Towards a new ITSG-Grace release: updated data products and improvements within the processing chain

T. Mayer-Gürr, S. Behzadpour, A. Kvas, F. Öhlinger, S. Krauss, S. Strasser, and B. Süsser-Rechberger
Institute of Geodesy, Graz University of Technology

Introduction

- The new ITSG-Grace gravity field model will be the latest release of the ITSG sequence, computed at Graz University of Technology, which covers the complete GRACE/GRACE-FO time-span. The new release will be based on the planned Level-1B RL05 data and the AOD1B RL07 dealiasing product [1]. In the Following, an overview of the developed methodologies within the processing chain are introduced.

Combined LRI and KBR solutions

- GRACE-FO has two independent low-low satellite-to-satellite tracking (SST) measurements:
  - K-band Ranging Instrument (KBR),
  - Laser Ranging Interferometer (LRI).
- Combining the two SST observation groups in gravity field modeling:
  - improves estimation of high-degree spherical harmonic coefficients,
  - near zonal coefficients for degrees above 60 are better determined.

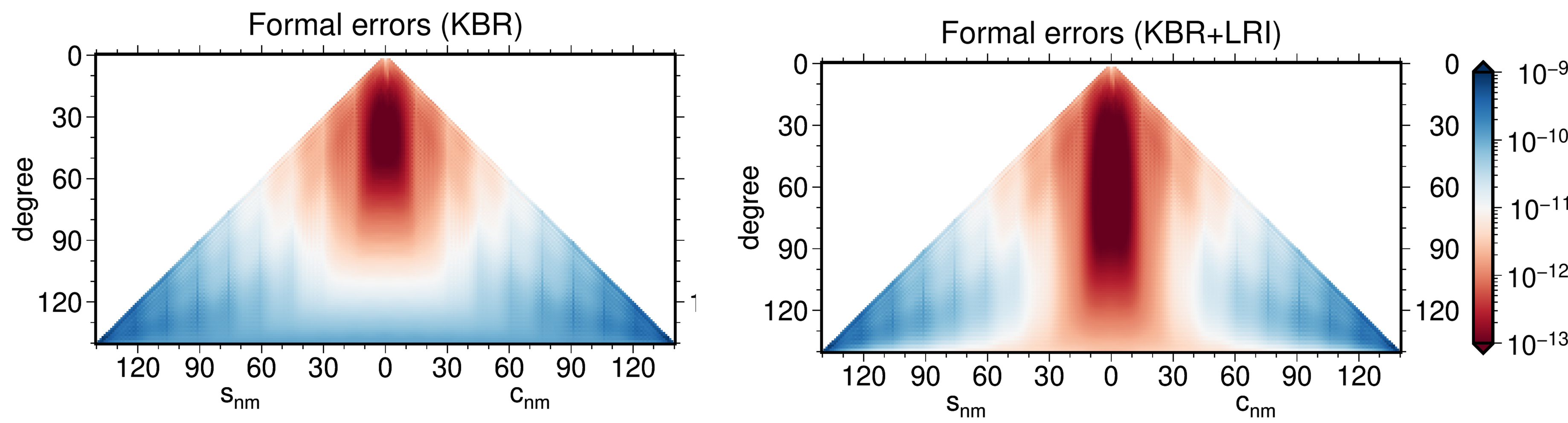

Fig.1: Comparison of formal errors of KBR-only solution (left) and combined solution (right) of March 2020.

- Observation groups including LRI (2s), KBR (5s), and POD1/POD2 (60s) are weighted by mean of Variance Component Estimation (VCE). Since both SST observation types are reduced by the same background models and accelerometer measurements, the resulting cross-correlations are considered in the covariance matrix.

$$\Sigma(\Delta l) = \begin{bmatrix} \Sigma_{KBR} + \Sigma_{ACC} & \Sigma_{ACC} \\ \Sigma_{ACC} & \Sigma_{KBR} + \Sigma_{LRI} \end{bmatrix}$$

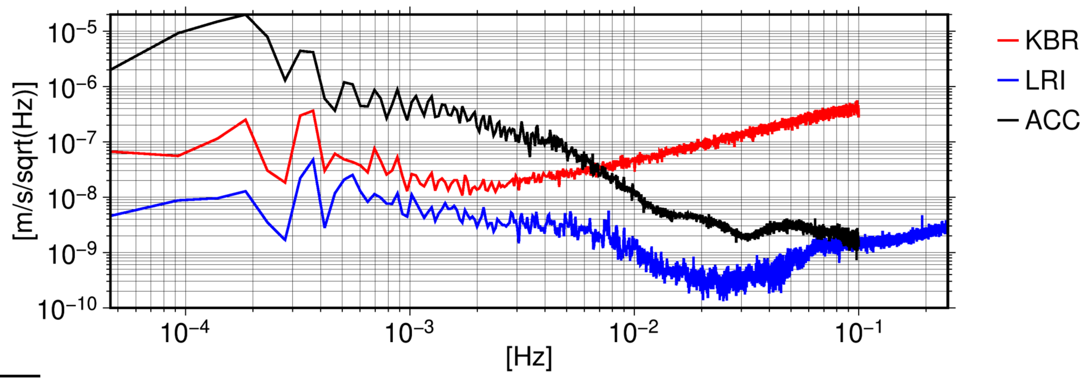

Fig.2: $\sqrt{PSD}$ of post-fit residuals based on each observation type.

Co-estimation of thruster response accelerations

- Since both GRACE-FO accelerometer respond unrealistically to thruster impulses [2], we estimate constant corrections, specified for each direction and thruster type, over a duration of 10 s.

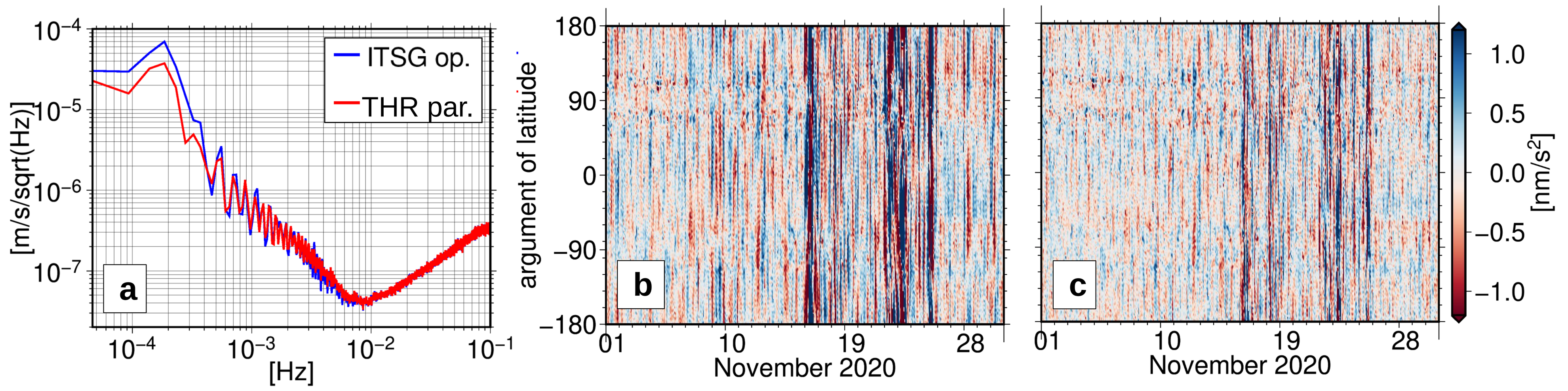

Fig.3: Postfit residuals $\sqrt{PSD}$ (a) and filtered timeseries before (b) and after (c) thruster parameter estimation.

Improved ocean tide model

- To mitigate potential errors of the global ocean tide model, we estimate zero-constrained corrections to FES2014b [3] in the long period, diurnal and semidiurnal frequency bands.
- Each frequency band (up to d/o 50) is estimated independently together with static and constrained daily, trend, and annual gravity field parameters over GRACE/GRACE-FO available timespan.
- Furthermore, including an additional third-degree ocean tide model [4] is also under assessment.
- Preliminary studies show up to 12 percent reduction of post-fit residuals in eastern pacific ocean.

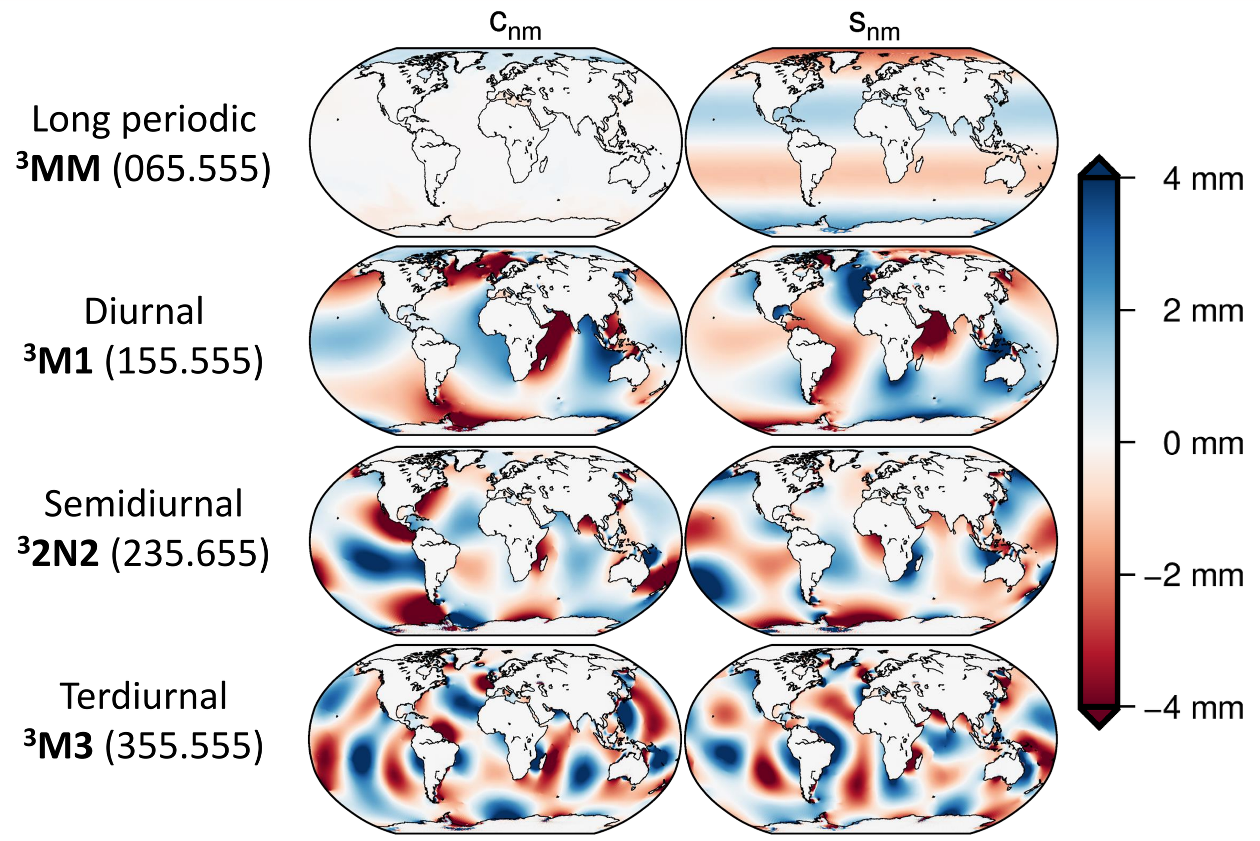

Fig.4: Third-degree ocean-tide model in terms of EWH.

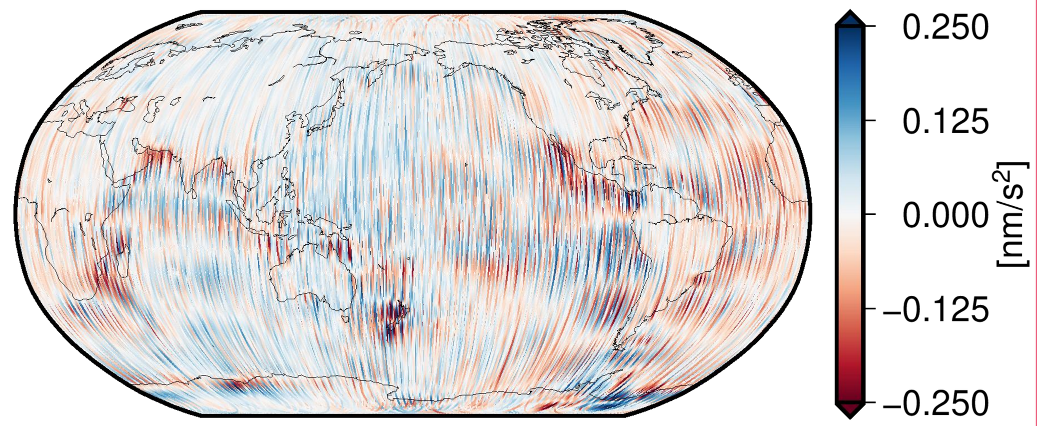

Fig.5: Reduced KBR residuals of Dec. 2021 after including third-degree ocean tide model.

Improved high-frequency mass variation model

- To mitigate temporal aliasing, background model errors are treated as an additional stochastic noise source [5].
- The spatio-temporal covariance matrices representing the noise process model (PM) are derived from the ESA Earth System Model [6].
- To reduce the computational demand, Principal Component Analysis (PCA) is applied to the spatial autocovariance matrix. The first 500 principal components, corresponding to approximately 99% of the total variance are retained.

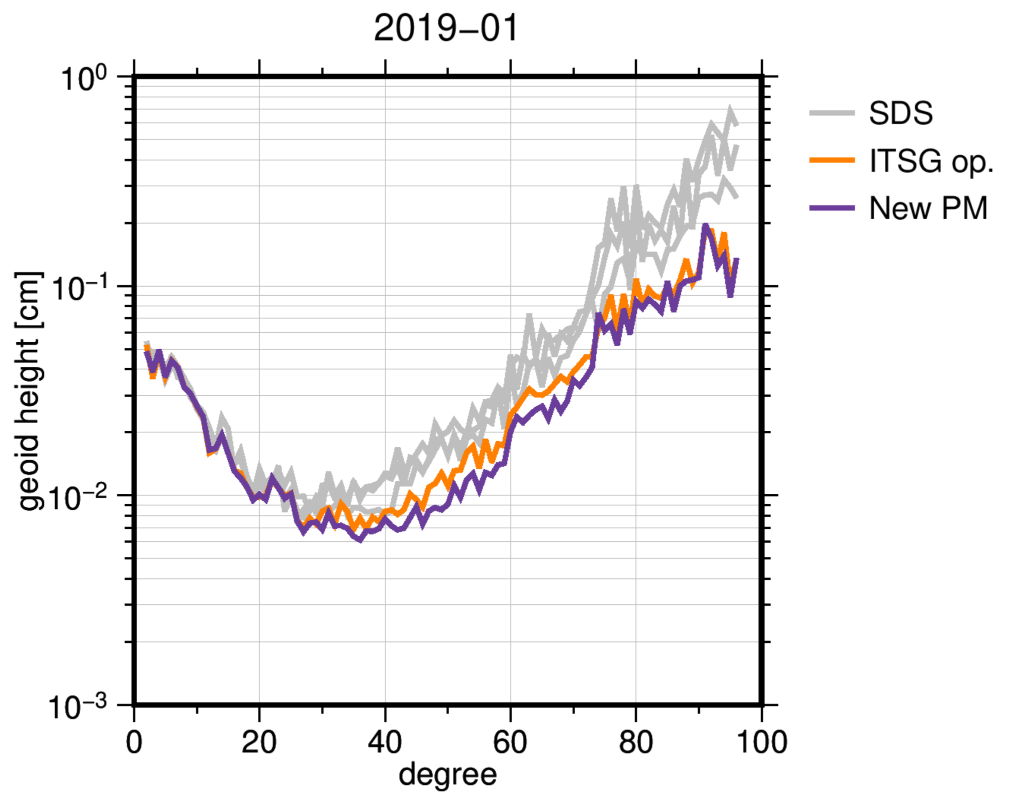

Fig.6: Difference of the degree amplitudes of the recovered monthly gravity field solution for the January 2019 computed w.r.t GOCO06s static field.

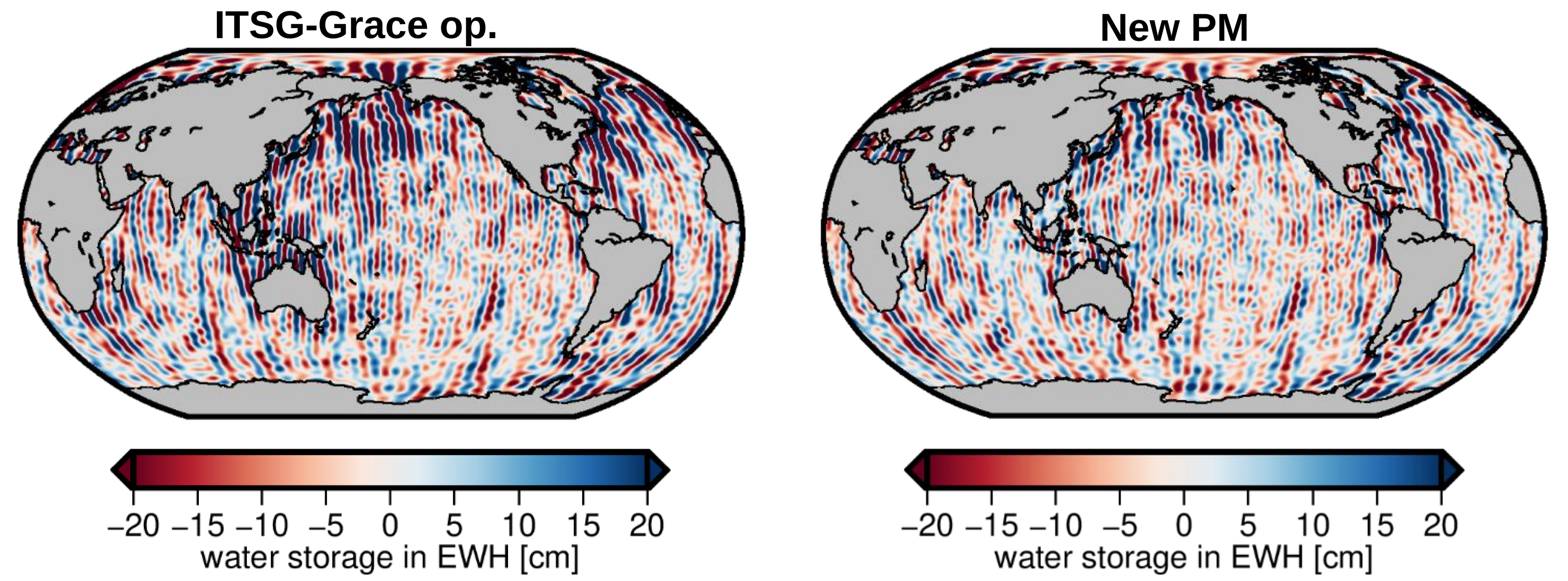

Fig.7: Difference of the recovered monthly gravity field solutions in terms of EWH for the January 2019 computed w.r.t GOCO06s static field.

Overview

- The final release of the new ITSG-Grace will consist of:
  - a high resolution static field with secular and annual variations,
  - unconstrained monthly solutions,
  - submonthly gravity field snapshots derived from Kalman filter approach.
- Spherical harmonic coefficients and full variance-covariance matrices for each component will be available.

Acknowledgments

The authors would like to thank the European Union's Horizon 2020 research and innovative programme under grant agreement No. 870353 and the Austrian Research Promotion Agency (FFG) for financial support.

HORIZON 2020

References

[1] Shihora, L. and Dobslaw, H. (2021): Towards AOD1B RL07, EGU General Assembly 2021, online, 19–30 Apr 2021, EGU21-1981, doi: 10.5194/egusphere-egu21-1981

[2] Harvey, N. et al. (2022): Modeling grace-fo accelerometer data for the version 04 release. Advances in Space Research, 69(3), 1393-1407. doi:10.1016/j.asr.2021.10.056

[3] Lyard, F. H. et al. (2021): FES2014 global ocean tide atlas: design and performance, Ocean Sci., 17, 615-649, doi:10.5194/os-17-615-2021

[4] Roman Sulzbach et al. (2022): Modeling gravimetric signatures of third-degree ocean tides and their detection in superconducting gravimeter records (submitted to Journal of Geodesy)

[5] Kvas, A., & Mayer-Gürr, T. (2019): GRACE gravity field recovery with background model uncertainties. Journal of Geodesy. doi:10.1007/s00190-019-01314-1

[6] Dobslaw, H., et al. (2015): The updated ESA Earth System Model for future gravity mission simulation studies. Journal of Geodesy, Vol. 89, p. 505-513, doi:10.1007/s00190-014-0787-8.

Contact

Torsten Mayer-Guerr
Email: mayer-guerr@tugraz.at