The new ITSG-Grace2016 release

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Outline

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

ITSG-Grace2016

Method:

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

Input:

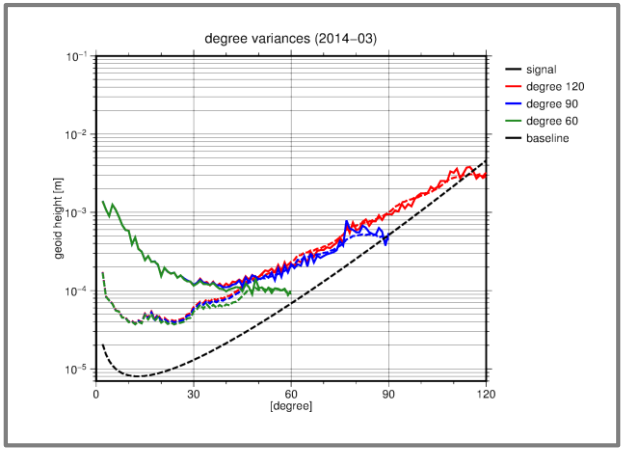
- GRACE Level-1B data from 2002-04 to 2016-01
- ITSG orbit product (Zehentner et al. 2015)
- Improved satellite attitude (Klinger et al. 2014)

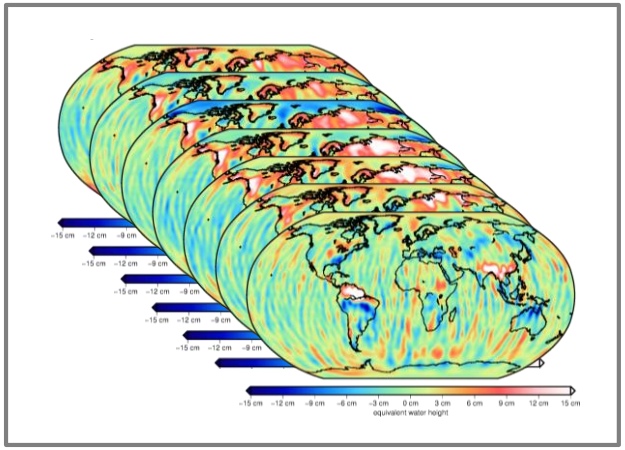
Unconstrained monthly solutions:

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

Daily Kalman smoothed solutions:

- Degree 40

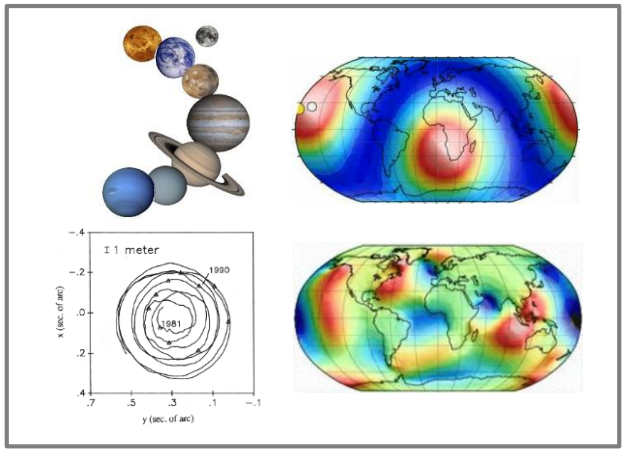




ITSG-Grace2016

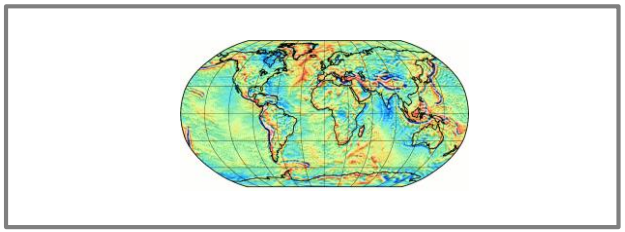
Background models:

- 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



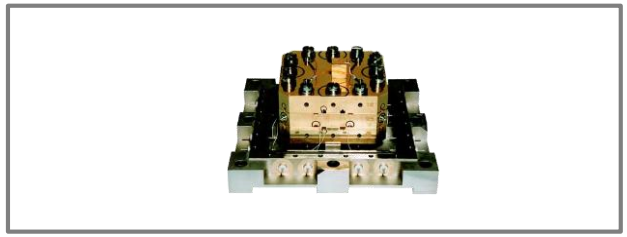
Restored models:

- 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



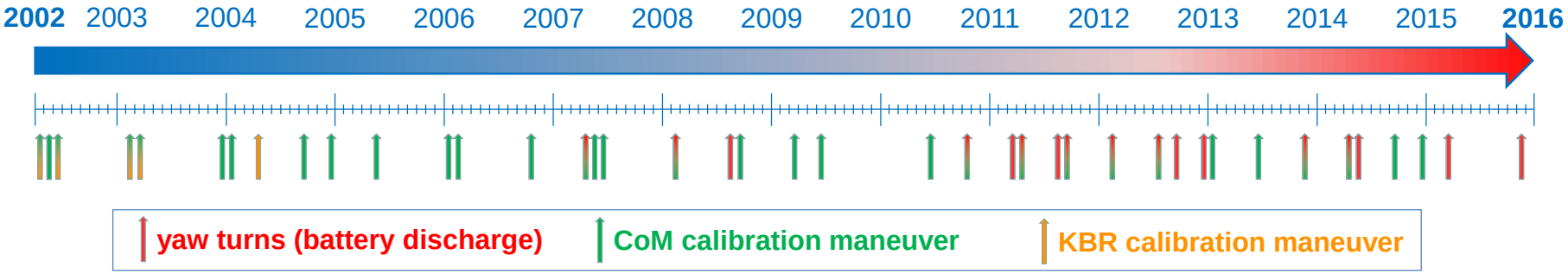
Processing details

Improvements since ITSG-Grace2014

Multiple improvements within the processing chain:

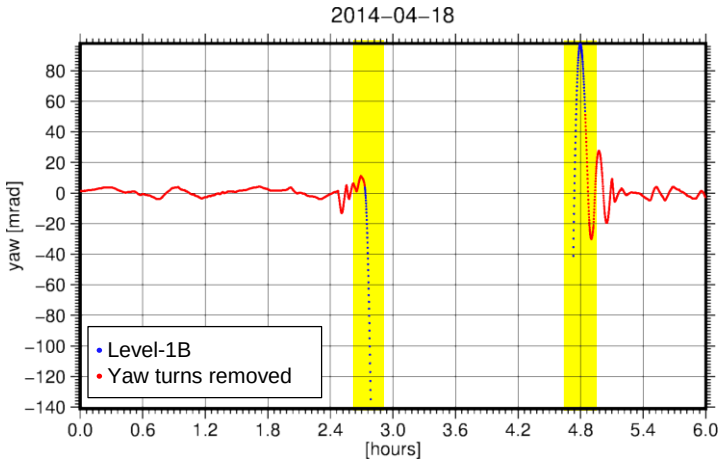
1) Updated background models
2) Instrument data screening
3) Improved accelerometer calibration
4) Improved numerical orbit integration
5) Improved covariance function estimation
6) Co-estimation of constrained daily variations:
   constraints based on improved error estimates for the dealiasing models

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

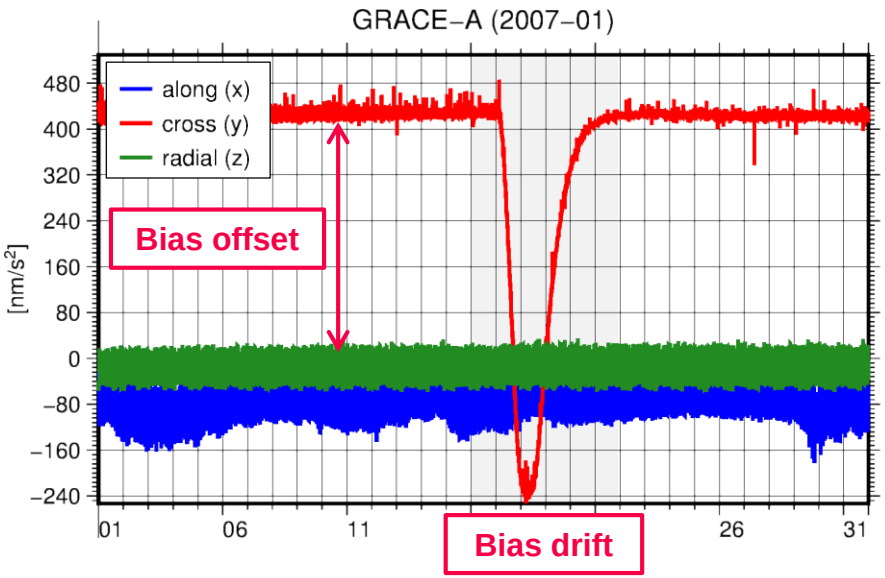
(2) Scale factors:

- 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

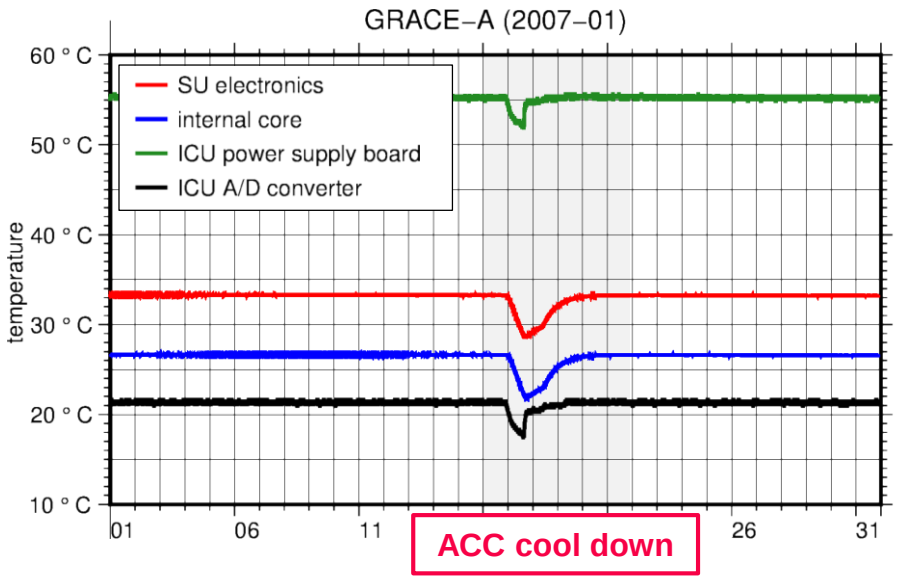
Accelerometer calibration

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

Accelerations - ACC1B
(calibrated according to TN-02)



Temperature - AHK1B



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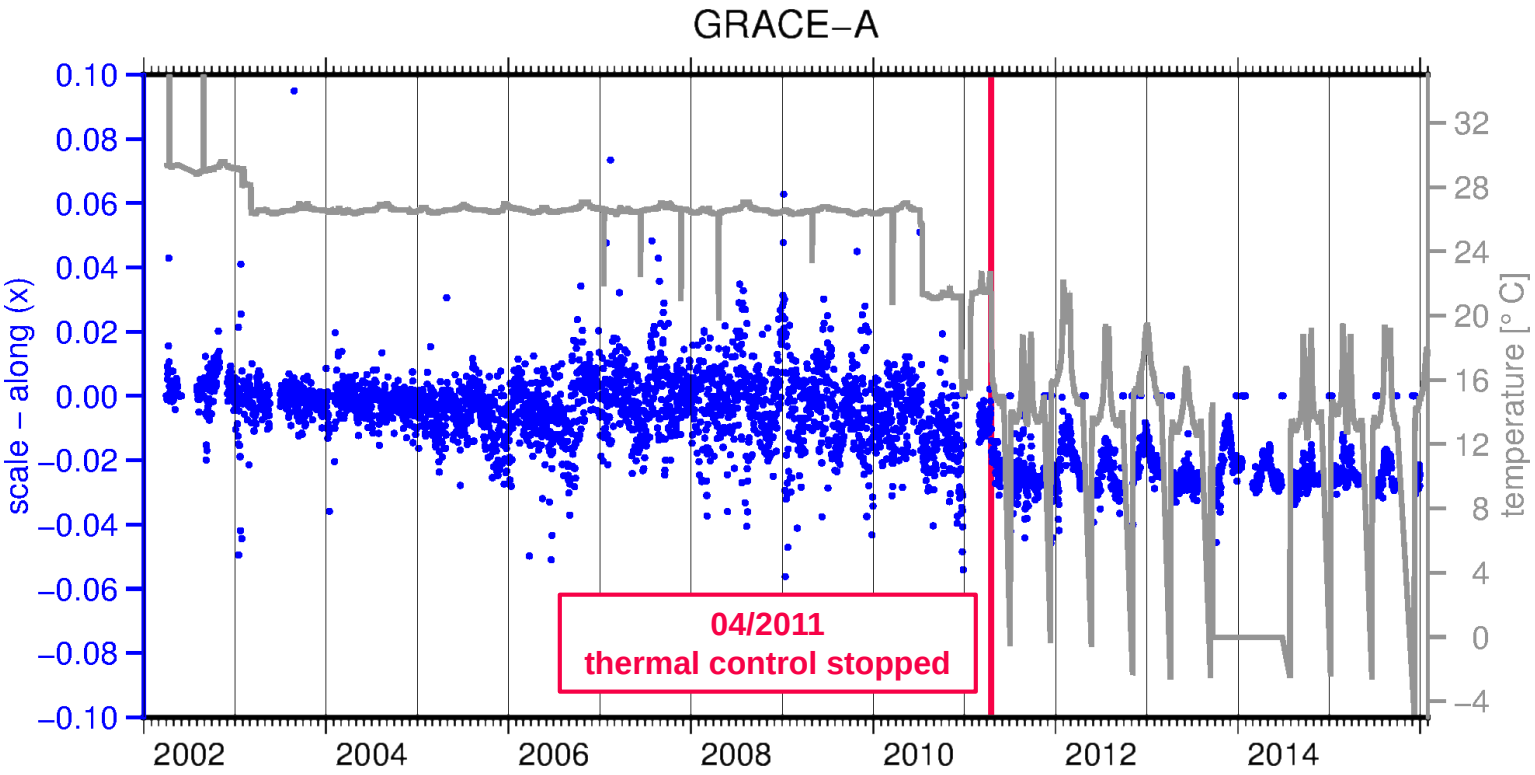
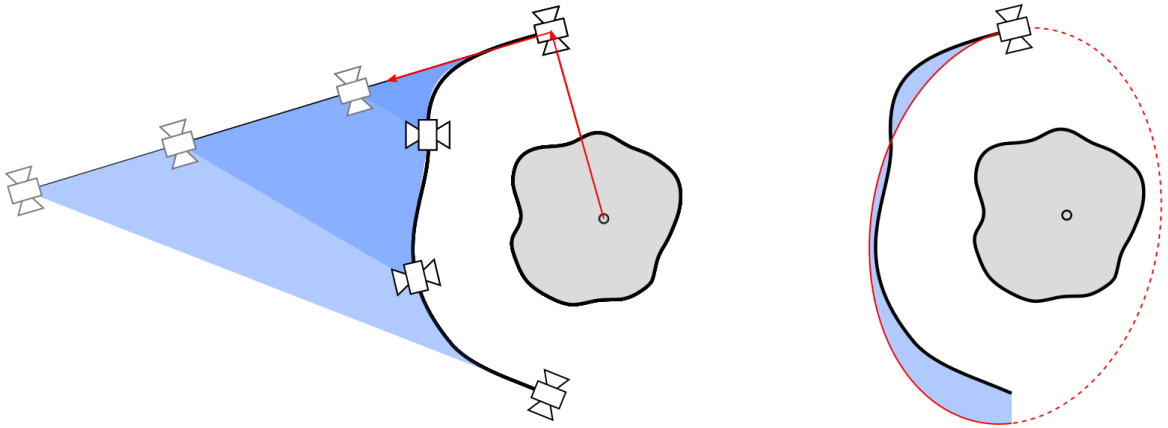


⇒ **Paper on this topic in preparation!**

Orbit integration

Elliptical reference orbit replaces linear motions:

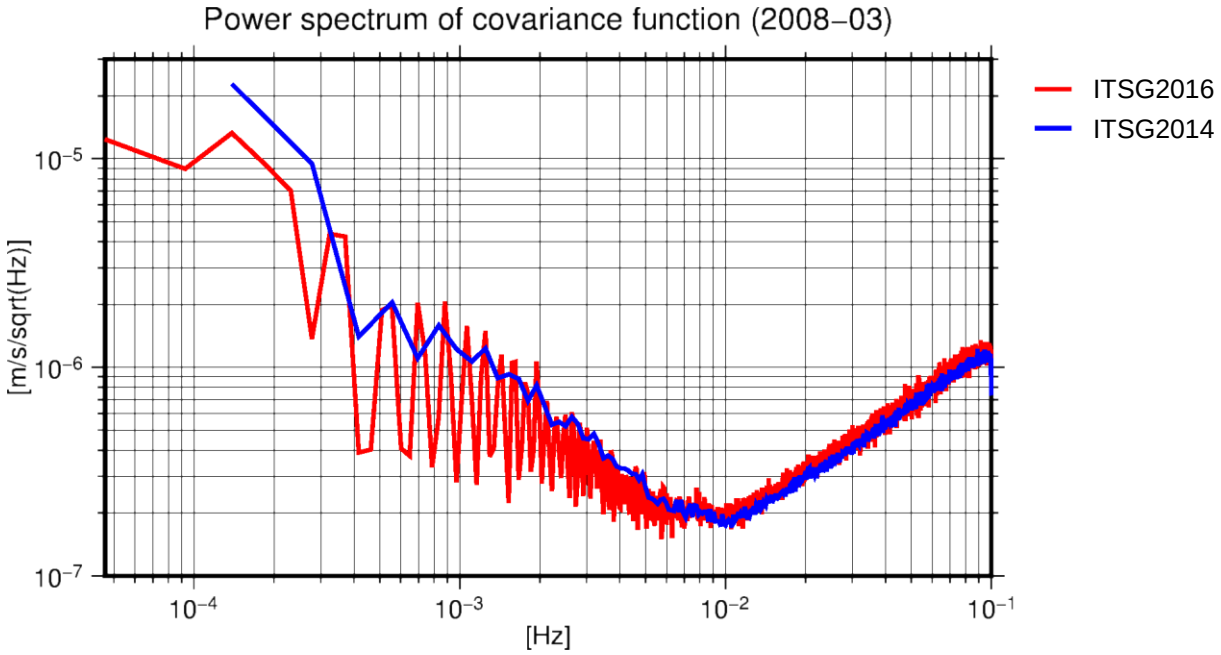
- Improved force model integration for dynamic orbit computation (Encke's method)
- Reduced processing artifacts in adjusted SST observations and residuals



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

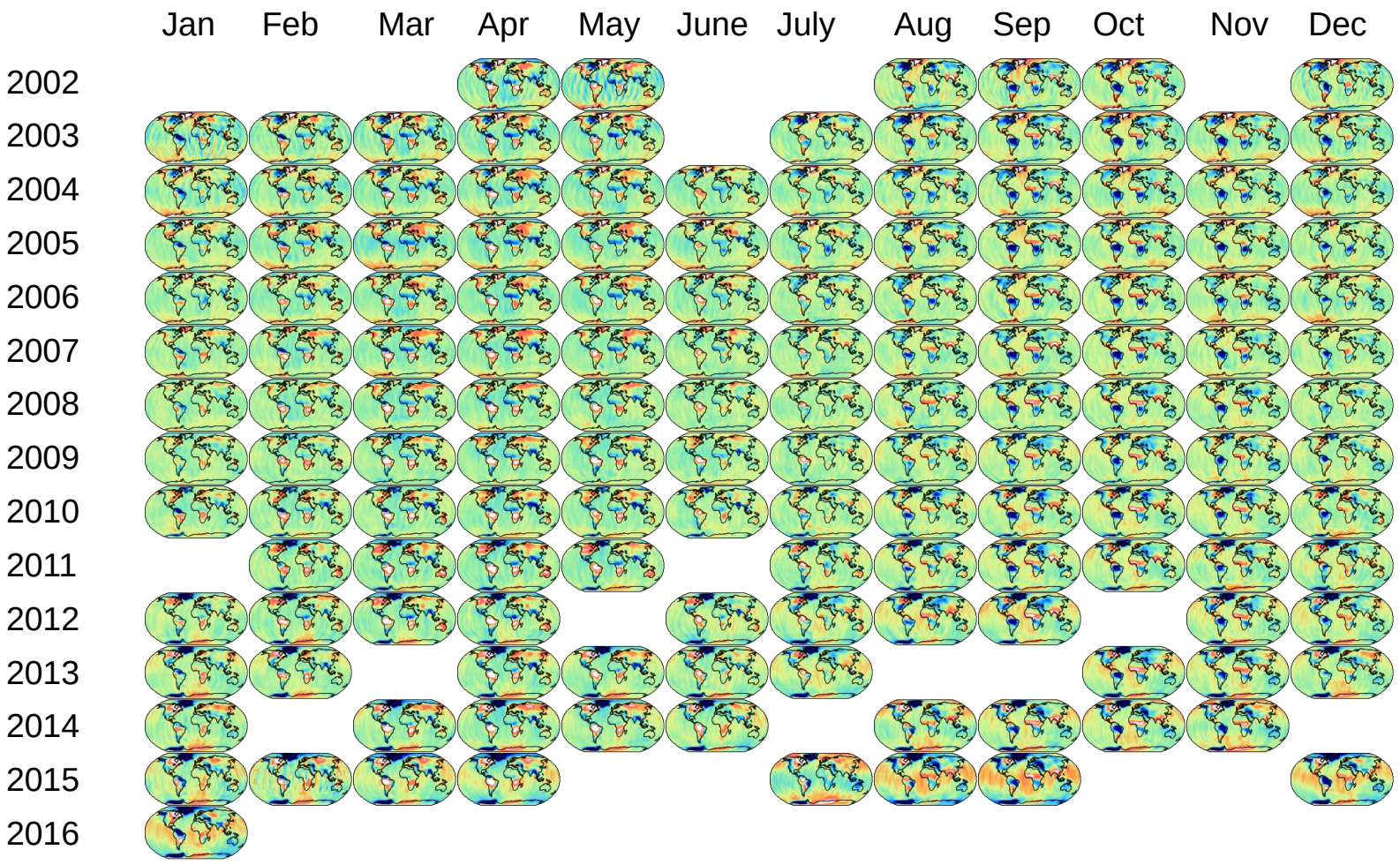
- **Empirical covariance function:** decorrelation of KBR range-rate data
- **Robust covariance estimator:** guarantees outlier-resistant covariance estimation



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*

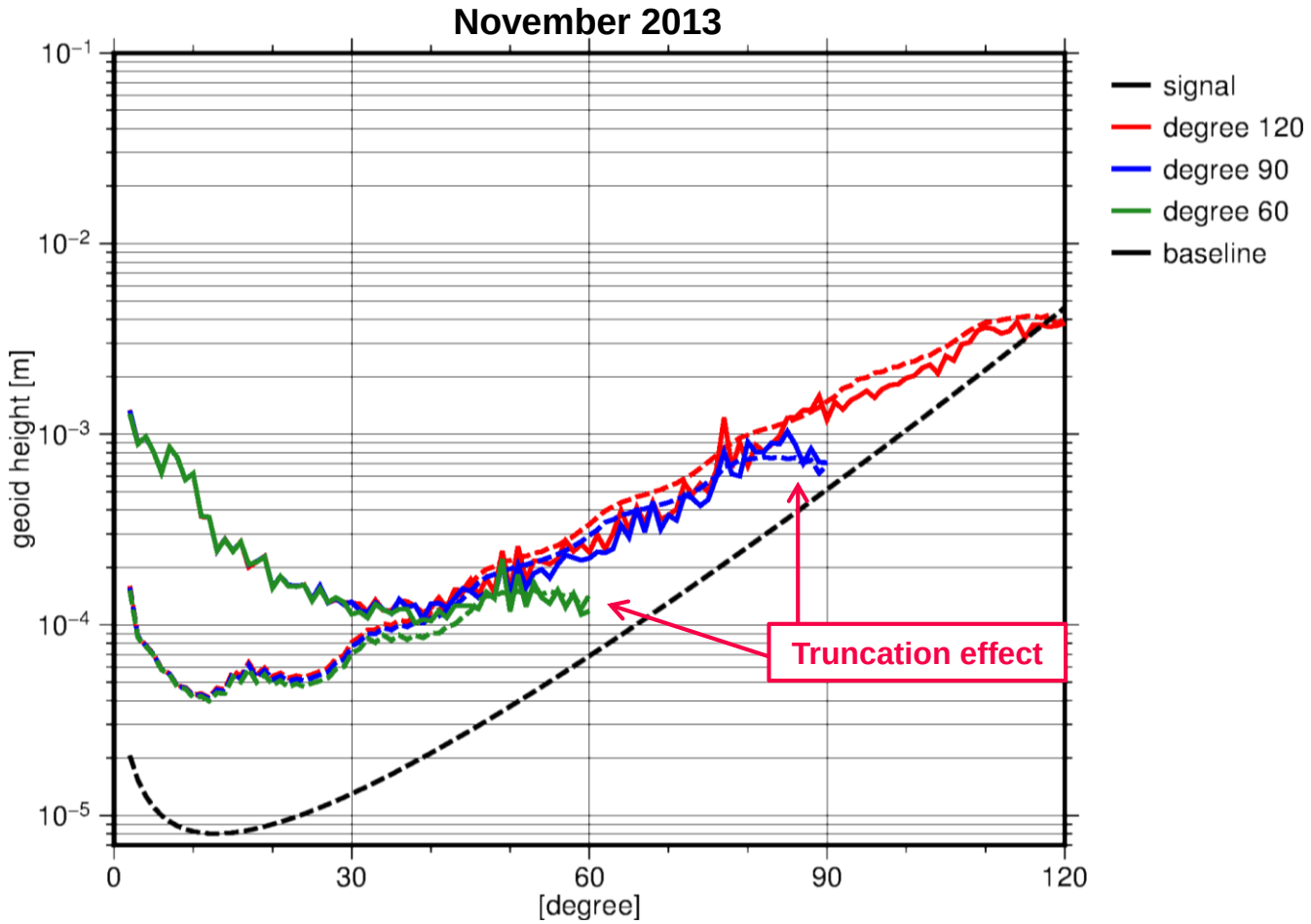
Unconstrained monthly solutions

ITSG-Grace2016 Monthly Solutions



ITSG-Grace2016 Monthly Solutions

Unconstrained monthly solutions: degree 60, 90 and 120



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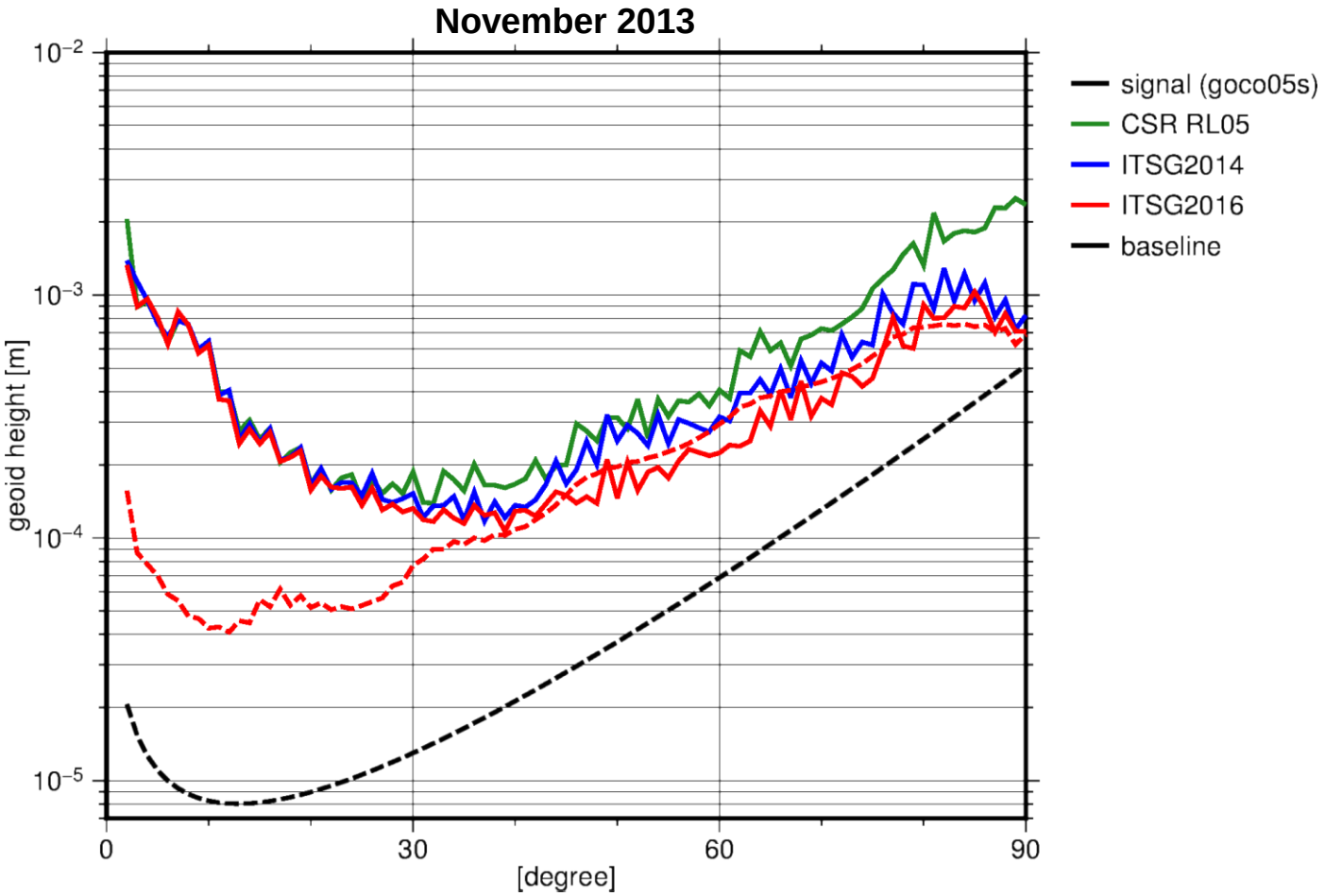
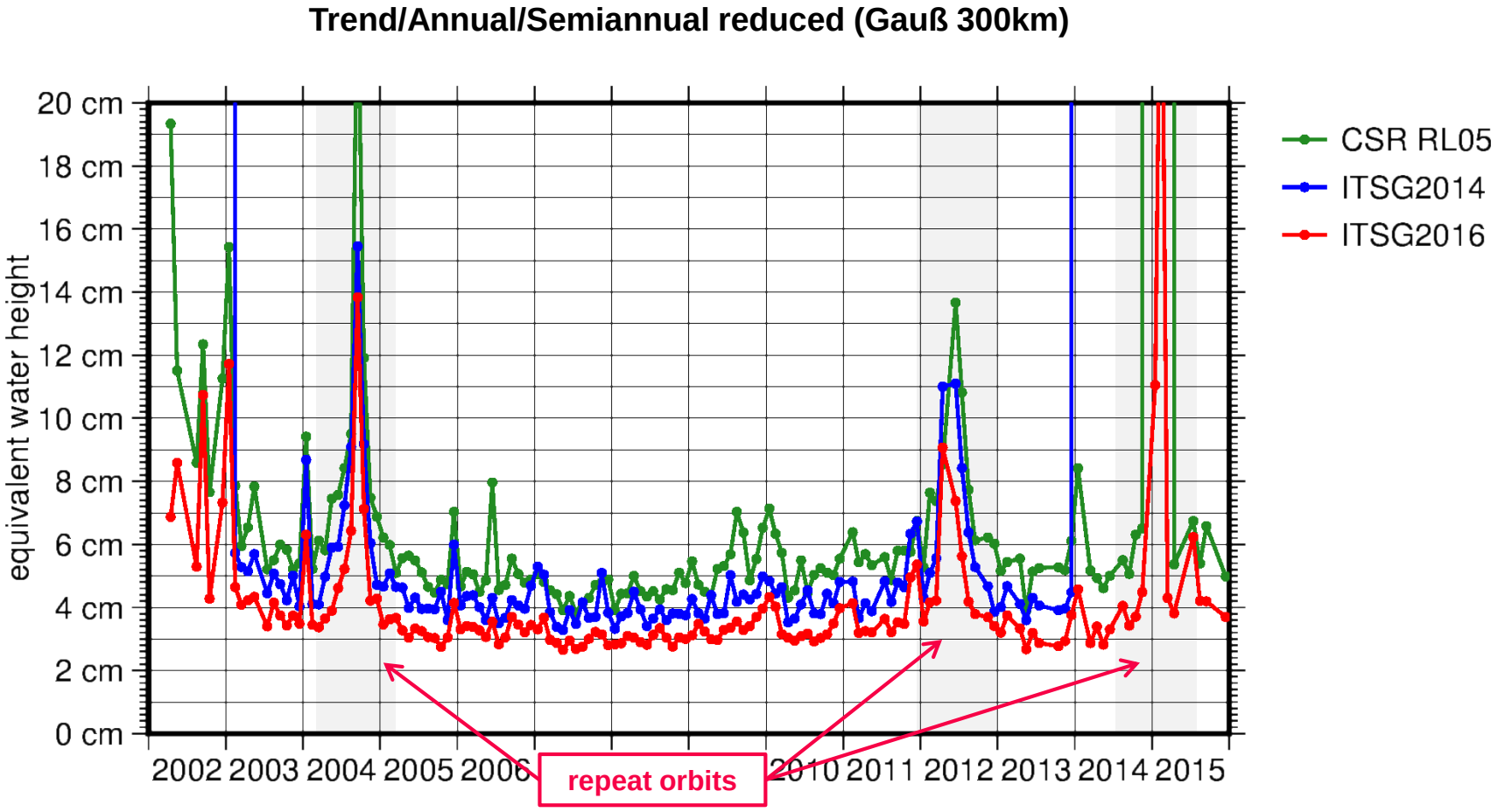


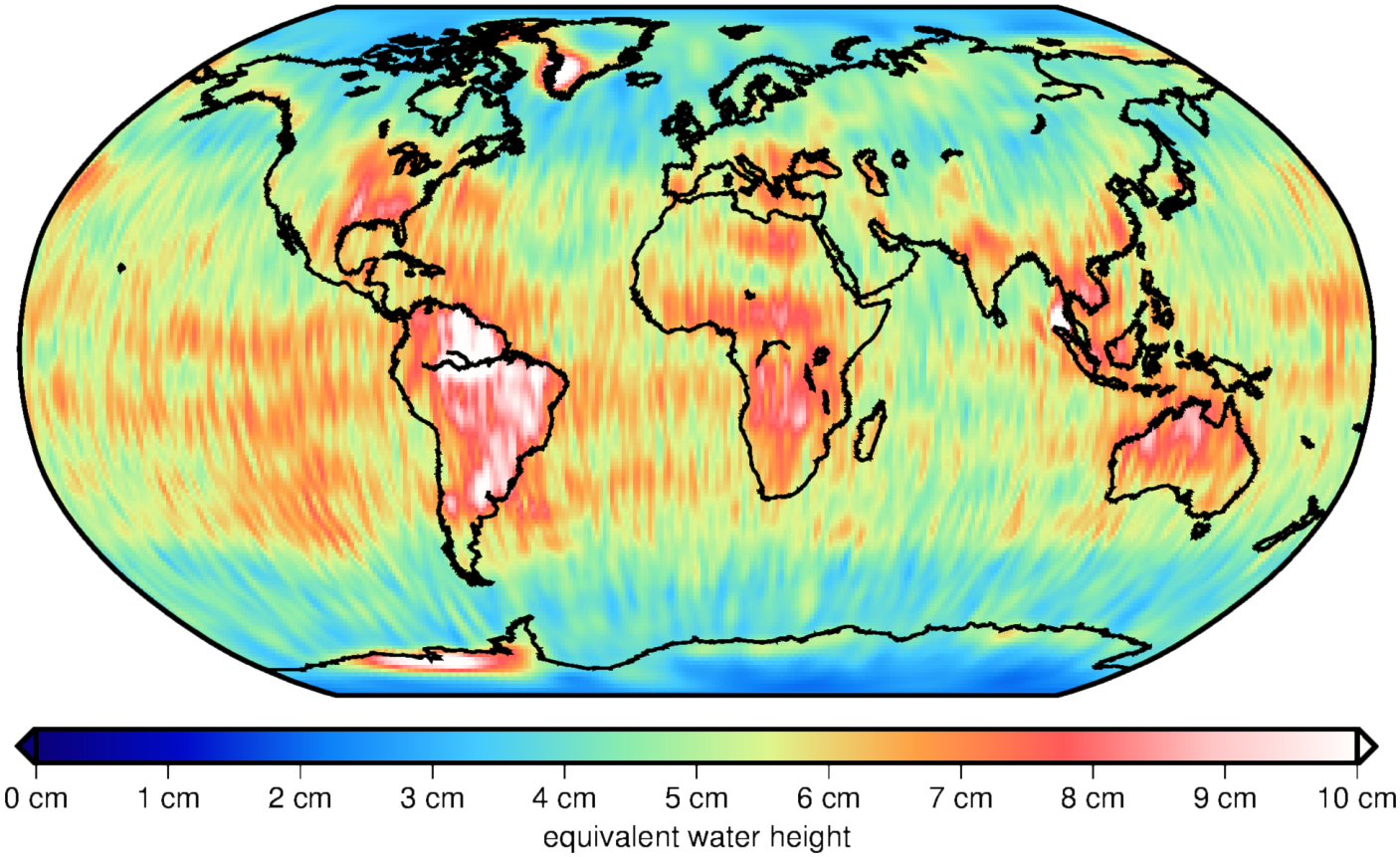
Variability over the Oceans



Temporal RMS

CSR RL05 - trend/SA/SSA (Gauß 300km)

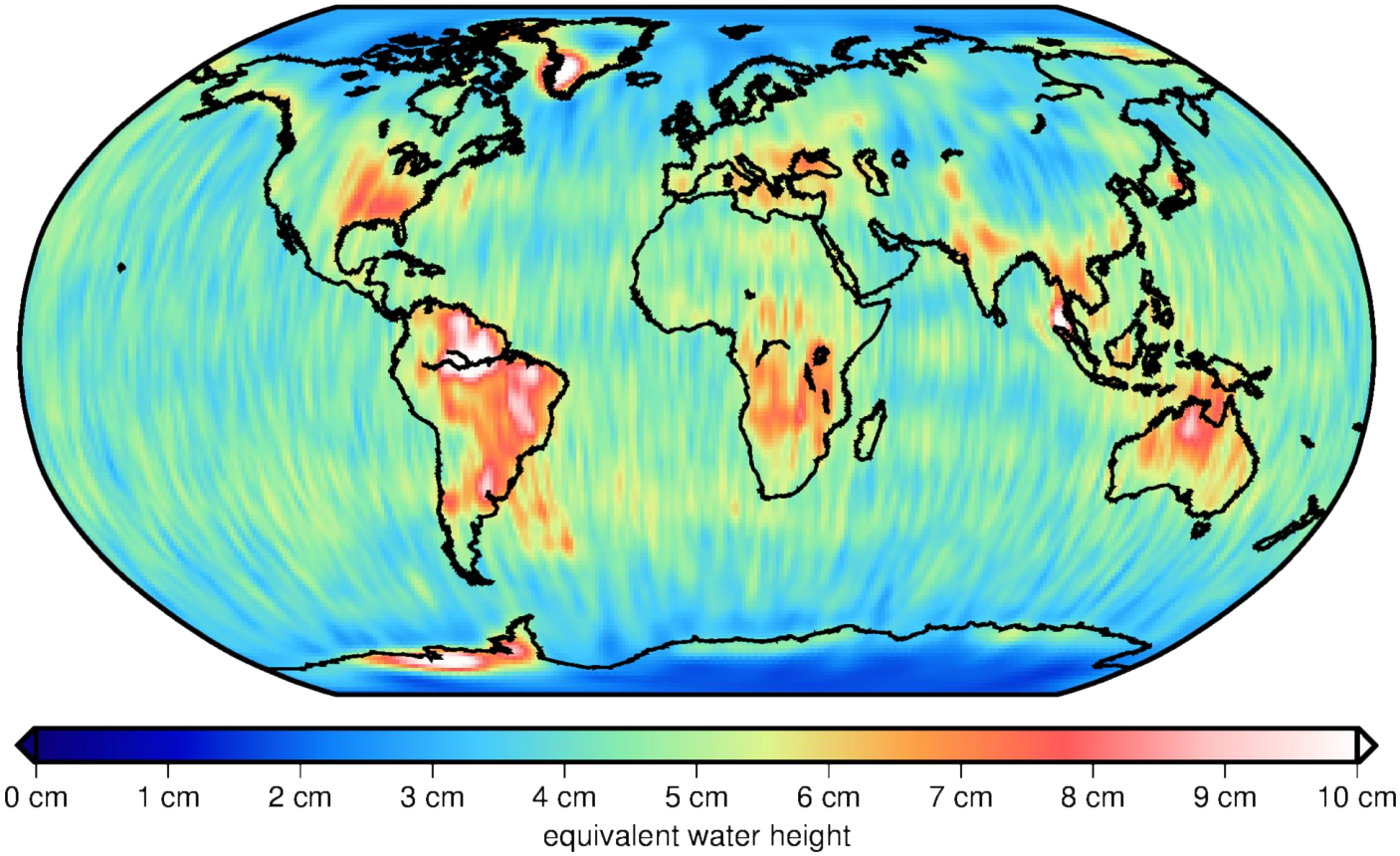
RMS = 5.5901



Temporal RMS

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

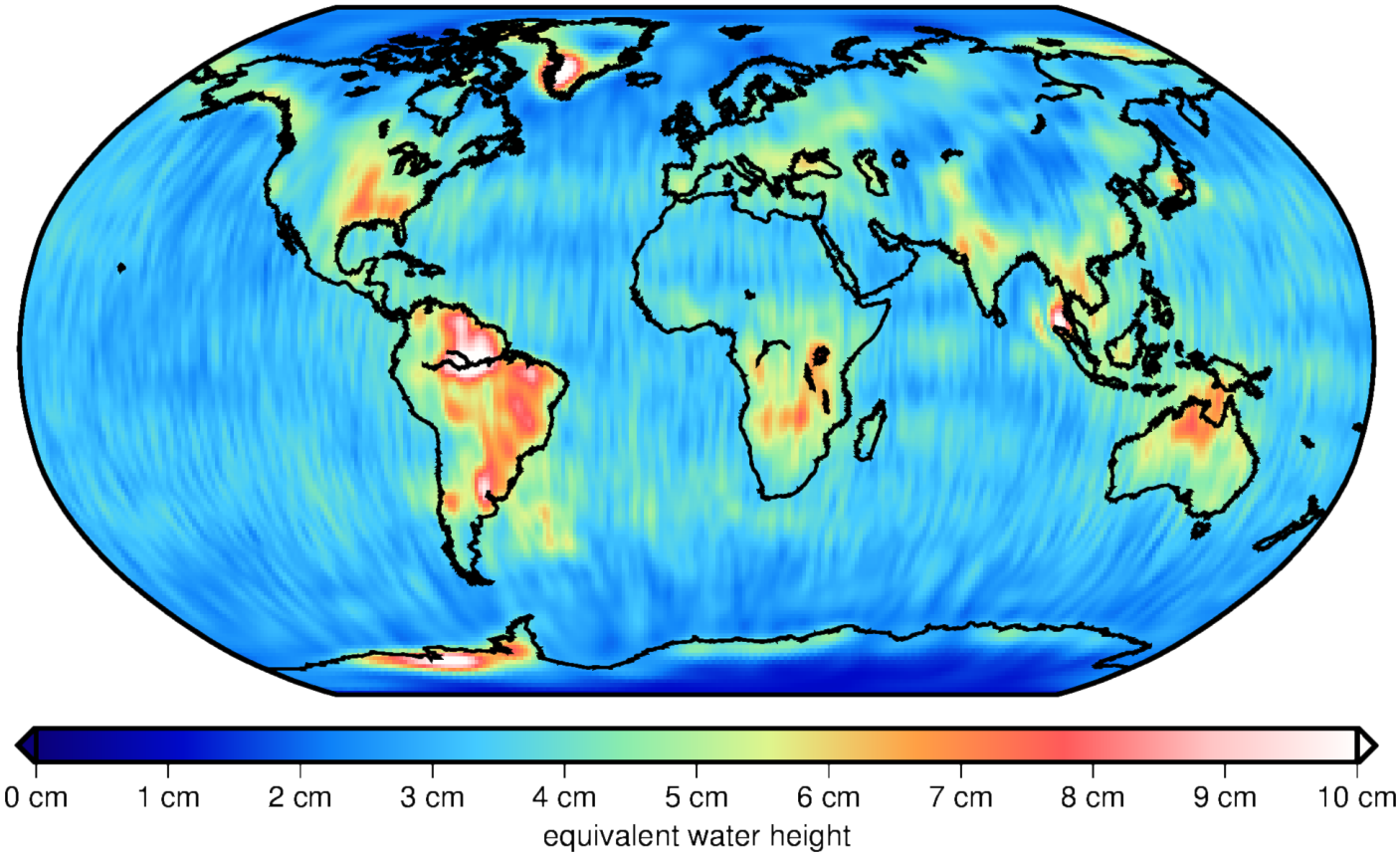
RMS = 4.6011



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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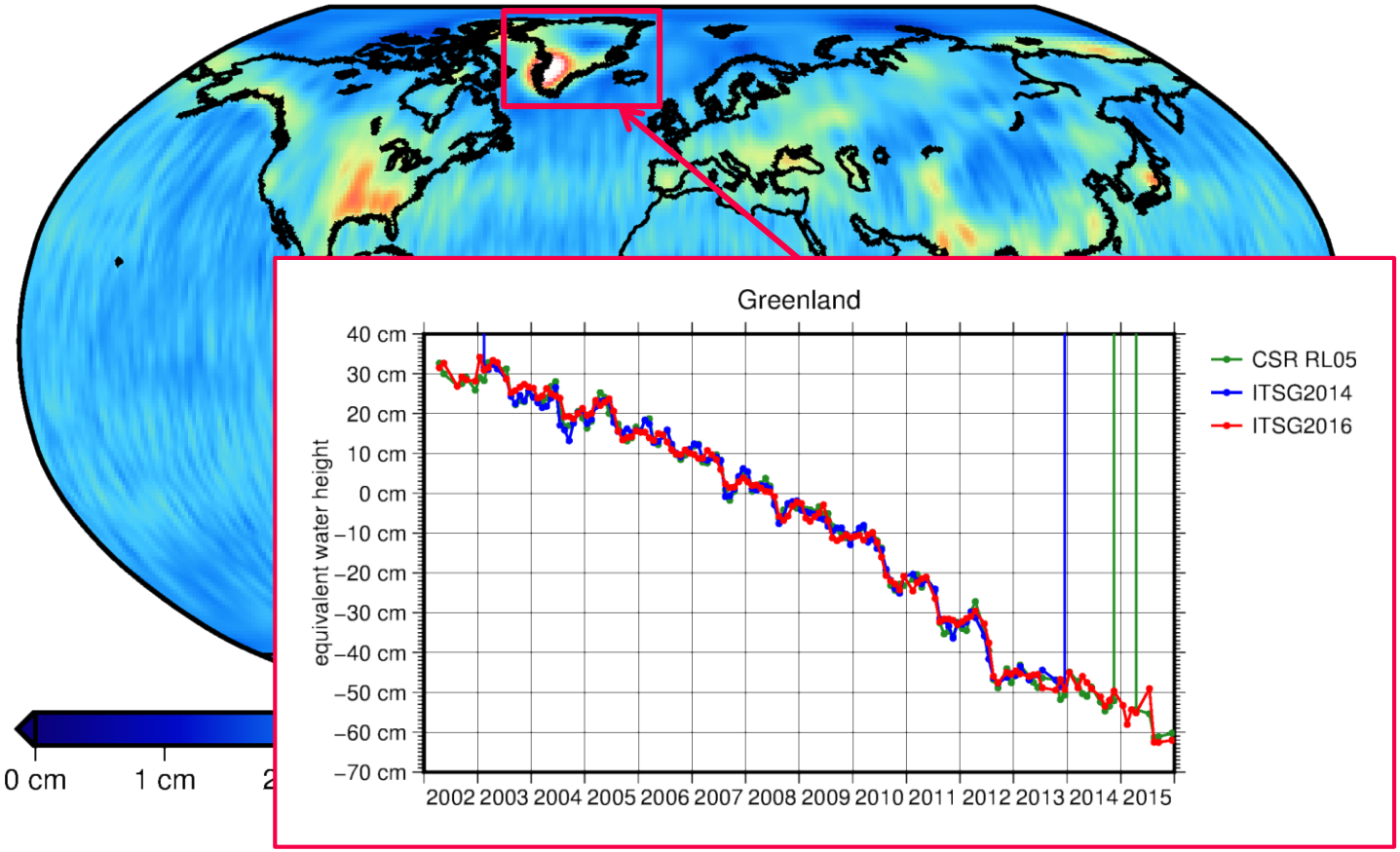

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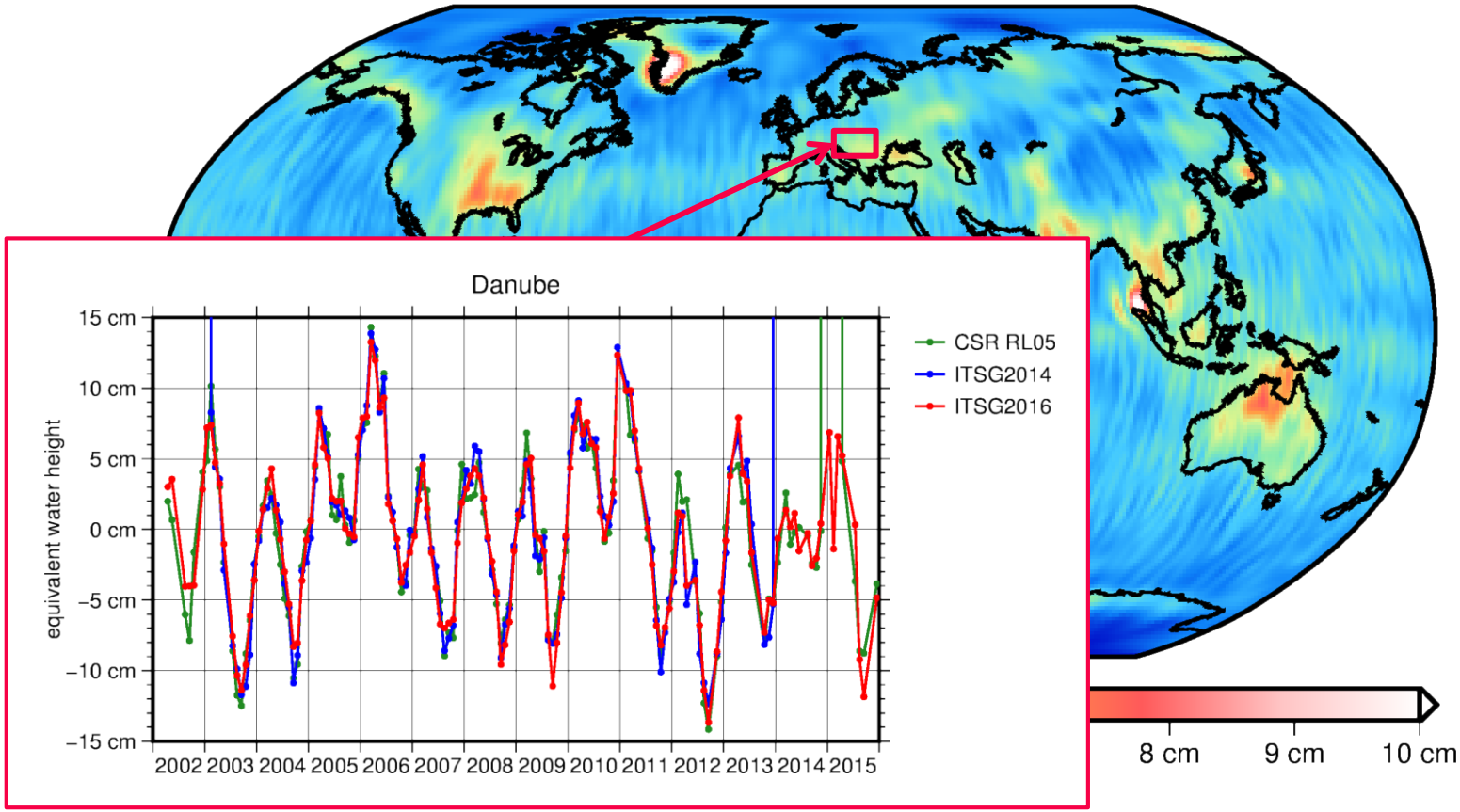

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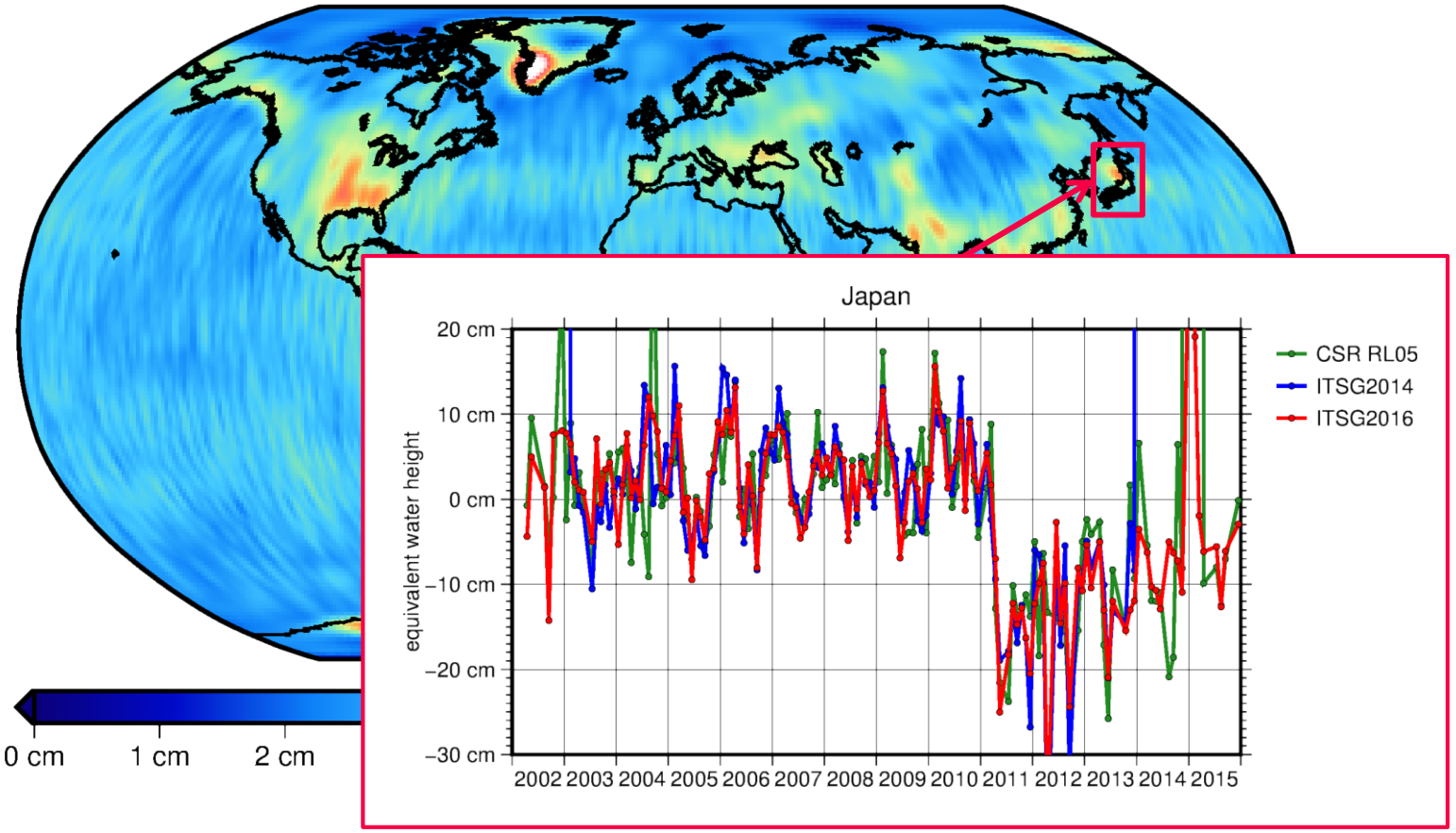
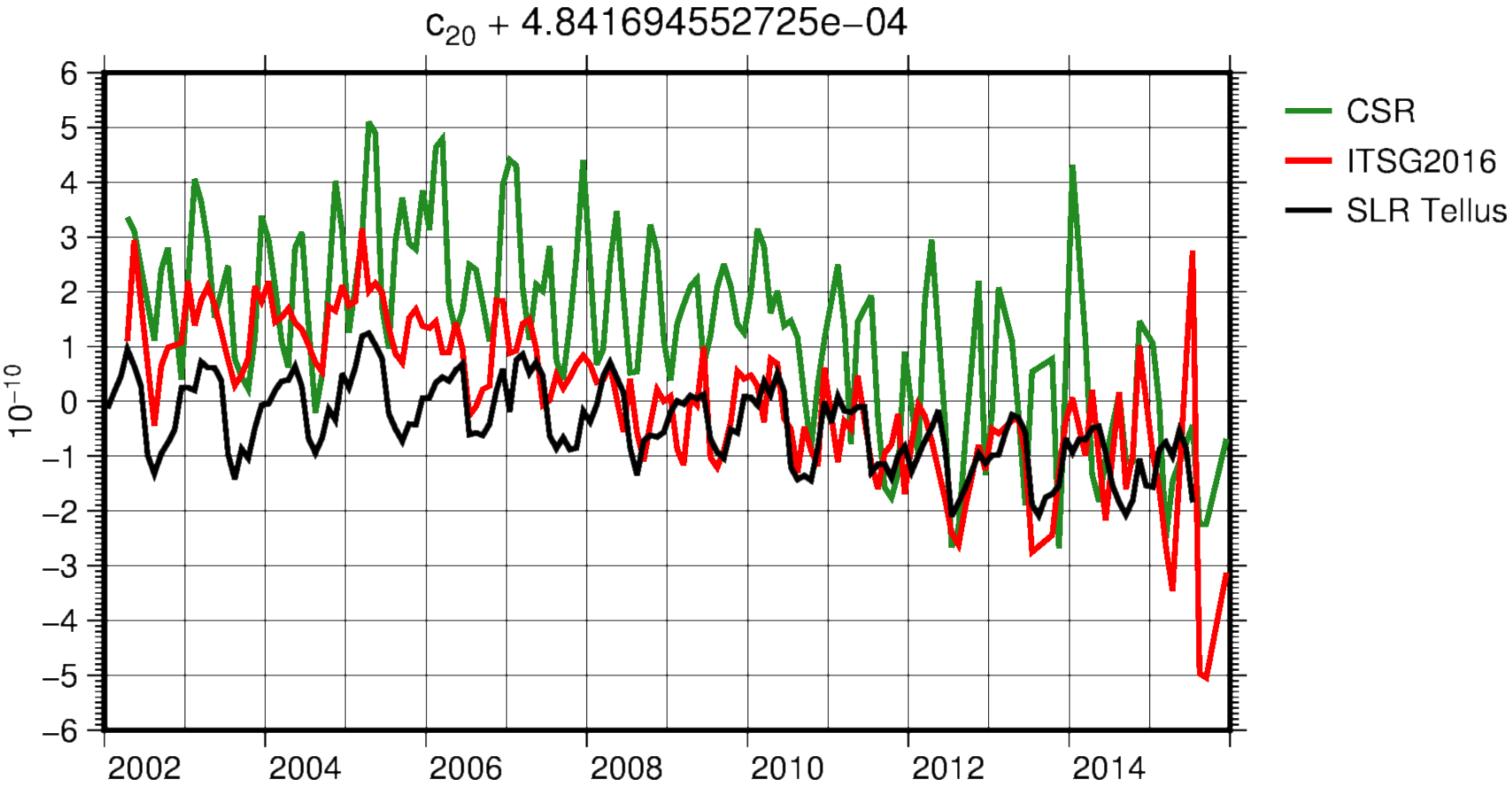


C20 – Temporal evolution



Summary & Conclusions

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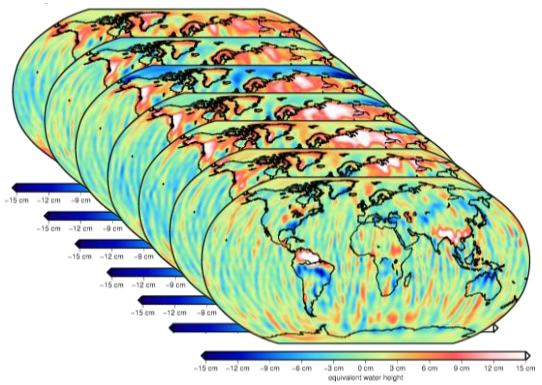

Daily Kalman smoothed solutions:

- Degree 40

New ITSG-Grace2016 Release available at:

- 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

Funding provided by:

- the *Austrian Research Promotion Agency*
- the European Union's
  Horizon 2020 research and innovative programme
  under grant agreement No. 637010