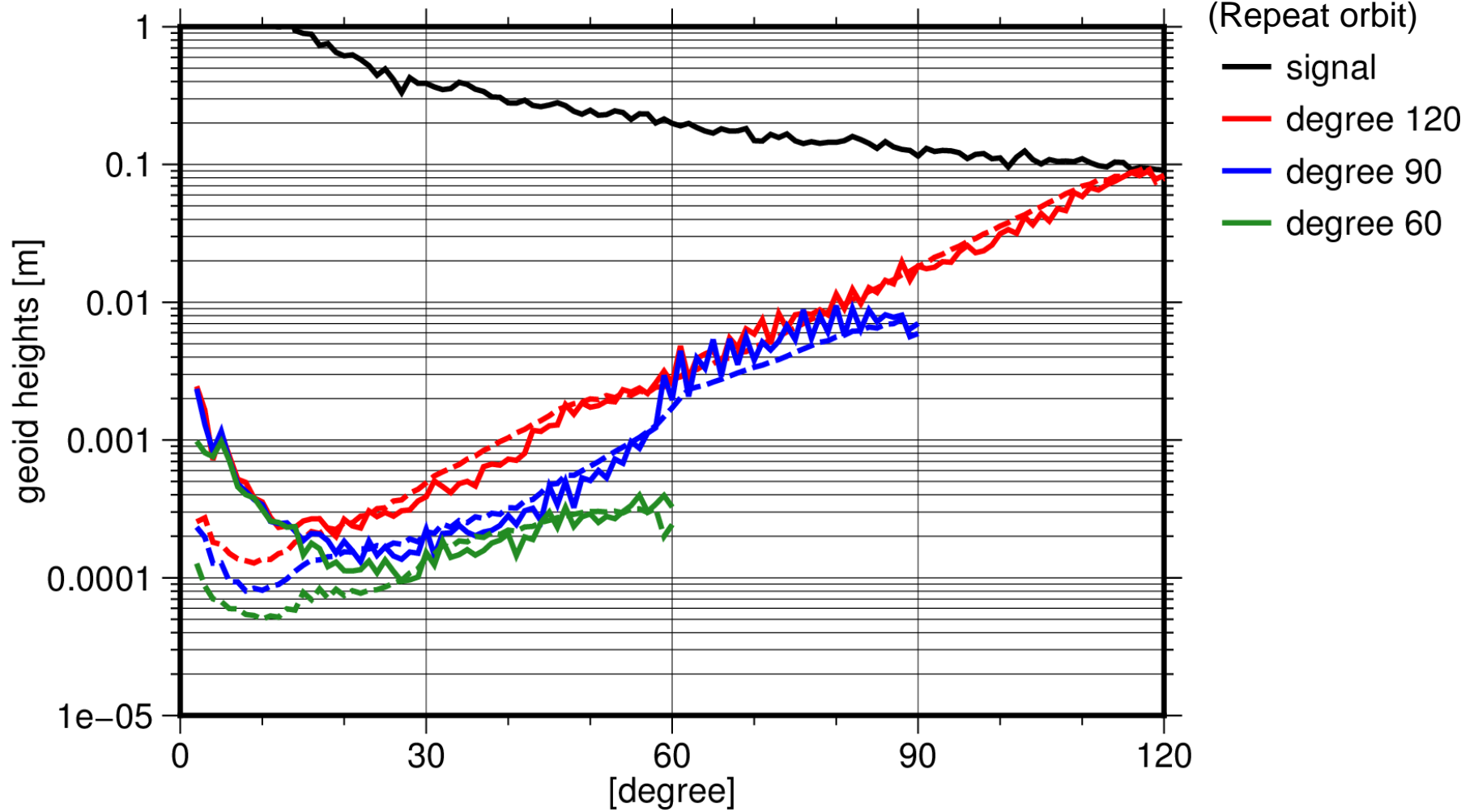
November 2008





# ITSG-Grace2014 Monthly solutions

Unconstrained solutions  
provided with degree  $n=60$ ,  $n=90$ ,  $n=120$

September 2004  
(Repeat orbit)

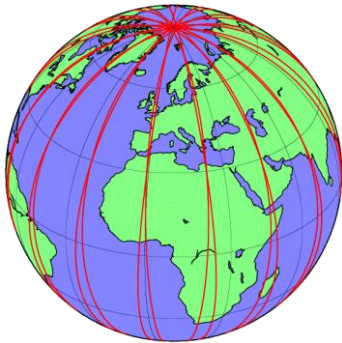


# Content

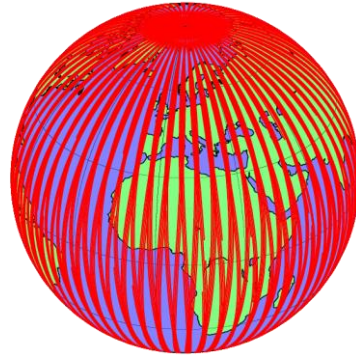
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# Daily Kalman solutions

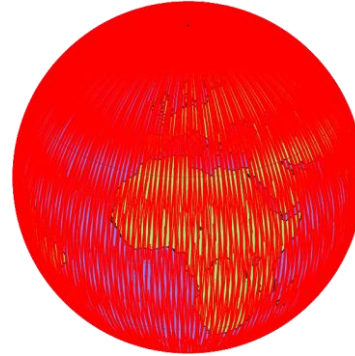
1. Data of one day is not sufficient



1 day



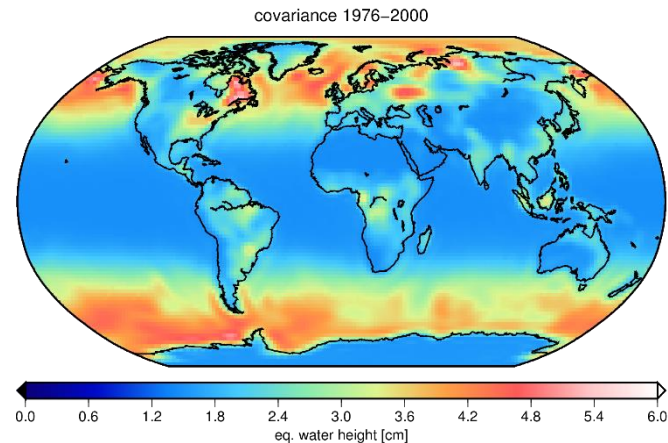
15 days



30 days

2. Stochastic prediction from previous day  
(Collocation):

$$\mathbf{x}_{i+1} = \Sigma_{i+1,i} \Sigma_{i,i}^{-1} \mathbf{x}_i$$

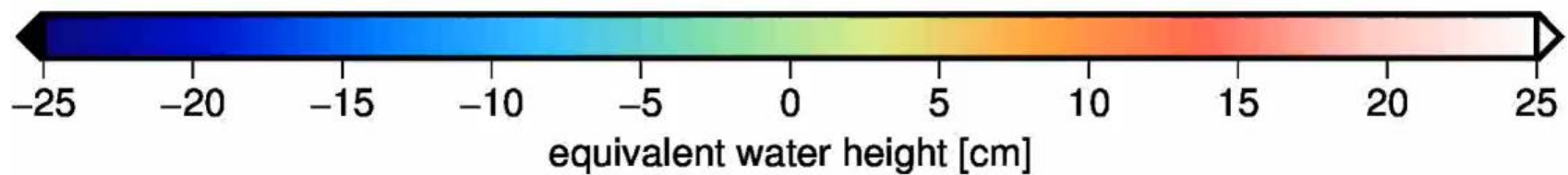
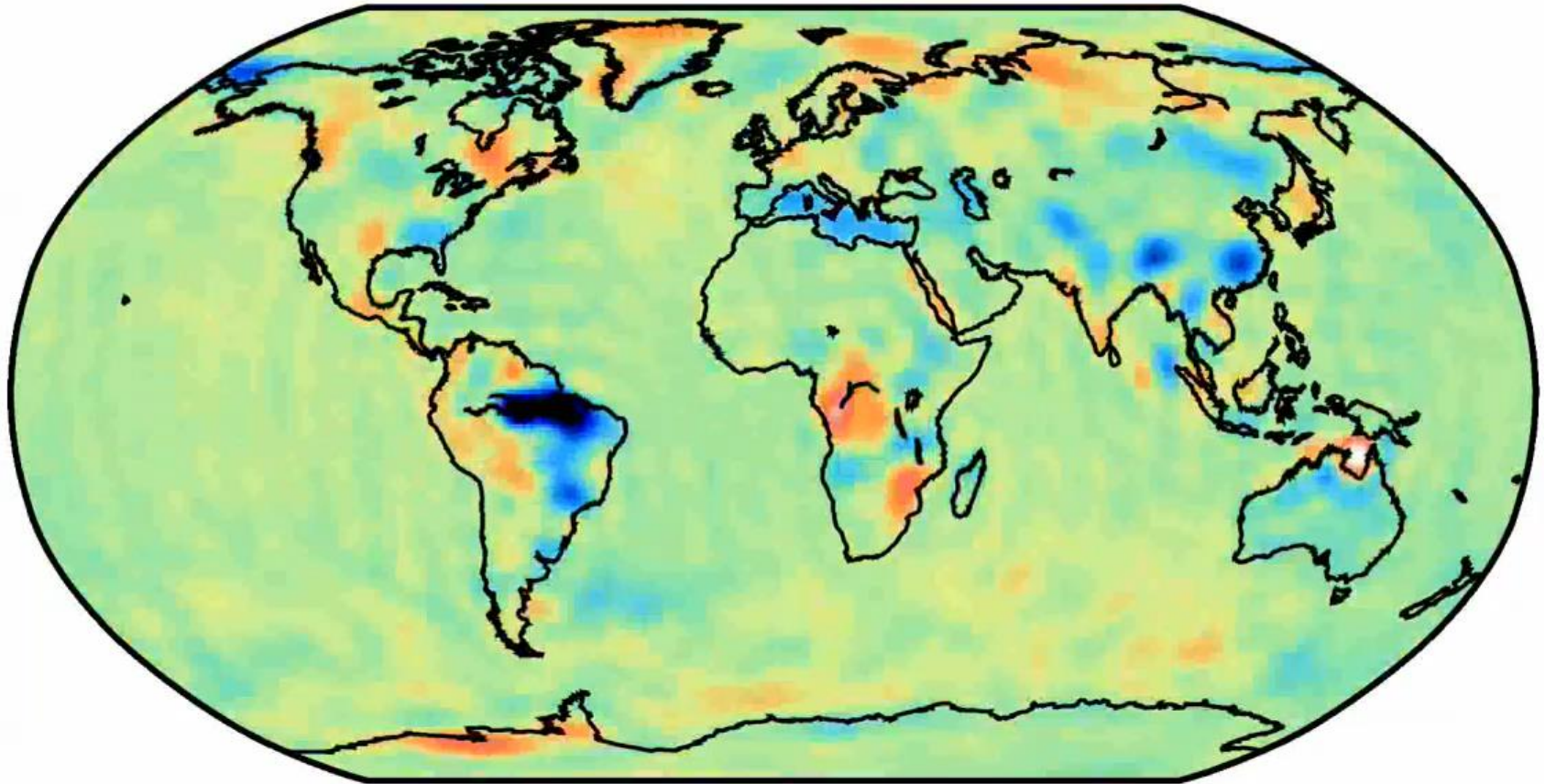


3. Combination with daily GRACE normals with a Kalman smoother



4. ITSG-Grace2014s annual and trend as fallback (for days without data)

# Daily Kalman solutions

ITSG-Grace2014 (2008-01-02)



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# ITSG-Grace2014

## High resolution static field

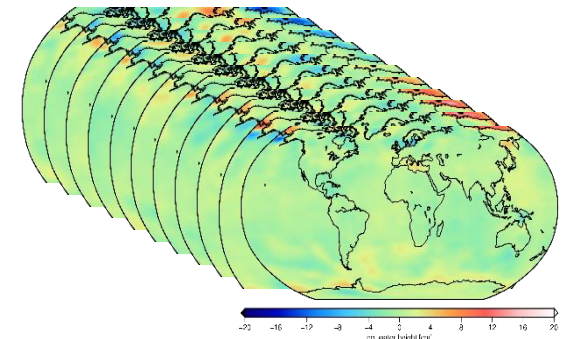
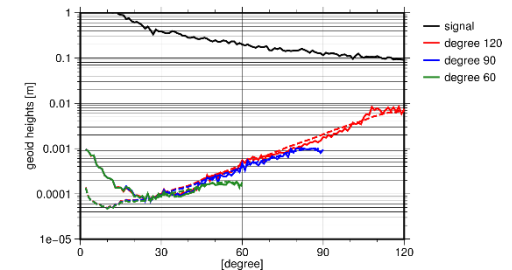
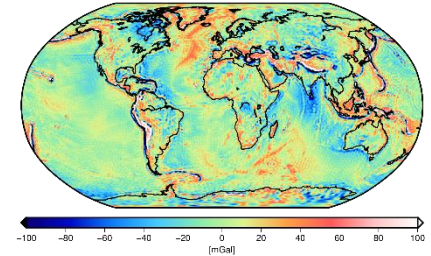
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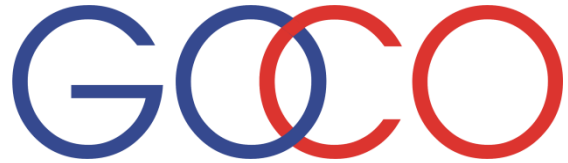
- Degree 60, 90, 120
- Full variance-covariances matrices are published

## Daily Kalman smoothed solutions

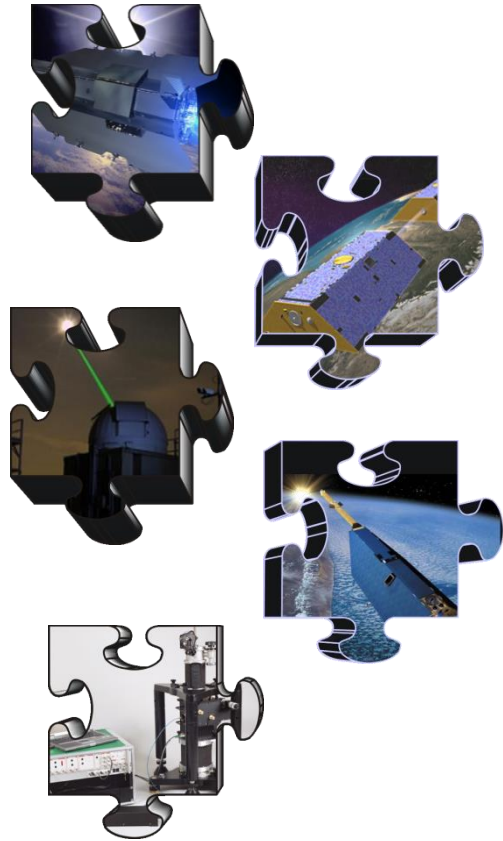
- Degree 40



[itsg.tugraz.at/research/ITSG-Grace2014](http://itsg.tugraz.at/research/ITSG-Grace2014)



# Gravity Observation Combination ([www.goco.eu](http://www.goco.eu))



Coming soon:

- ITSG-GRACE2014s
- GOCE TIM 5
- SLR
- Kinematic orbits from  
CHAMP, TerraSar, TandemX, Cosmic, ...