COST-G: recent developments and future perspectives

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1. Introduction to COST-G

The International Combination Service for Time-variable Gravity Fields (COST-G; Jäggi et al, 2020) is a Product Center of the International Gravity Field Service (IGFS) of the IAG. COST-G continues the activities of the H2020 project European Gravity Service for Improved Emergency Management (EGSIEM, 2015-2017; Jäggi et al, 2019) to realize the long-awaited standardization of gravity-derived mass transport products.

COST-G products:

- Combined gravity field solutions in spherical harmonic (SH) coefficients (Level-2 products) derived from a weighted combination of the individual solutions generated by different Analysis Centers (ACs),
- Spatial grids (Level-3 products) of the combined solutions for hydrological, oceanic and polar ice sheets applications.

COST-G ACs: AIUB, GFZ, TU Graz, cnes, Leibniz Universität Hannover, COST-G, Southern University of Science and Technology, HUST, Sun Yat-sen University, Tongji University

COST-G provides consolidated monthly global gravity models in terms of SH coefficients and thereof derived grids by combining solutions from individual ACs (Fig 1). The ACs adopt different analysis methods but apply agreed-upon consistent processing standards to deliver time-variable gravity field models, e.g. from GRACE-FO low-low satellite-to-satellite tracking (ll-SST). The individual solutions are combined by the Analysis Center Coordinator (ACC) at AIUB.

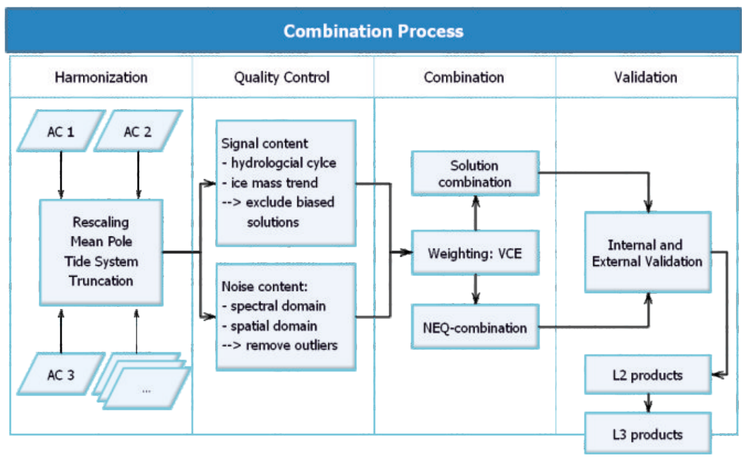

Figure 1: Work-flow of the COST-G gravity field combination.

2. COST-G GRACE/GRACE-FO RL02.1

The COST-G GRACE RL02 has been extended to include the contributions of the new COST-G ACs. It has first been presented at EGU 2025. Also GRACE-FO has been recombined, including the solutions from HUST (Fig. 2).

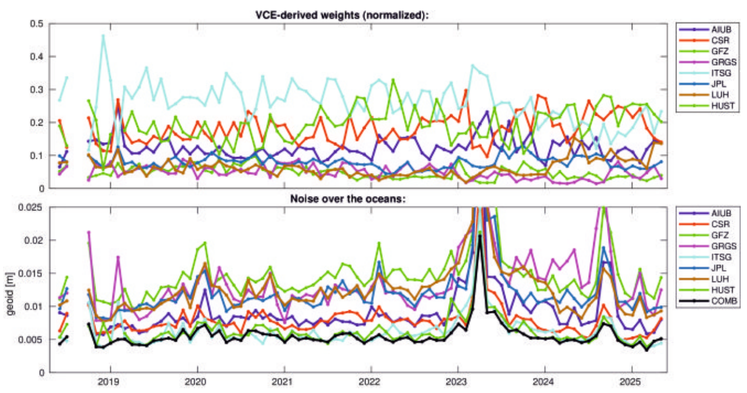

Figure 2: Relative weights and noise assessment of the GRACE-FO RL02.1 contributions and combination.

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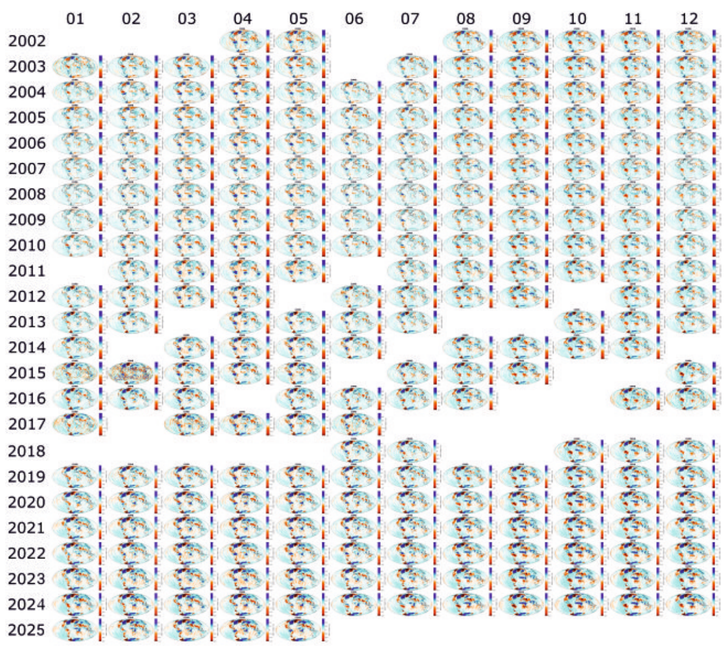

Figure 3: The COST-G GRACE/GFRACE-FO RL02.1 spans more than 23 years of monthly gravity field combinations.

To distinguish the new release from the operational GRACE-FO RL02 combination it has been released as RL02.1 on https://icgem.gfz-potsdam.de/home and https://gravis.gfz.de/home.

3. Preparation for NGGM/MAGIC

To continue the time-series of GRACE/GRACE-FO monthly gravity fields in the future, ESA prepares for the launch of the Next Generation Gravity Mission (NGGM), which together with the NASA mission GRACE-C will form the Mass-Change and Geosciences International Constellation (MAGIC).

The low degree gravity field SH-coefficient C_{20} determined from GRACE/GRACE-FO is contaminated by so-called tone errors. The official recommendation is to replace it by values derived from Satellite Laser Ranging (SLR). In case of NGGM/MAGIC a combination with SLR on normal equation (NEQ) level is envisaged. For preparation, test combinations of GRACE-FO + SLR have been performed (Fig. 4). Due to the high sensitivity of GRACE-FO to higher degree gravity field coefficients the contribution of low-flying SLR satellites (SLR-LEOs) is neglectable, while C_{20} is mainly determined from the LAGEOS SLR-observations.

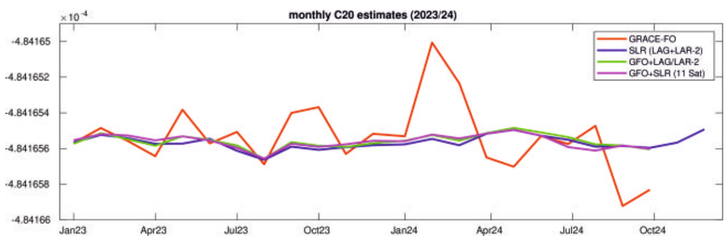

Figure 4: C_{20}-estimates determined from monthly GRACE-FO data, 30-day LAGEOS/LARES-2 data, and GRACE-FO + SLR combinations on normal equation level (including SLR-LEOs).

4. Combination of SLR normal equations from different analyis centers

For the first time, SLR-NEQs from different ACs shall be combined to strengthen the SLR-contribution to the combined NGGM/SLR solutions. In a first step the individual SLR-NEQs are combined AC-wise with relative weights determined by variance component estimation (VCE). The individual weights of LAGEOS 1, LAGEOS 2 and LARES 2 5-day NEQs (Fig. 5) reflect data screening and orbit modeling deficits that are aggravated by tight constraints on the commonly co-estimated periodic empirical cross-track and along-track accelerations that are highly correlated with the C_{20} and C_{30} gravity field coefficients, respectively.

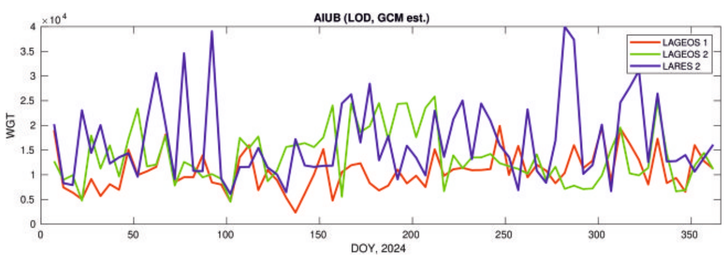

Figure 5: VCE-determined weights of the 5-day SLR normal equations from AIUB.

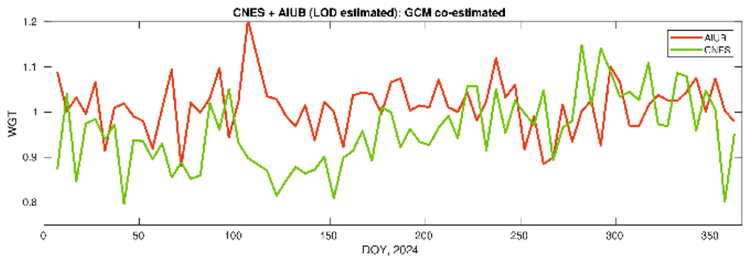

Figure 6: Relative weights of the 5-day SLR-NEQs (LAGEOS 1+LAGEOS 2+LARES 2) of CNES and AIUB, determined by VCE.

The SLR-only solutions from AIUB turned out to be sensitive to the choice of the Earth rotation parameters (ERPs). Since C_{20} and length of day (LOD) are highly correlated and inconsistencies with the apriori LOD cannot be absorbed by the empirical cross-track accelerations (fixed to 0 for the C_{20}-estimation), at least LOD has to be co-estimated to avoid artifacts in the C_{20}-estimates. The CNES solutions in contrary seem to be polluted by artifacts in C_{30}, which are also reflected by high formal errors and therefore do not impair the combined solution. To assess the quality of the degree 1 coefficients (representing Geocenter motion) the time-series is still too short (Fig. 7).

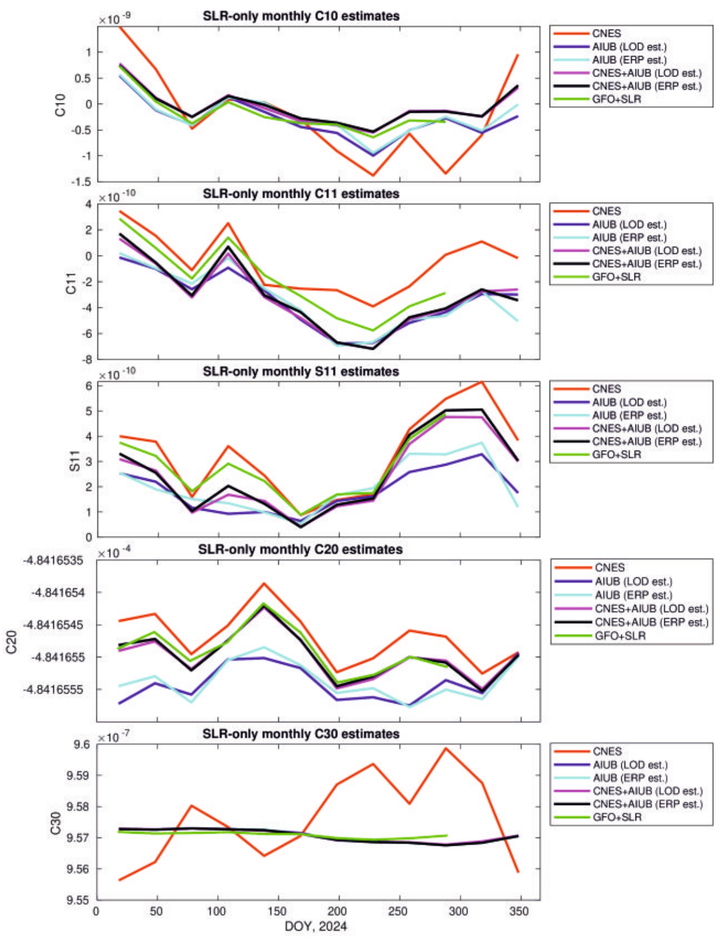

Figure 7: Estimates of selected gravity field coefficients from the NEQ-combination of GRACE-FO and the SLR-contributions from CNES and AIUB.

5. Summary and Outlook

- COST-G GRACE/GRACE-FO RL02.1 including the new ACs from China is finally available at ICGEM (Level-2 data) and GravIS (Level-3 data).
- The feasability of inter-technique combinations using VCE has been confirmed by successful test combinations of monthly GRACE-FO NEQs and 10 day LAGEOS/LARES-2 NEQs, both provided by AIUB (the GRACE-FO NEQs generated applying an empirical, i.e. realistic noise model).
- First experience with the combination of SLR-NEQs of different ACs has been gained based on the 5 day SLR-NEQs generated by CNES and AIUB in the frame of the ESA MPEF project.

6. Acknowledgments

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