The EGSIEM combination service: final results and further plans

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Introduction

In the frame of the Horizon 2020 project **E**uropean **G**ravity **S**ervice for **I**mproved **E**mergency **M**anagement (EGSIEM, 2015-17) the prototype of a scientific combination service for time-variable gravity fields has been installed at the **A**stronomical **I**nstitute of the **U**niversity of **B**ern (AIUB). It provides consistent, reliable and validated monthly GRACE gravity fields that are combined on **N**ormal **Eq**uation (NEQ) level from standardized NEQs of all associated **A**nalysis **C**enters (ACs). While the EGSIEM standards on reference frame and Earth rotation guarantee consistency of the NEQs, the different ACs are free to use their specific processing approaches and the background force models and de-aliasing products of their choice. The latter is restored in the final L3-products (global grids) to provide full (non-tidal) signal content, specificly post-processed for hydrological or oceanographic applications.

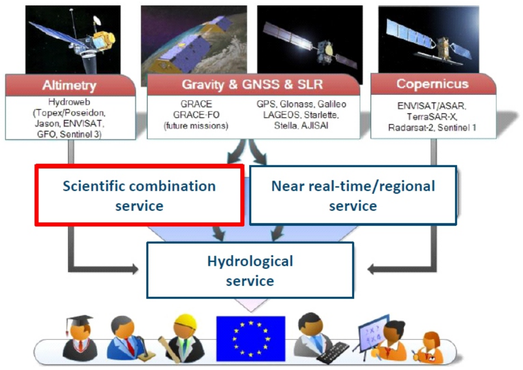

Fig. 1: EGSIEM has installed three services related to temporal gravity field variations.

Combination strategy

The individual NEQs are first scaled empirically to contribute equally to pair-wise combinations. In a second step relative weights are derived iterative by **V**ariance **C**omponent **E**stimation (VCE) on solution level (Jean et al, 2018). Finally these factors and weights are applied in the combination of the NEQs on normal equation level.

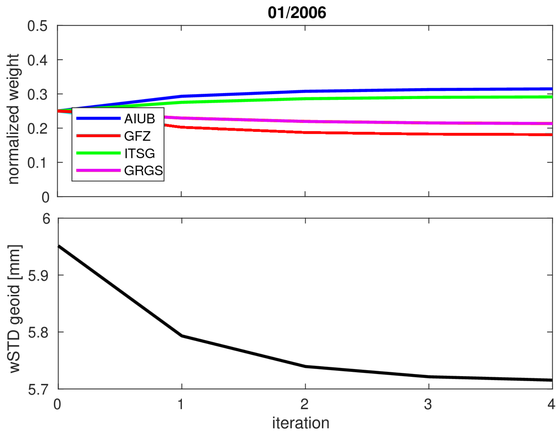

Fig. 2: Weights on solution level are derived iterative (top), the STD of anomalies over the oceans (bottom) indicates the corresponding noise.

Test combinations 2006/07

In the frame of EGSIEM monthly gravity fields of two test years 2006 and 2007 were combined. For these two years contributions from four ACs were available:

- Astronomical Institute University of Bern (AIUB),
- Groupe de Recherche de Géodésie Spatiale (GRGS),
- Helmholtz Centre Potsdam (GFZ), and
- Institute of Geodesy, Graz (ITSG).

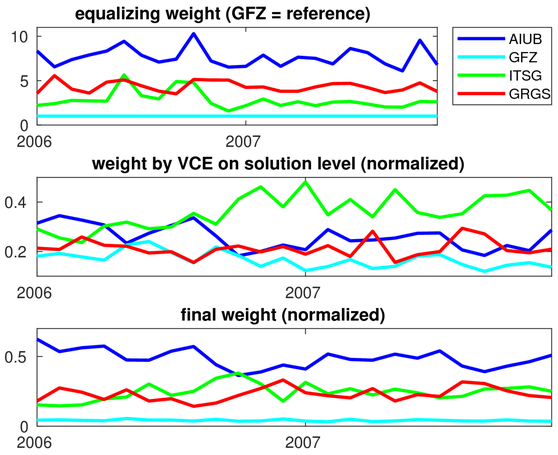

Fig. 3: Relative weights applied for the combination of the monthly NEQs:

- *empirical scaling factors (top) account for the different parametrization, noise models and choice of observations (GPS phases versus kinematic orbits),*
- *weights derived by VCE on solution level (middle) represent the different noise levels of the individual contributions,*
- *the final weights (bottom) are the monthly products of the empirical factors and the relative weights based on the different noise levels.*

Quality control

For independent quality control anomalies are computed. They are defined as the residuals after removal of a best fitting trend and seasonal variations. Anomalies are either derived coefficient wise in the spherical harmonic domain or per grid cell of global grids in the spatial domain. In the latter case they may be evaluated over the ocean areas, where no short-periodic temporal mass variations are expected, to provide monthly estimates of the noise levels.

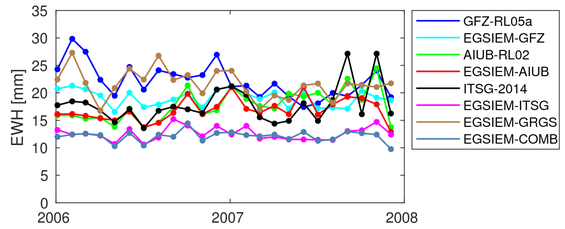

Fig. 4: Monthly quality control in the spatial domain of the ACs individual contributions, compared to the corresponding EGSIEM time-series and the combination. Shown is the RMS of anomalies over the oceans (smoothed by a 400km Gauss filter), weighted by the cosine of the latitude of the grid cells.

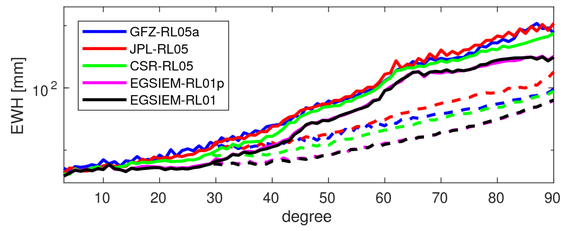

Fig. 5: Quality control in the spectral domain of the EGSIEM combination compared to the GRACE SDS time series. Shown is the RMS of degree amplitudes of anomalies, either including all orders (solid lines), or truncated at order 29 to focus on the signal dominated part of the spectrum (dashed).

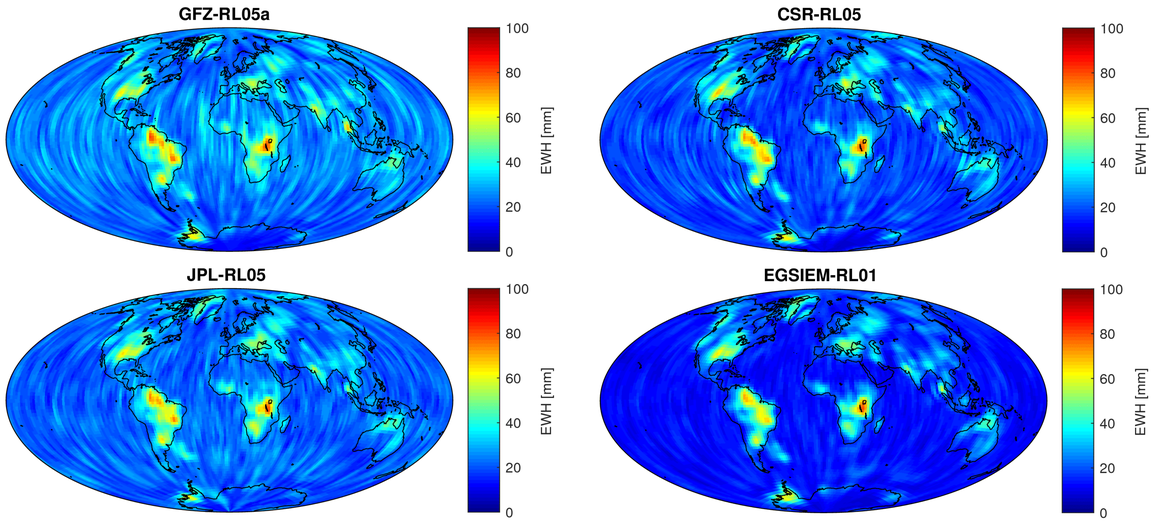

Fig. 6: For quality control the noise level of the combined EGSIEM gravity fields are compared to the official GRACE SDS time series. Shown are anomalies, i.e. residuals after removal of trends and seasonal variations. Over the oceans the anomalies mainly represent noise.

Extension of the EGSIEM time series

At the end of the EGSIEM project the focus shifted to providing an extended combined gravity field time-series covering at least the period 2004-10. For this extended period only three contributions are available yet, namely the AIUB, GRGS and ITSG contributions. During the years 2004/05 noise levels are high (due to high solar and consequently ionosphere activity, a period of orbit resonance in fall 2004, and data quality problems). These problems are reflected in oscillating weights and the fact that the combination is not always better than the best individual contribution (normally from ITSG). With more homogeneous quality in 2008-10 the combination again outperforms all individual contributions.

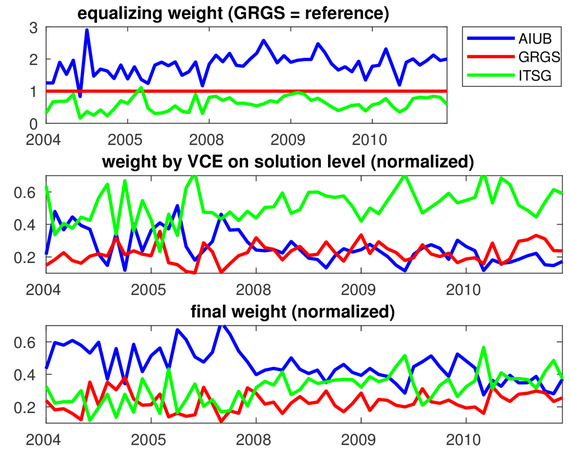

Fig. 7: Relative weights applied for the combination of the NEQs of the extended time-series.

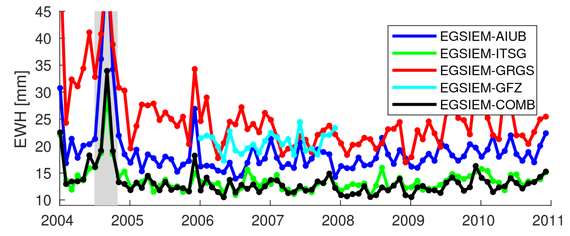

Fig. 8: Monthly RMS of EWH anomalies over the oceans for the extended time-series (smoothed by a 400km Gauss filter). Reduced quality during fall 2004 (gray box) coincides with a period of orbit resonance. The peak in RMS in 01/2004 is caused by reduced data quality, in 12/2005 a satellite swap maneuvre took place. Note that during the availability of GFZ-EGSIEM the combination consists of four monthly contributions, otherwise only of three.

Future plans: COST-G

The end of the EGSIEM project is not the end of the scientific combination service. It is being transformed into the International **Co**mbination **S**ervice for **T**ime-variable **G**ravity field solutions (COST-G), the Product Center of the IGFS for time-variable gravity fields. It is envisaged to provide combined monthly fields of the whole GRACE mission period, taking into account the EGSIEM, the GRACE SDS RL06 and further time-series that pass the EGSIEM quality control (as soon as SDS RL06 becomes available).

References: Jean Y, Meyer U, Jäggi A (2018): Combination of GRACE monthly gravity field solutions from different processing strategies. Journal of Geodesy, https://doi.org/10.1007/s00190-018-1123-5

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