

# The new ITSG-Grace2016 release

Beate Klinger, Torsten Mayer-Gürr, Saniya Behzadpour, Matthias Ellmer,  
Andreas Kvas and Norbert Zehentner

Institute of Geodesy  
NAWI Graz, Graz University of Technology

# Outline

- ITSG-Grace2016
- Processing details
- Unconstrained monthly solutions
- Summary & Conclusions

# ITSG-Grace2016

## Method:

- Variational equations
- 24h arc length
- 3h covariance length

## Input:

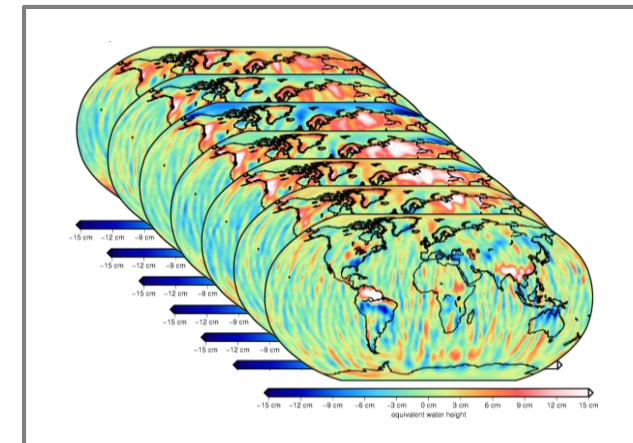
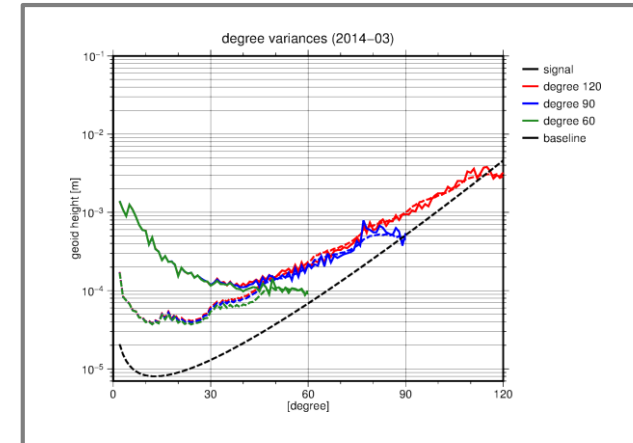
- GRACE Level-1B data from 2002-04 to 2016-01
- ITSG orbit product (Zehentner et al. 2015)
- Improved satellite attitude (Klinger et al. 2014)

## Unconstrained monthly solutions:

- Degree 60, 90, 120
- Full normal equations in SINEX format are published

## Daily Kalman smoothed solutions:

- Degree 40



# ITSG-Grace2016

## Background models:

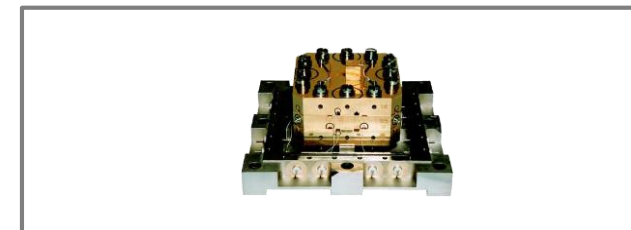
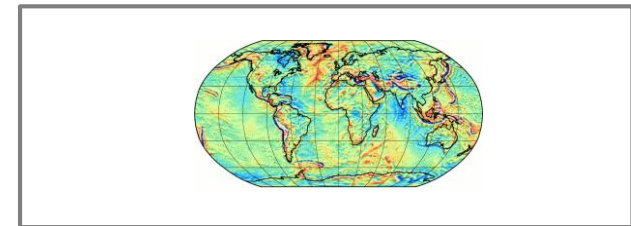
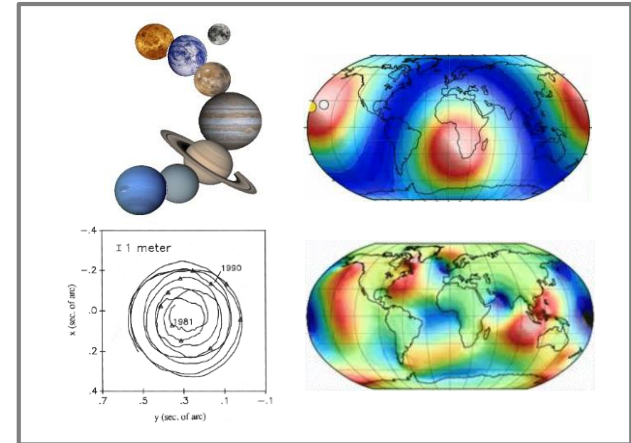
- Third body forces: JPL DE421
- Solid earth tides: IERS 2010
- Pole tides: IERS 2010
- Ocean tides: EOT11a
- Ocean pole tides: Desai 2004
- Atmospheric tides: Van Dam & Ray 2010
- Dealiasing: AOD1B RL05
- Relativistic effects: IERS 2010

## Restored models:

- Static field: GOCO05s
- Trend, Annual: GOCO05s

## Non-gravity parameters:

- Once per day: satellite state vector
- Once per day: accelerometer bias per axis (basis splines)
- Once per day: accelerometer scale factors



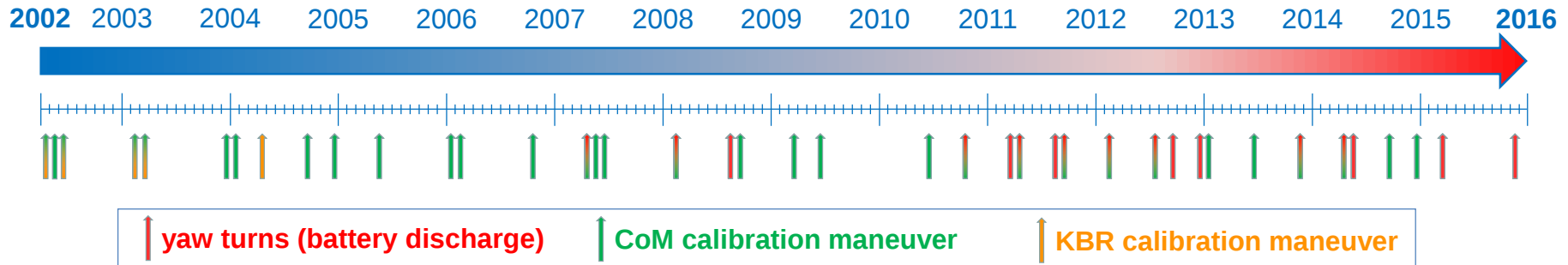
# Processing details

# Improvements since ITSG-Grace2014

## Multiple improvements within the processing chain:

- 1) Updated background models
- 2) Instrument data screening
- 3) Improved accelerometer calibration
- 4) Improved numerical orbit integration
- 5) Improved covariance function estimation
- 6) Co-estimation of constrained daily variations:  
constraints based on improved error estimates for the dealiasing models

# Data screening

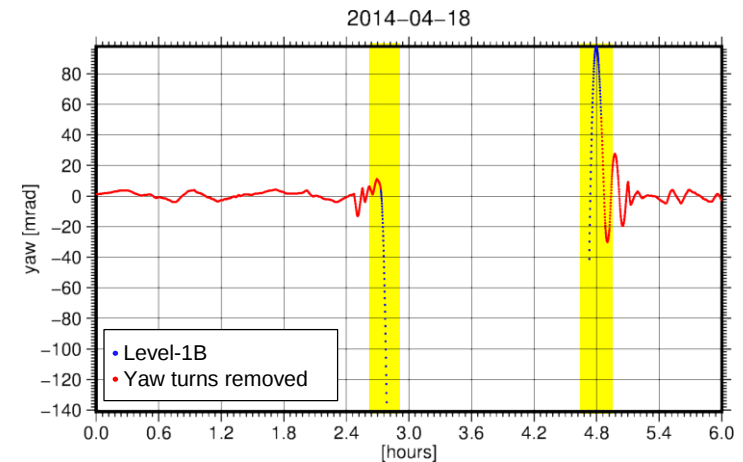


## Exclusion of:

- Time periods around yaw-turns:  
based on inter-satellite pointing angles (yaw)
- CoM and KBR calibration maneuvers (SoE file)

## Threshold-based outlier detection:

- To detect large-scale outliers
- Based on ACC1B data & simulated ACC1B data



# Accelerometer calibration

## Accelerometer bias & scale factors:

- Two-step approach: a-priori calibration for data screening
- Calibration equation:  $\mathbf{a}_{\text{true}} = \mathbf{S} \mathbf{a}_{\text{obs}} + \mathbf{b}$

with  $\mathbf{S} = \begin{bmatrix} s_x & \alpha + \zeta & \beta - \epsilon \\ \alpha - \zeta & s_y & \gamma + \delta \\ \beta + \epsilon & \gamma - \delta & s_z \end{bmatrix}$

- Main-diagonal elements
- Shear parameter
- Rotation parameter

## (1) Bias:

- Estimation: once per day
- Parameterization: uniform cubic basis splines (UCBS), with a 6h knot interval

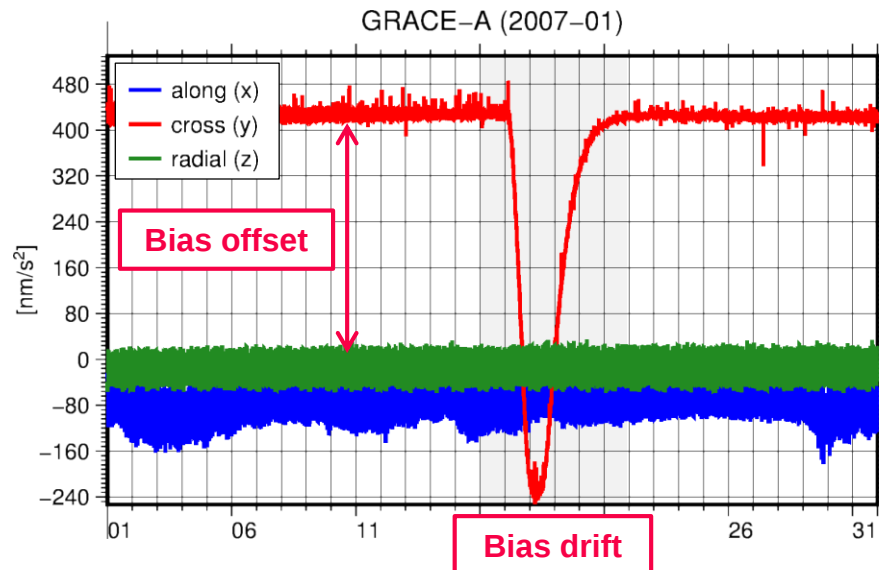
## (2) Scale factors:

- Estimation: once per day
- Parameterization: fully-populated scale factor matrix
- Off-diagonal elements: non-orthogonality of accelerometer axes (cross-talk), misalignment between SRF and AF

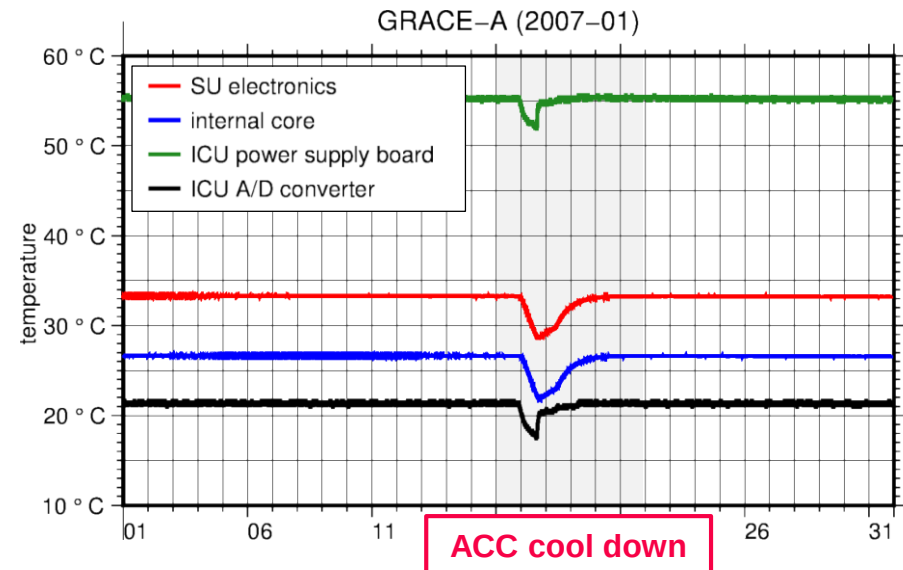
# Accelerometer calibration

- Temperature-dependent behavior (bias & scale factors)
- Parameterization significantly affects C20 coefficients

**Accelerations - ACC1B**  
(calibrated according to TN-02)

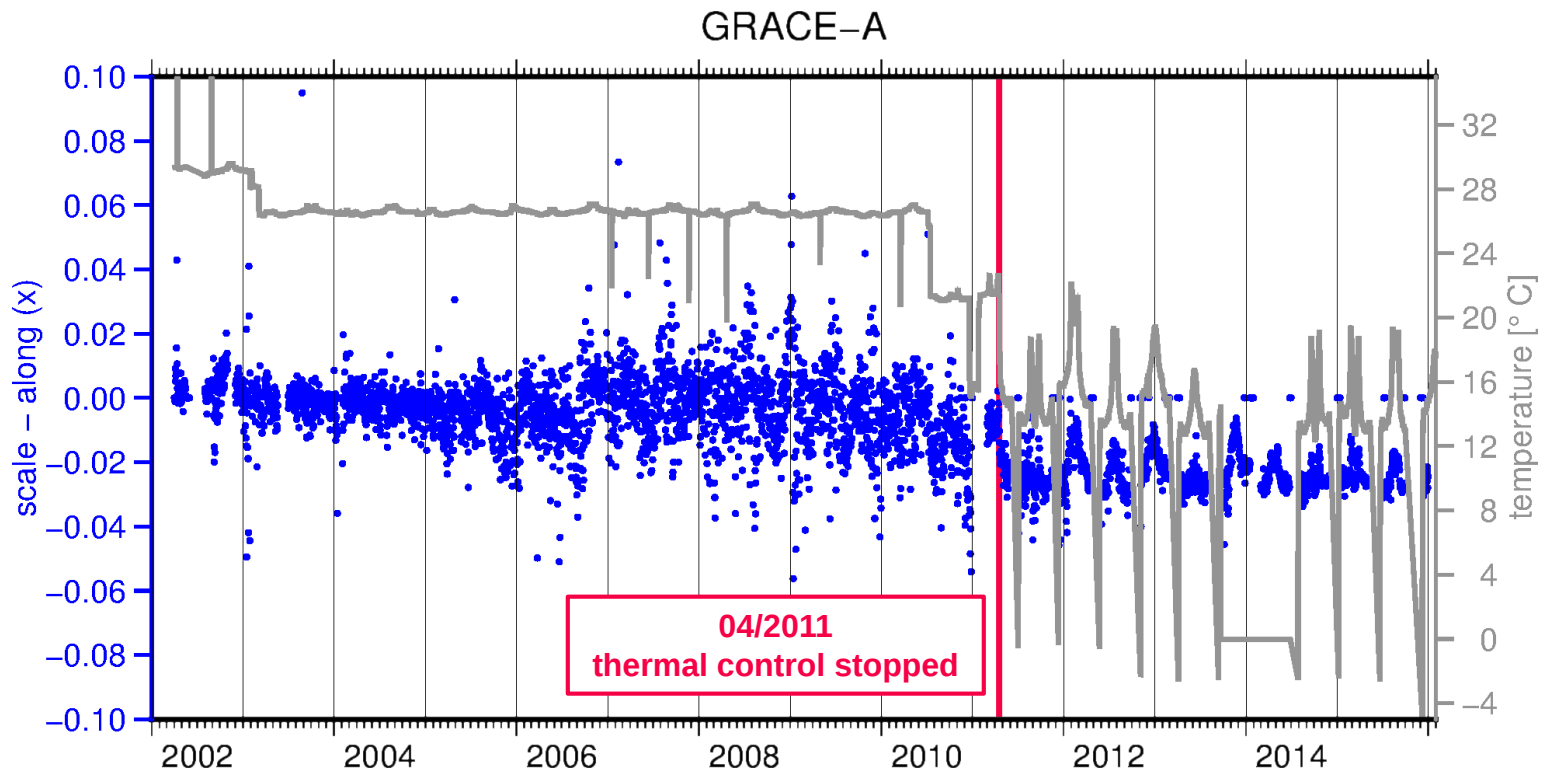


**Temperature - AHK1B**



# Accelerometer calibration

- **Temperature-dependent behavior** (bias & scale factors)
- **Parameterization significantly affects C20 coefficients**

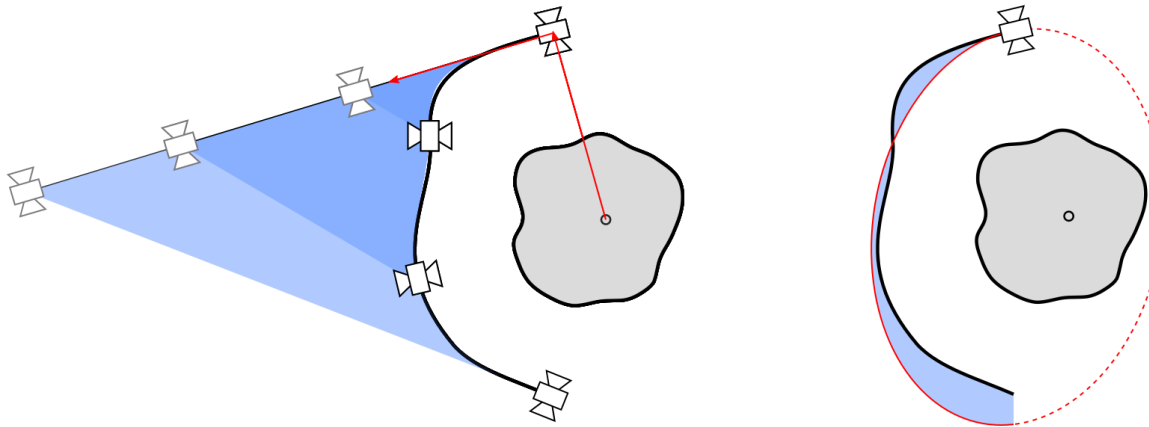


⇒ Paper on this topic in preparation!

# Orbit integration

## Elliptical reference orbit replaces linear motions:

- Improved force model integration for dynamic orbit computation (Encke's method)
- Reduced processing artifacts in adjusted SST observations and residuals

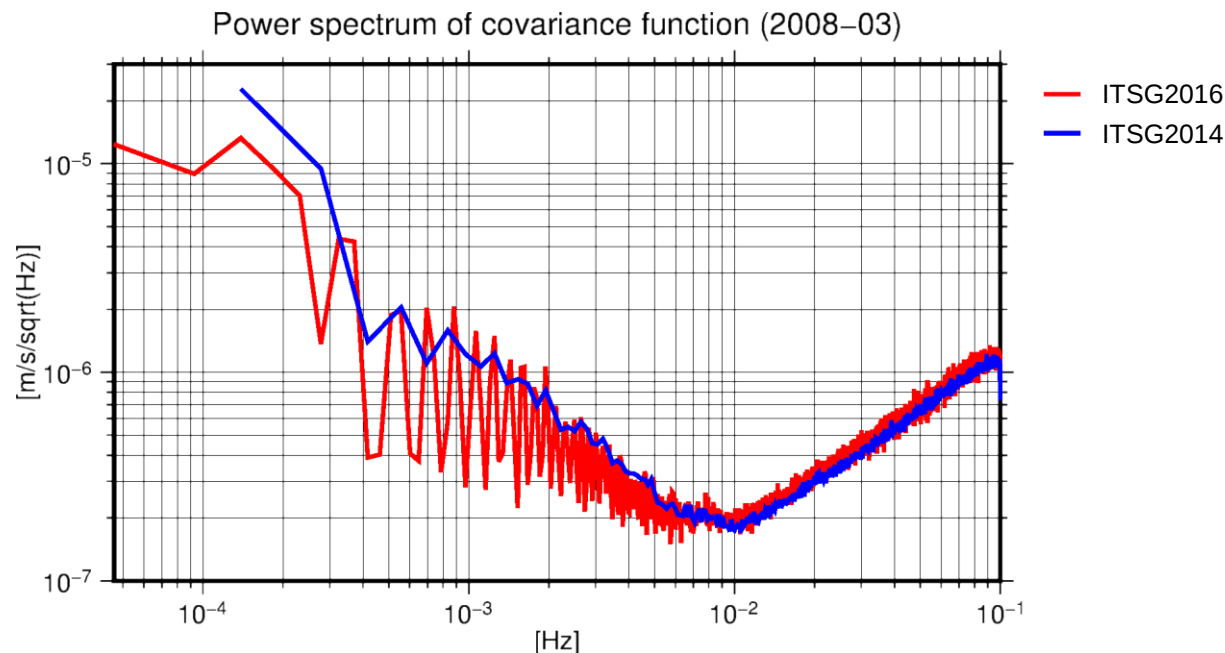


**Thu, 17:30-19:30 | Posters | Hall X2**

Matthias Ellmer & Torsten Mayer-Gürr: *Numerically stable approach for high-precision orbit integration using Encke's method and equinoctial elements*

# Noise modeling – covariance function

- **Empirical covariance function:** decorrelation of KBR range-rate data
- **Robust covariance estimator:** guarantees outlier-resistant covariance estimation

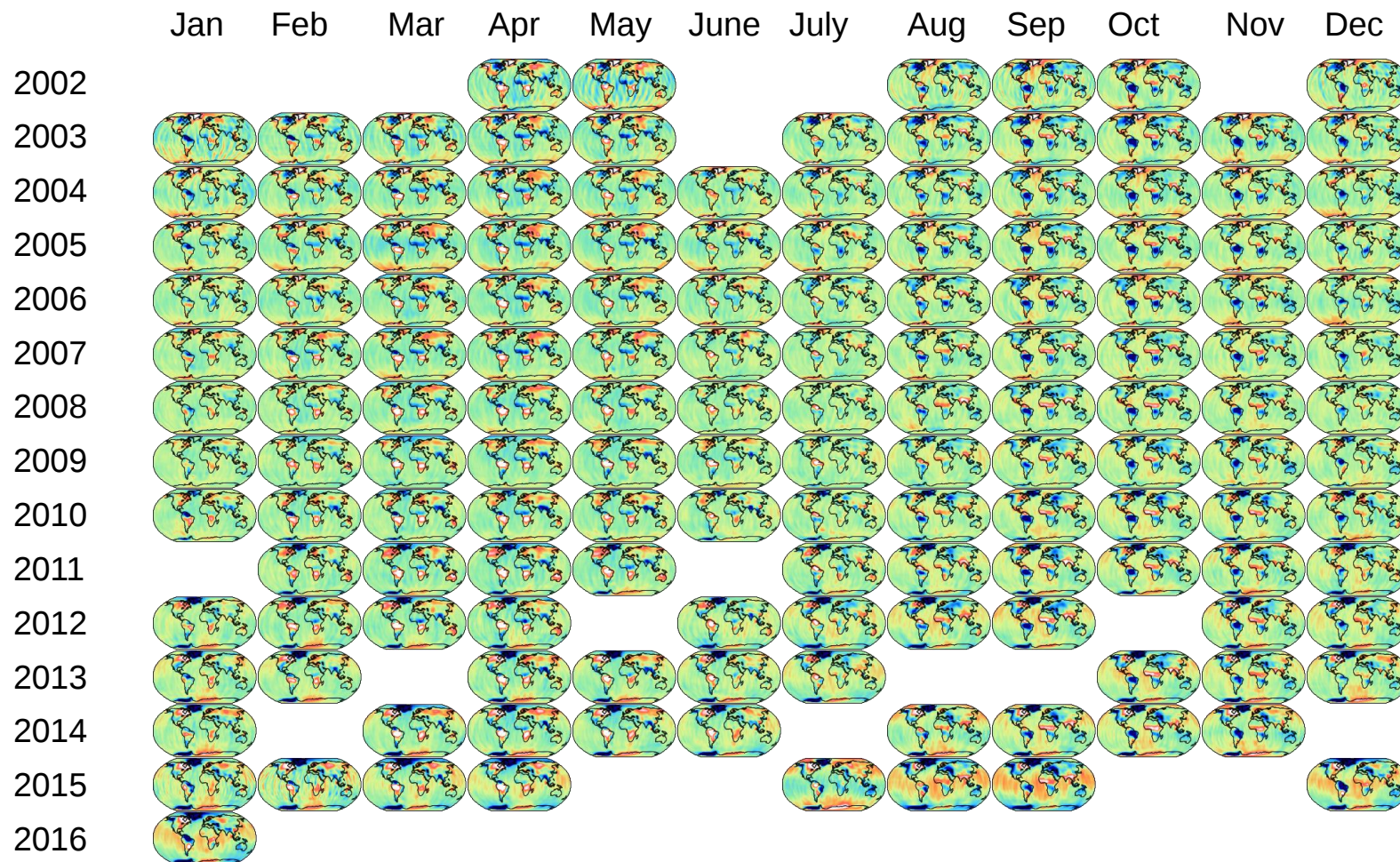


**Wed, 17:30-19:00 | Posters | Hall X3**

Saniya Behzadpour, Torsten Mayer-Gürr & Jakob Flury: *Robust estimation of error covariance functions in GRACE gravity field determination*

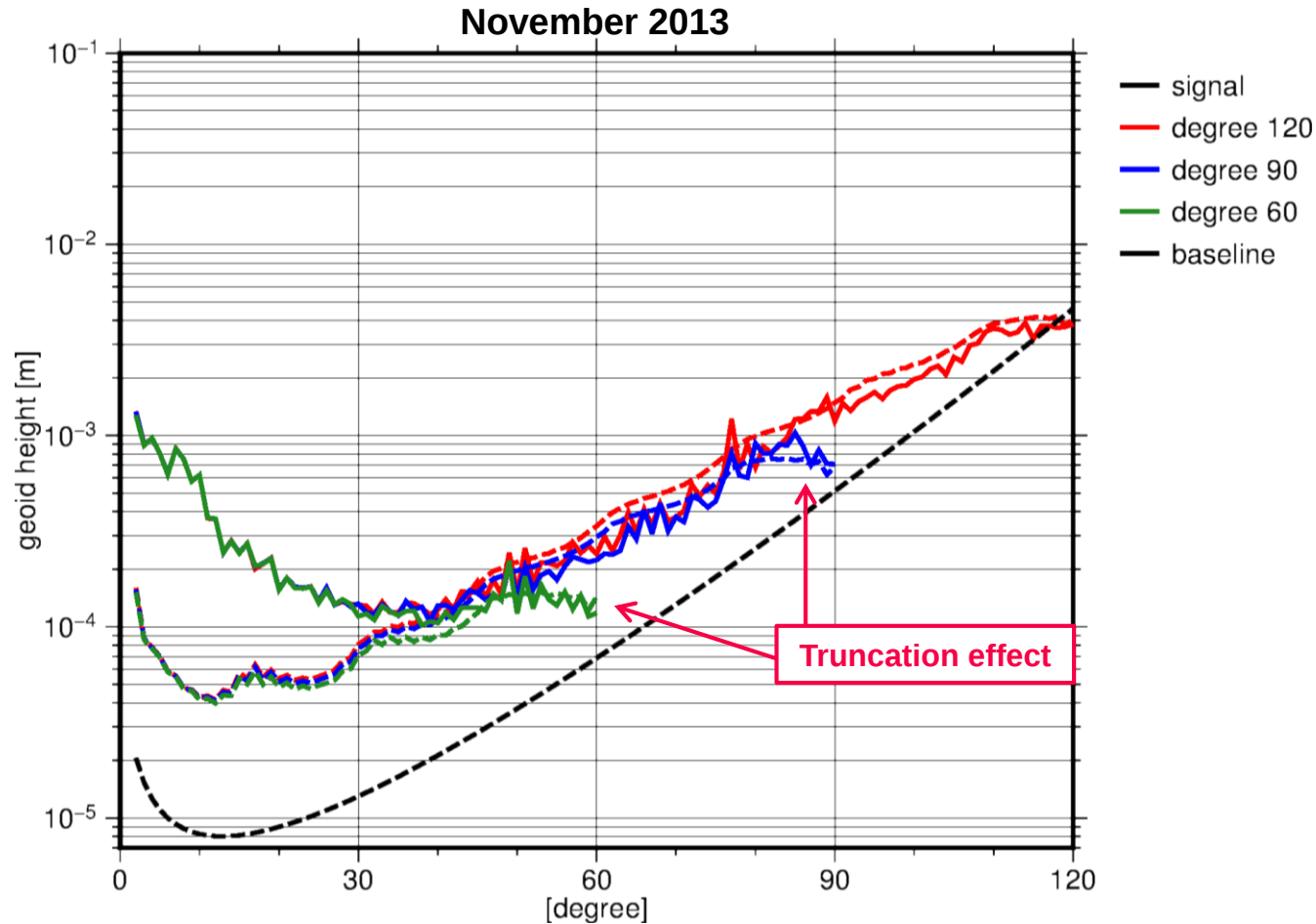
# Unconstrained monthly solutions

# ITSG-Grace2016 Monthly Solutions



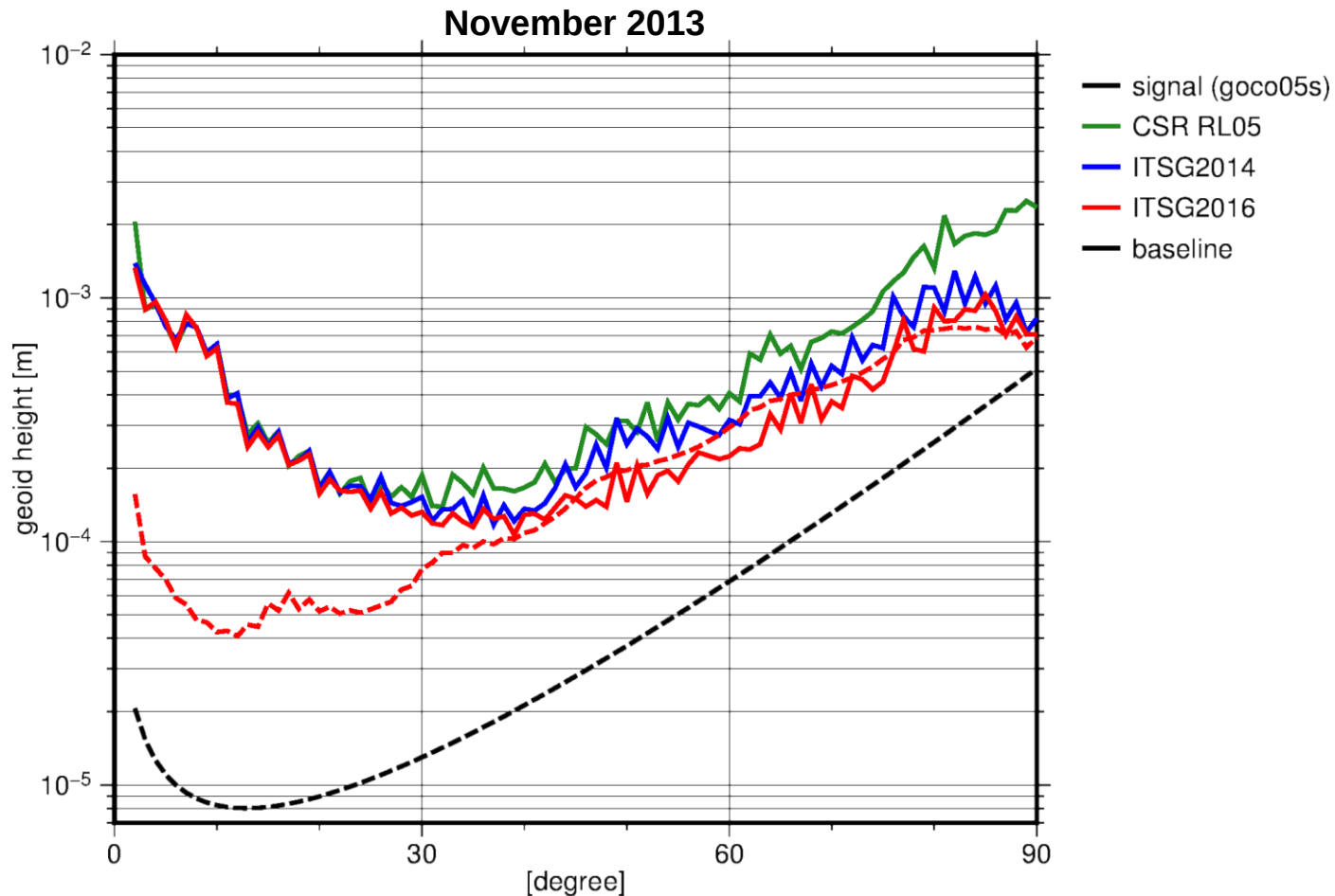
# ITSG-Grace2016 Monthly Solutions

Unconstrained monthly solutions: degree 60, 90 and 120



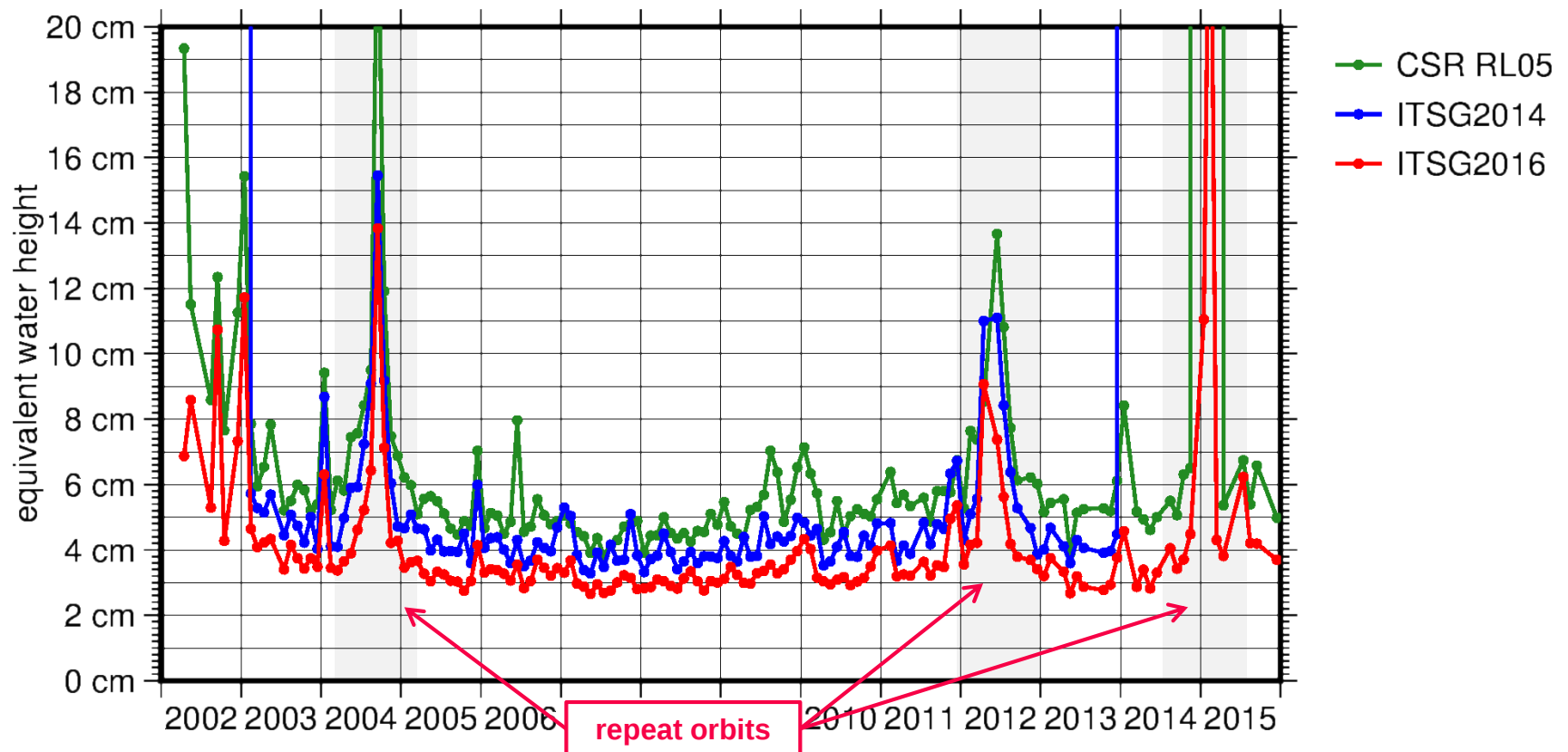
# ITSG-Grace2016 Monthly Solutions

Unconstrained monthly solutions: degree 60, 90 and 120



# Variability over the Oceans

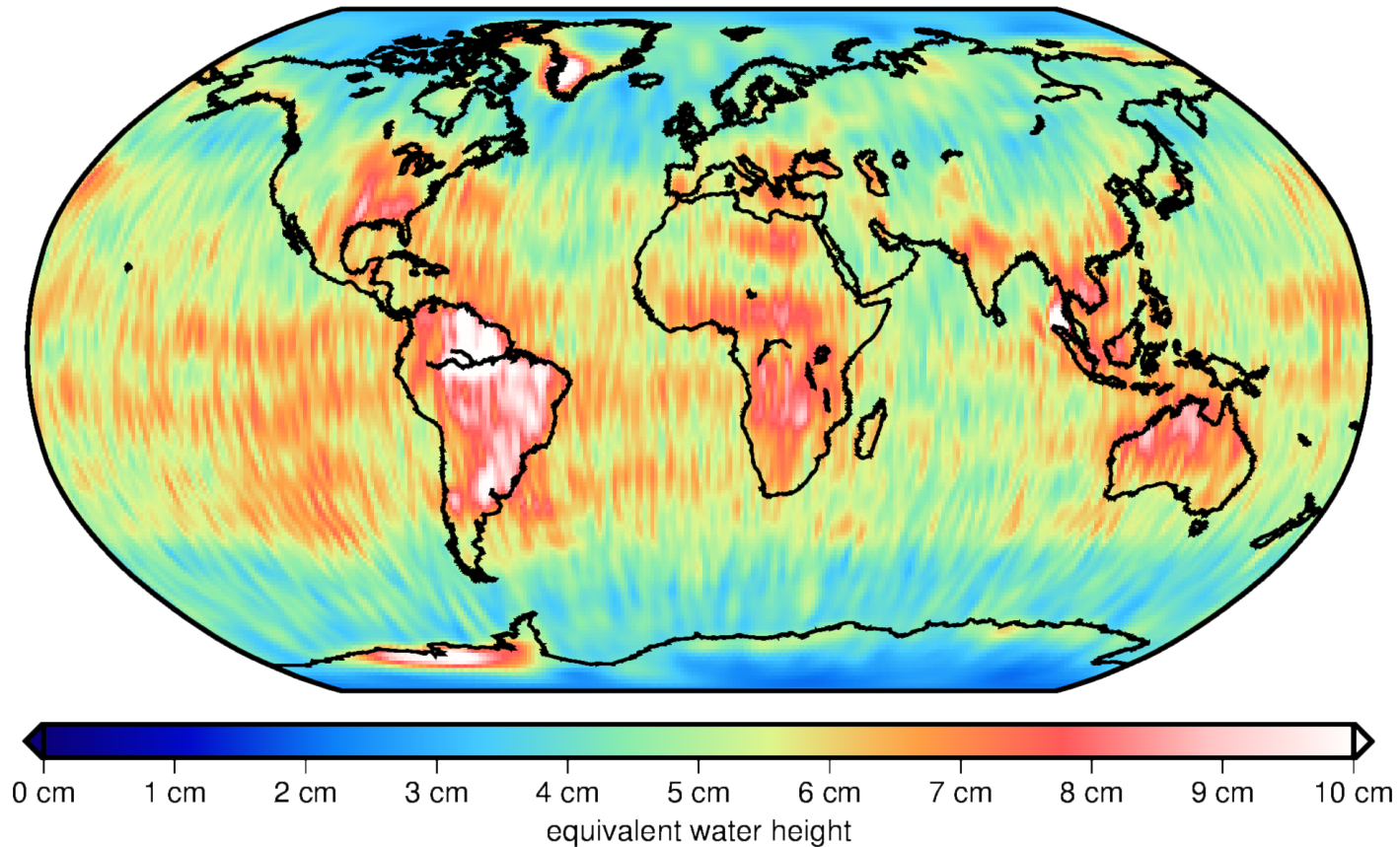
Trend/Annual/Semiannual reduced (Gauß 300km)



# Temporal RMS

CSR RL05 - trend/SA/SSA (Gauß 300km)

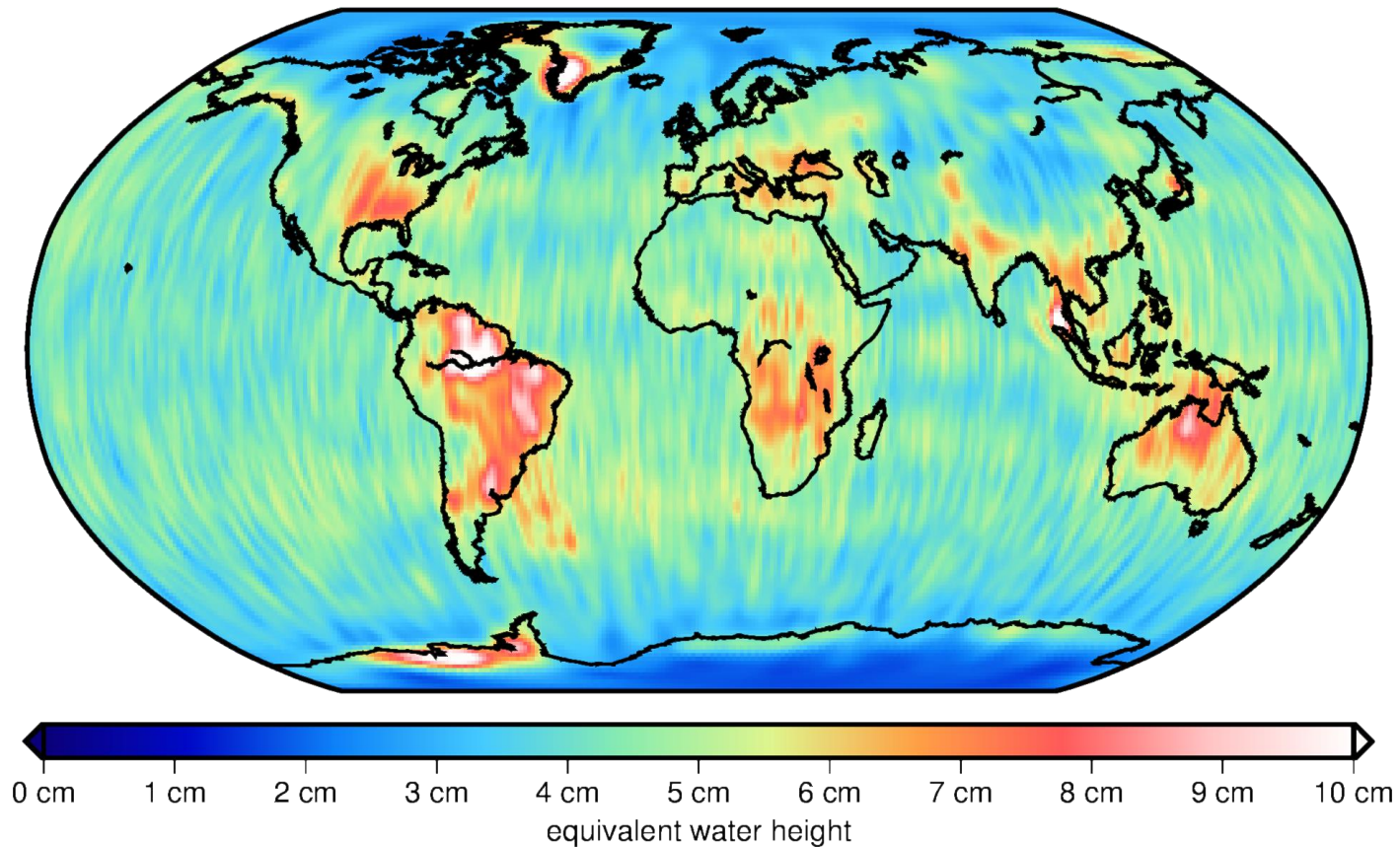
RMS = 5.5901



# Temporal RMS

ITSG-Grace2014 - trend/SA/SSA (Gauß 300km)

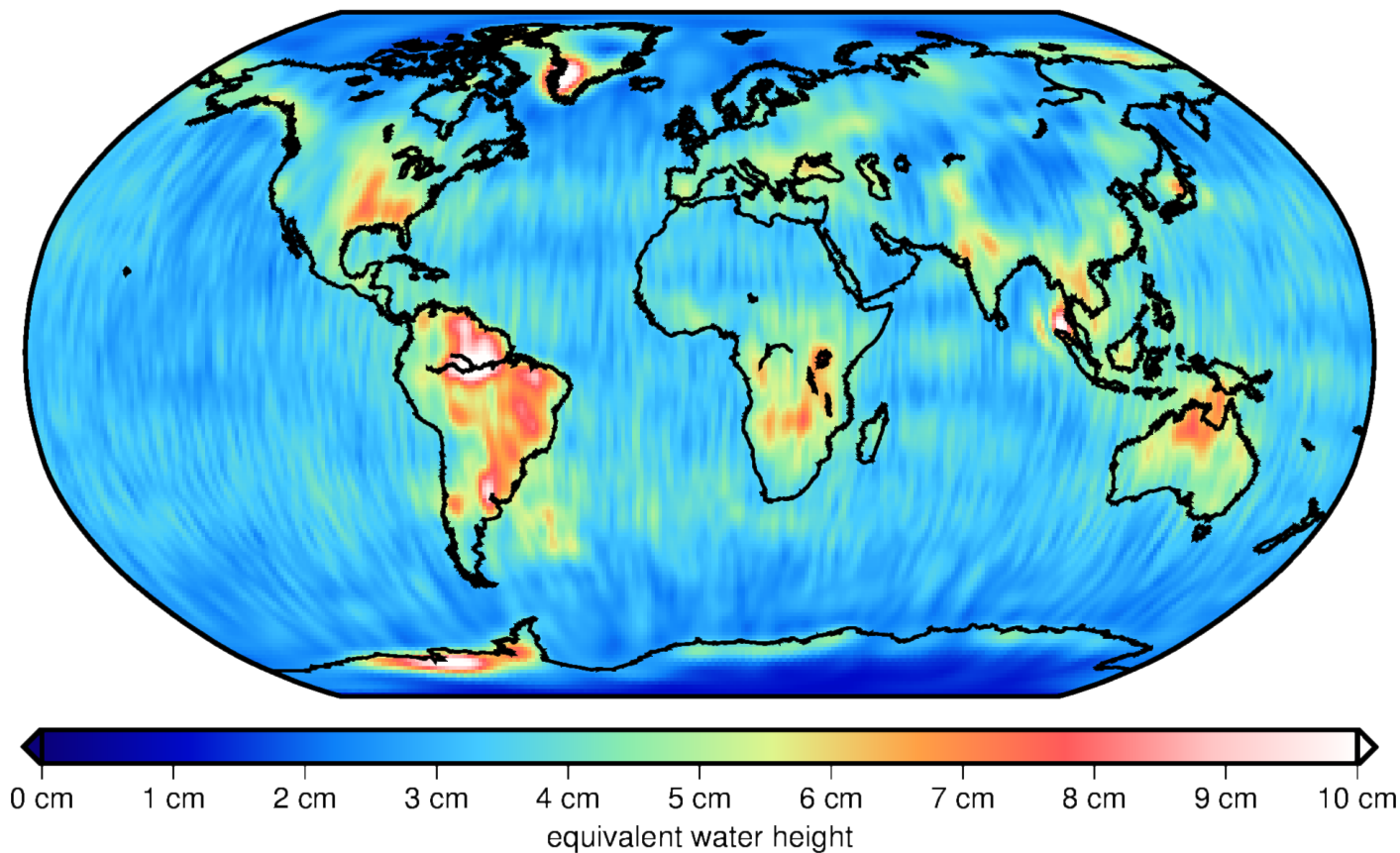
RMS = 4.6011



# Temporal RMS

ITSG-Grace2016 - trend/SA/SSA (Gauß 300km)

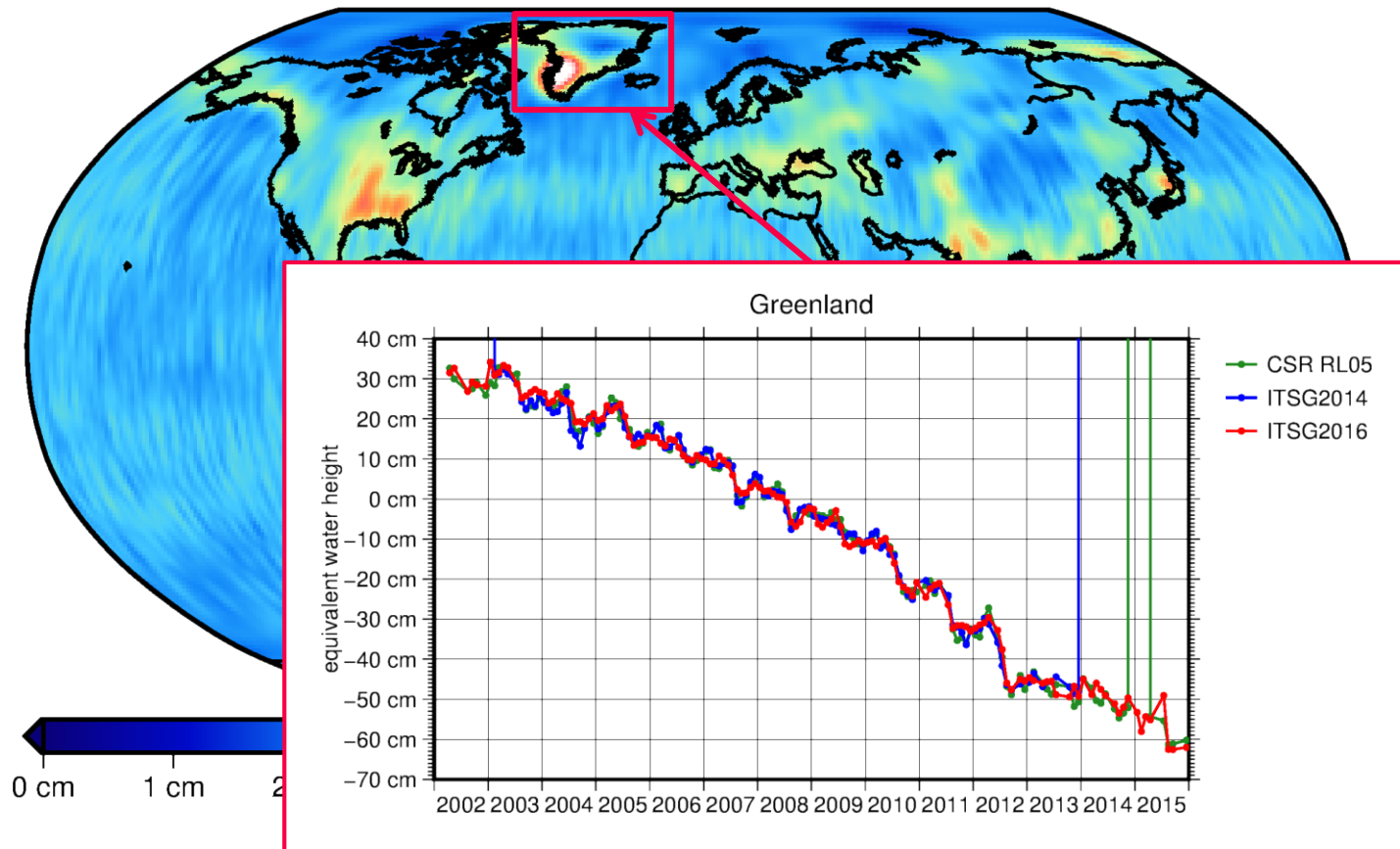
RMS = 3.7209



# Comparison of signals

ITSG-Grace2016 - trend/SA/SSA (Gauß 300km)

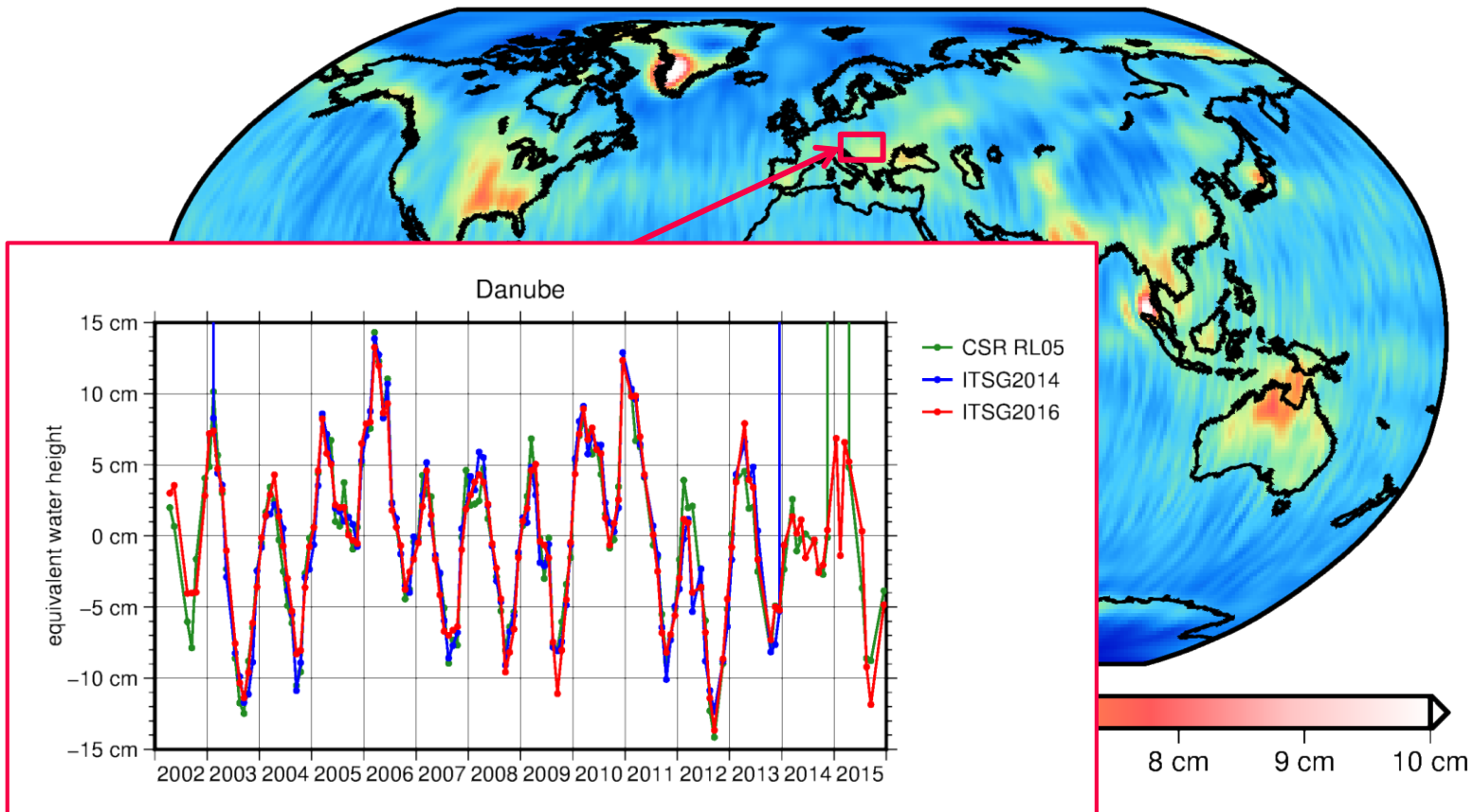
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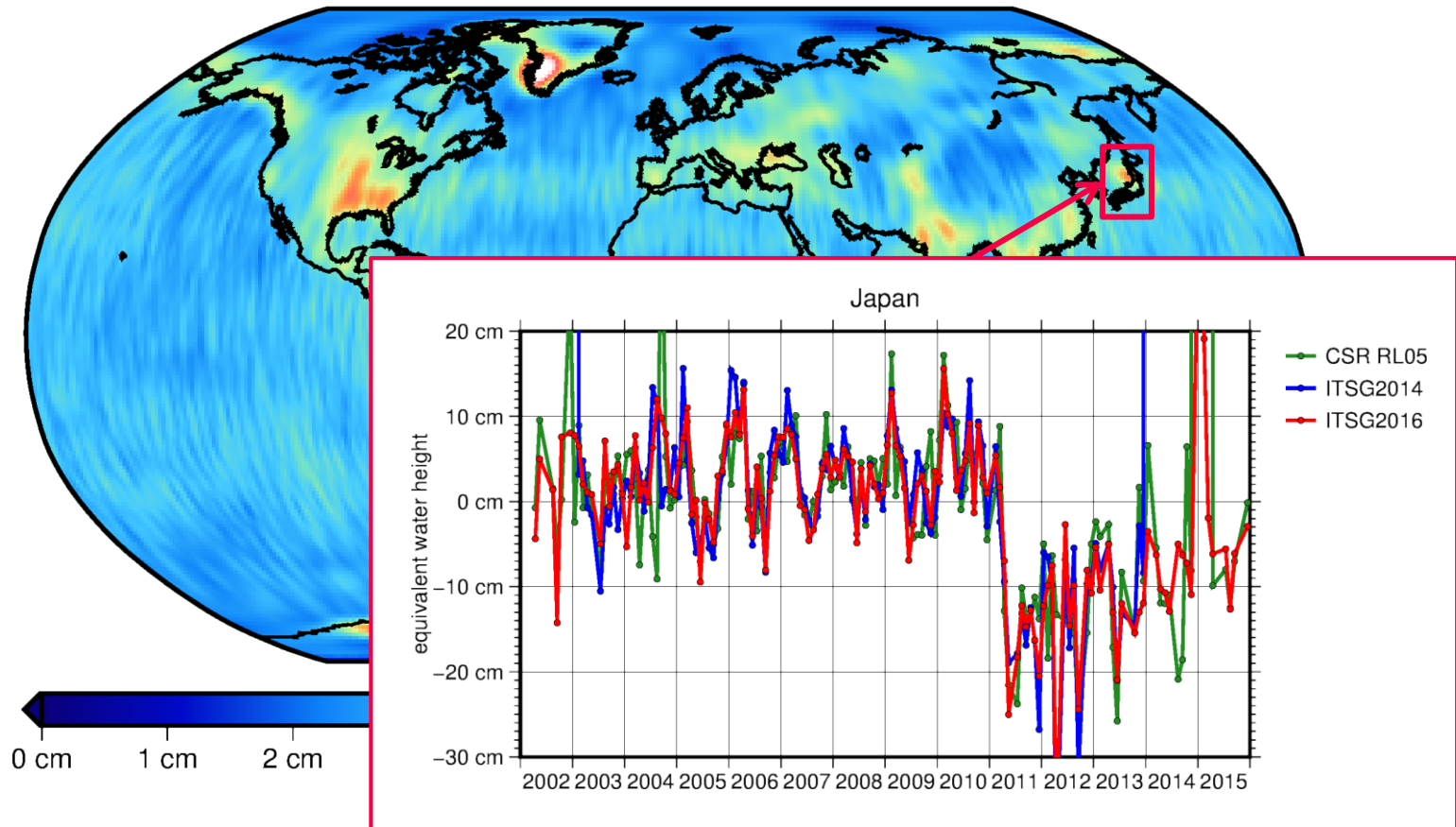
RMS = 3.7209



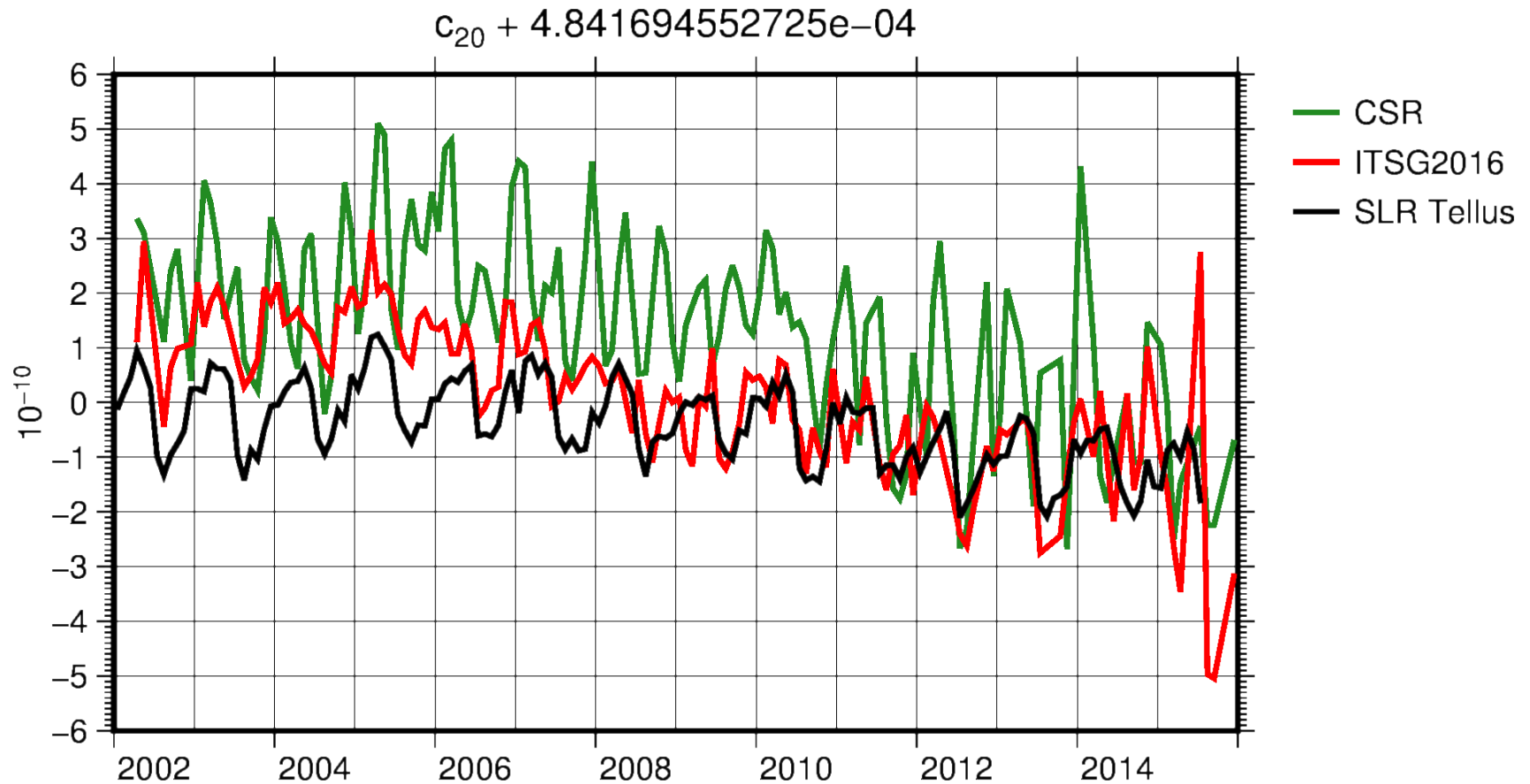
# Comparison of signals

ITSG-Grace2016 - trend/SA/SSA (Gauß 300km)

RMS = 3.7209



# C20 – Temporal evolution



# Summary & Conclusions

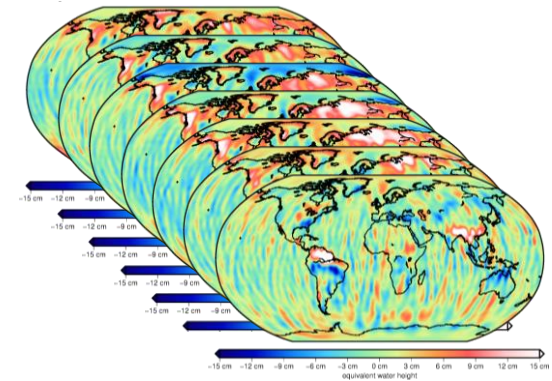
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## Daily Kalman smoothed solutions:

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**New ITSG-Grace2016 Release available at:**

- [ifg.tugraz.at/ITSG-Grace2016](http://ifg.tugraz.at/ITSG-Grace2016)

# Conclusions

## ITSG-Grace2014 vs. ITSG-Grace2016:

- Improved processing contributes to overall accuracy of monthly gravity field solutions
- Noise reduction w.r.t. ITSG-Grace2014 in the order of
  - 20% for  $n=15-25$
  - 40% for  $n=25-40$
  - 25% for  $n=40-90$
- Fully-populated scale factor matrix significantly improves C20 coefficients

**Wed, 17:30-19:00 | Posters | Hall X3**

Martin Horwath, Andreas Groh & the EGSiEM Team: *Evaluation of recent GRACE monthly solution series with an ice sheet perspective*

# THANK YOU

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