COST-G: Status and new developments

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Introduction

The Combination Service for Time-Variable Gravity fields (COST-G) is a product center of the International Gravity Field Service (IGSF) of the International Association of Geodesy (IAG). It operationally generates combinations of the monthly gravity field solutions of the COST-G Analysis Centers (ACs) and Partner Analysis Centers (PCs) of GRACE-FO data, and of the consistently reprocessed gravity field solutions derived from the data of the GRACE mission.

The relative weights for the combination are derived by Variance Component Estimation (VCE) on solution level (Jean et al., 2018), based on the unfiltered spherical harmonic coefficients up to degree 90 and order 60. High-order coefficients are excluded because they suffer from non-stochastic noise that causes AC-specific systematic differences in the derived weights (Meyer et al., 2024).

The combined fields in spherical harmonic coefficients (Level-2 products) are available from the International Center for Global Earth Models (ICGEM). Post-processed global grids and time-series of mass-change in selected regions (Level-3 products) are available from the Gravity Information Service (GravIS) of the German Research Center for Geosciences (GFZ).

COST-G GRACE-FO RL02

The operationally combined COST-G GRACE-FO RL02 products are generated with approx. 2-3 months latency from the operational monthly solutions provided by the ACs and PCs of COST-G, which pass the quality control performed by COST-G to ensure comparable signal content in order to guarantee an unbiased combination. The combination (Fig. 1) has lately been extended by the high-quality contribution of the Huazhong University of Science and Technology (HUST) and is now based on 8 solutions contributing to the combination.

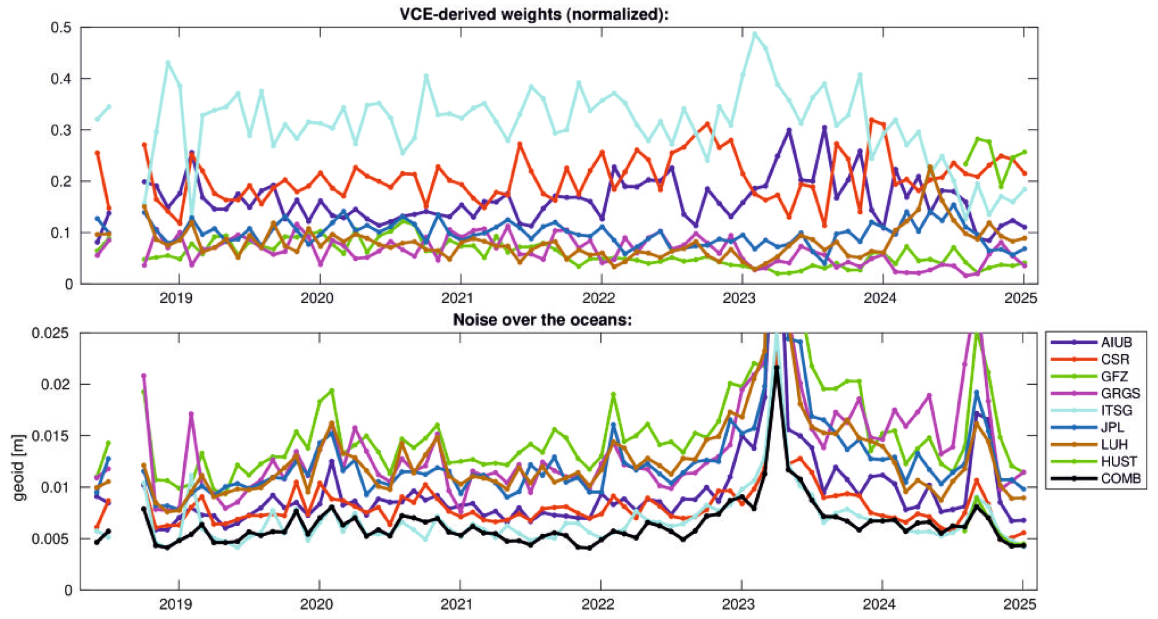

Fig. 1: Relative weights (top) and noise assessment (bottom) of the individual monthly contributions and the combined GRACE-FO gravity fields.

COST-G GRACE RL02

The COST-G GRACE combination has been re-combined consistently to GRACE-FO RL02 with a significantly increased data base compared to RL01. A reduction of the noise level compared to RL01 could be achieved mainly during periods with data problems at the beginning and end of the GRACE mission (Figs. 2 and 3).

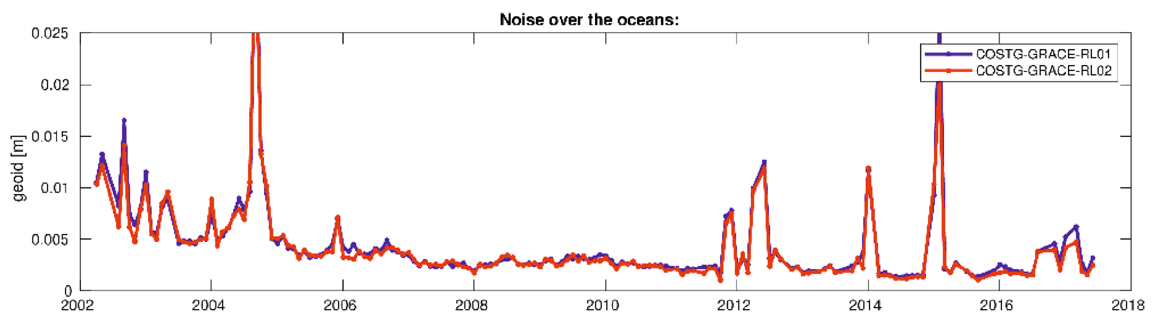

Fig. 2: Noise assessment over quiet ocean areas for COST-G GRACE RL01 and RL02.

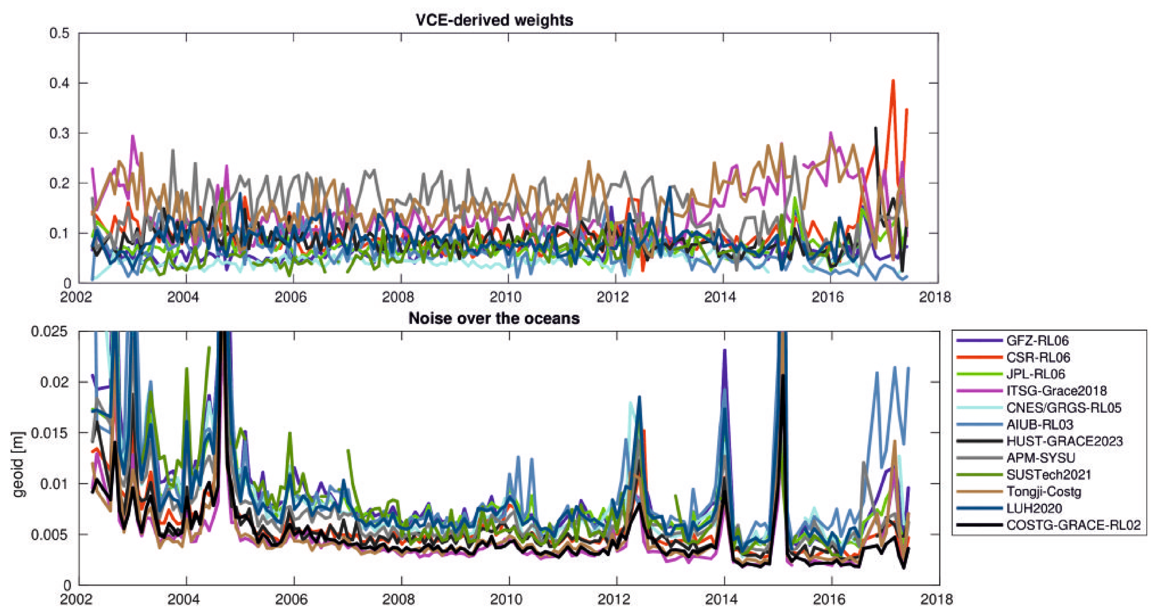

Fig. 3: Relative weights (top) and noise assessment (bottom) of the individual monthly contributions and the COST-G GRACE RL02 combination.

Water mass variations in river basins

The evaluation of hydrological mass change in river basins gives very consistent results of COST-G GRACE RL01 and RL02. Small differences are visible early and late in the GRACE mission, when the gravity field determination is challenging due to high solar activity and data problems (Fig. 4). The signal-to noise ratio in individual river basins (Fig. 5), mainly depends on the basin size, latitude and of course the signal amplitude of the seasonal variations (Boergens et al. 2022).

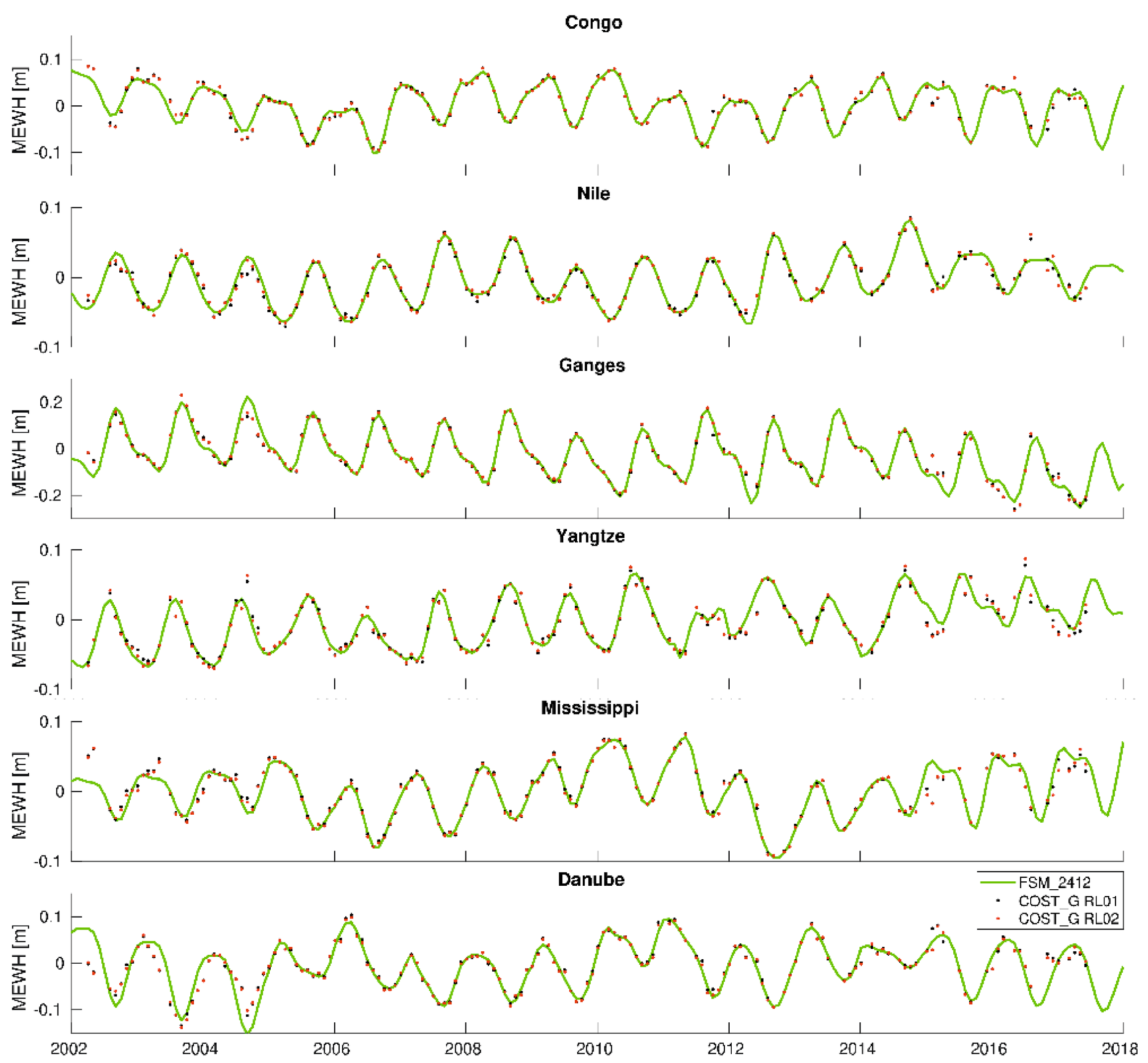

Fig. 4: Mass change in selected river basins. Dots indicate individual monthly mass estimates, the green line a signal model fitted to the monthly solutions (Peter et al., 2022).

Polar ice mass trends

At the Technical University of Dresden (TUD), as a member of the COST-G Product Evaluation Group (PEG), ice mass trends in glacial basins of Greenland and Antarctica were determined for the validation of the COST-G GRACE RL02 products. As already indicated by the COST-G quality control, the mass trends turned out very consistent among the ACs (with the exception of GFZ in East Antartica), COST-G GRACE RL01, and RL02 (Figs. 6 and 8). The noise assessment revealed minor improvements for individual basins (Figs. 7 and 9), overall the quality of COST-G GRACE RL01 and RL02 turned out very comparable.

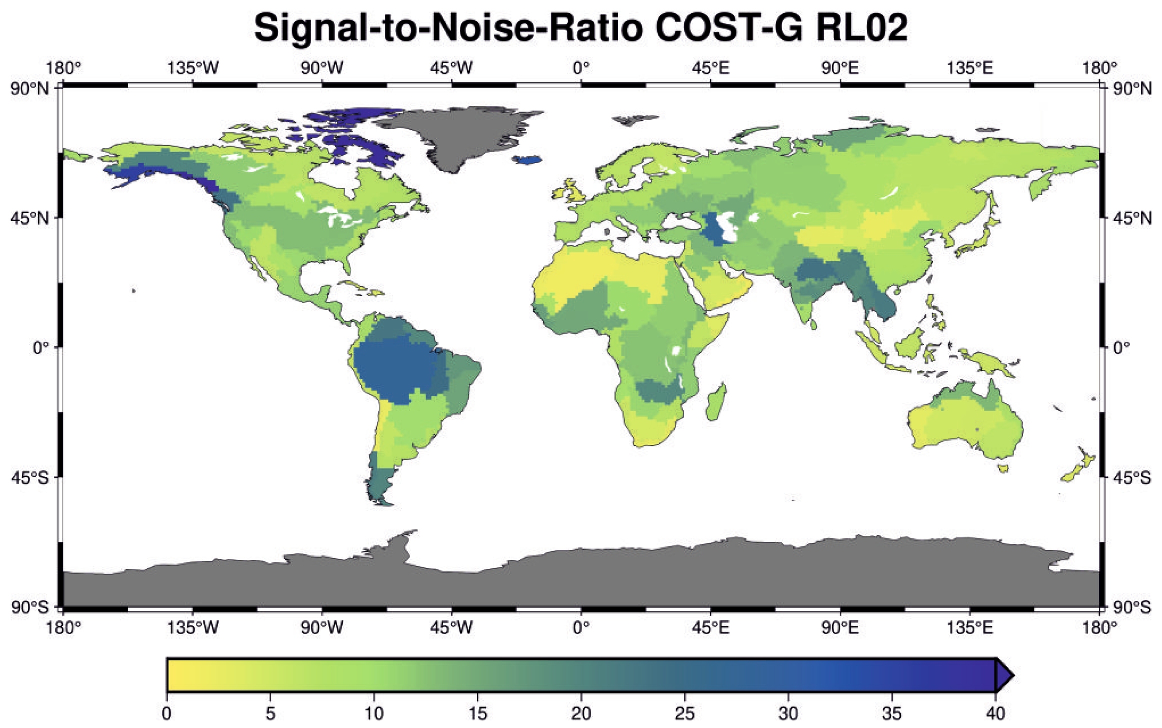

Fig. 5: Signal/noise assessment for the COST-G GRACE and GRACE-FO RL02 mass change time-series in individual river basins.

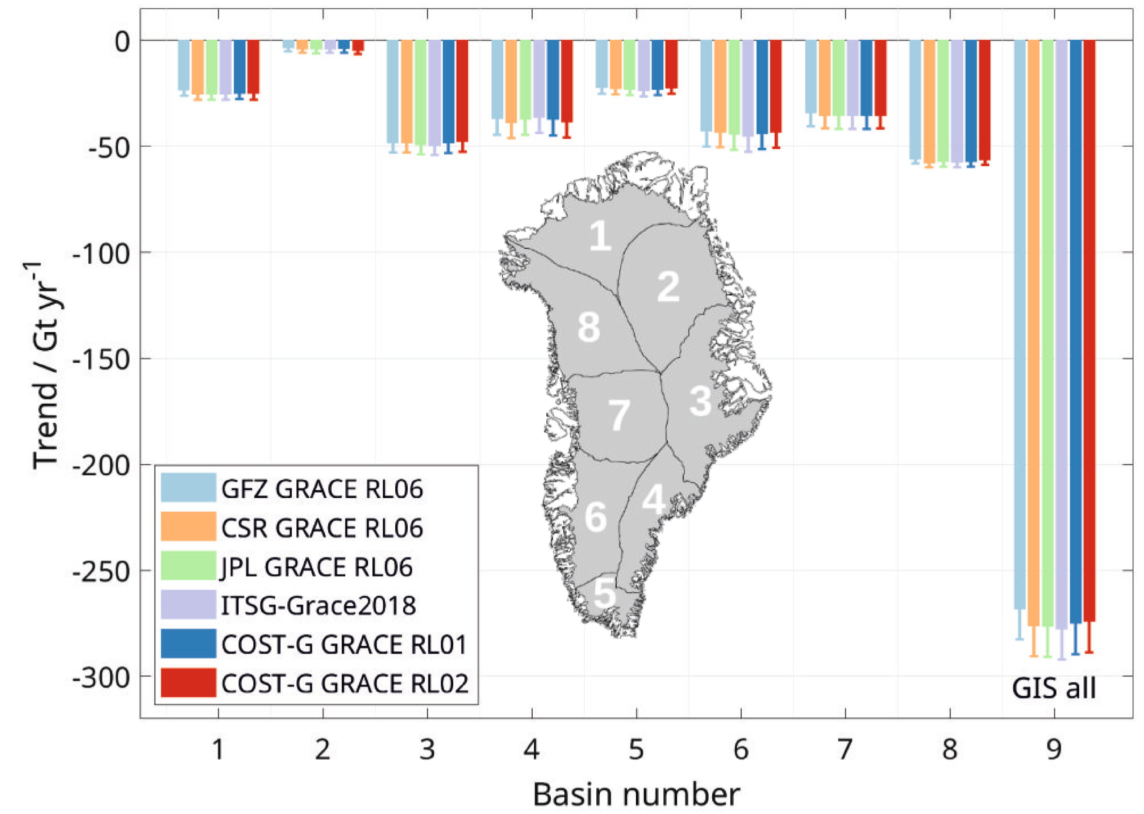

Fig. 6: Comparison of ice mass trends and uncertainties in Greenland.

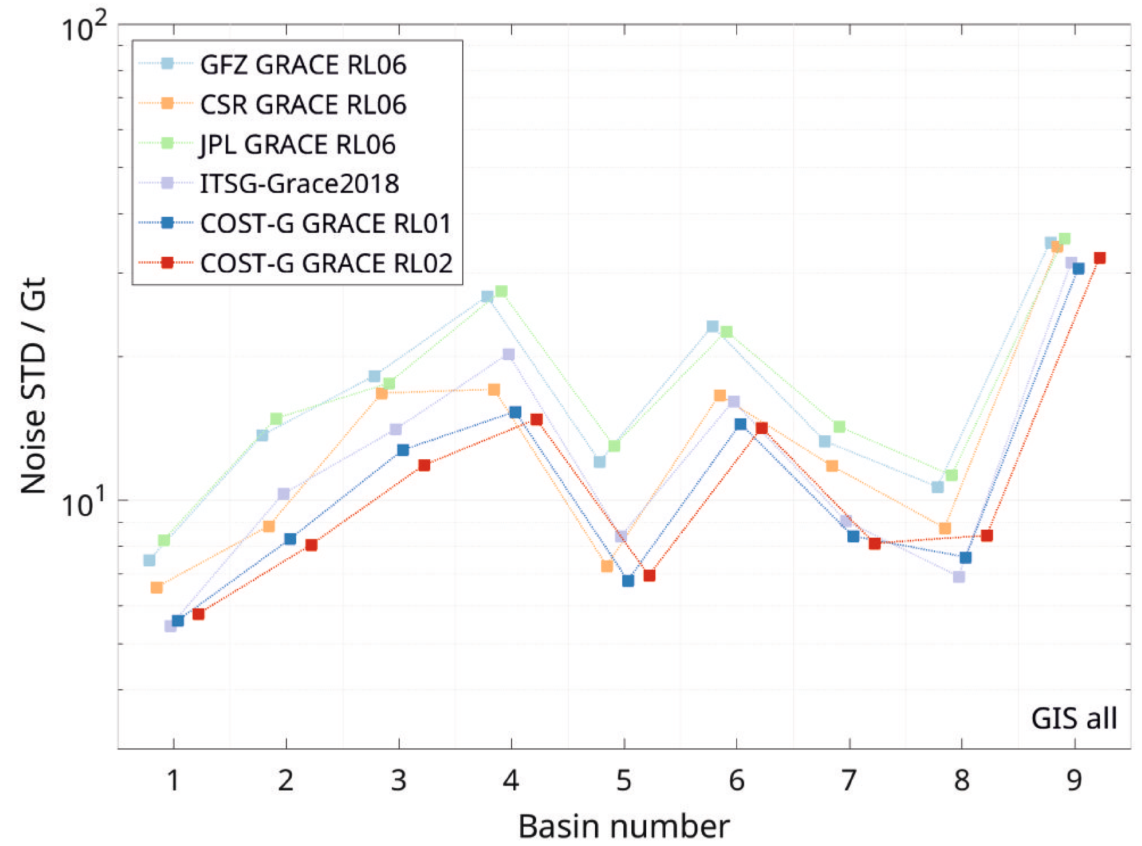

Fig. 7: Noise assessment for ice mass trends in Greenland.

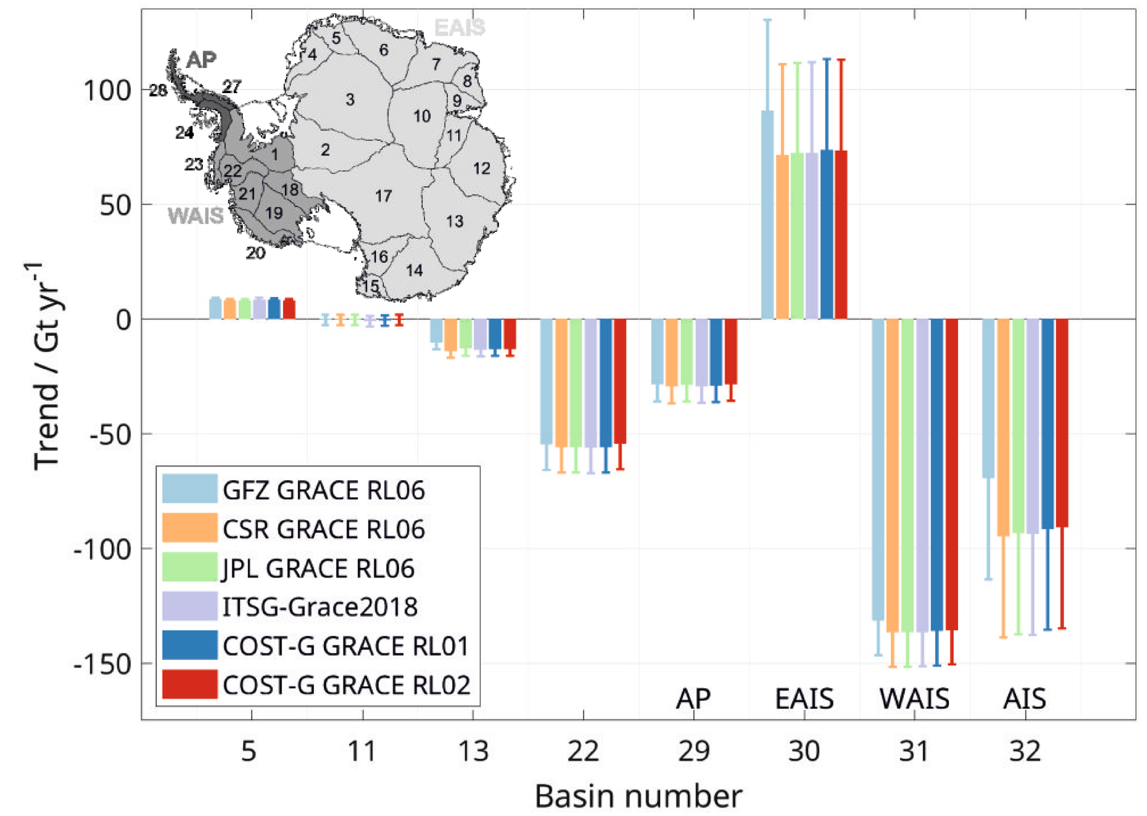

Fig. 8: Comparison of ice mass trends and uncertainties in Antarctica.

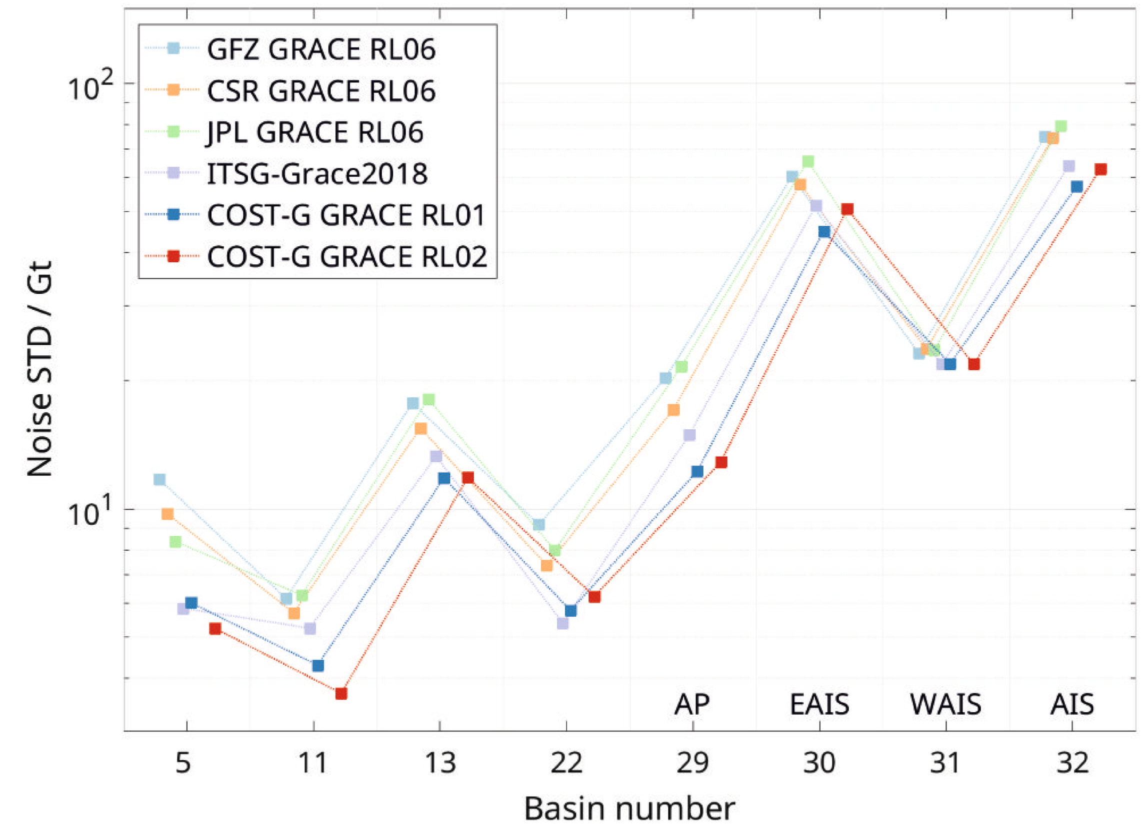

Fig. 9: Noise assessment for ice mass trends in Antarctica.

Future plans

With the advent of NGGM/MAGIC, further developments will come into the focus of COST-G:

- combination of different ACs and satellite missions on the normal equation level,
- combination of low degree spherical harmonic coefficients with Satellite Laser Ranging (SLR), again on the normal equation level,
- reconstruction of the full signal content (including gravitational background models) prior to combination, to avoid biases induced by the use of different background models.

Conclusions

The signal content of COST-G GRACE RL01 and RL02 is very consistent. A minor reduction of noise can be observed mainly in the early and late GRACE mission phase, when solar activity was high and data gaps and artifacts complicated the data analysis, and during orbit repeat cycles with reduced sensitivity at small spatial scales. This improvement can be explained by the increased robustness of RL02 due to the larger data-base of 11 contributing ACs, all applying their own independent and stand-alone analysis software for the gravity field determination.

A special focus in the generation of COST-G GRACE RL02 has been put on the consistent use of the de-aliasing product AOD1B-RL06 and on a consistent weighting strategy with COST-G GRACE-FO RL02 to facilitate the geophyical interpretation of the combined time-series of GRACE and GRACE-FO.

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