LUH-GRACE2018: A NEW TIME SERIES OF MONTHLY GRAVITY FIELD SOLUTIONS FROM GRACE

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A – Introduction

In this contribution, we present a new time series of monthly gravity field solutions mainly obtained from GRACE K band range rate (KBRR) measurements. Our monthly solutions are computed using the in-house developed GRACE-SIGMA software.

The processing is based on variational equations and consists of two main steps. In the first step, 3-hourly orbital arcs of the two satellites and the state transition and sensitivity matrices are dynamically integrated using a tailored Gauss-Jackson integrator. In this step, initial state vectors and 3D accelerometer bias parameters are adjusted using GRACE L1B reduced dynamic positions as main observations.

In the second step, normal equations are accumulated and the normalized spherical harmonic coefficients up to degree and order 80 are estimated along with empirical and previously mentioned parameters from step 1. Here we use KBRR measurements as main observations and introduce reduced dynamic positions to solve for the low frequency coefficients.

In terms of degree standard deviations, our gravity field solutions agree well with solutions of CSR, GFZ and JPL. In this contribution, processing details and derived mass variations are presented. The new time series, entitled as LUH-GRACE2018, can be downloaded from IfE or ICGEM websites.

B – Force Modeling

Several force effects of gravitational and non-gravitational nature have to be considered for gravity field recovery. Force models, corresponding parameters and additional information are summarized in Tab. 1

Tab. 1: Standard force models for gravity field recovery at IfE (d/o: indicates the maximum degree/ order of the spherical harmonic coefficients).

Force	*Model*
Gravity Field (*GF*)	– Mean background: **GIF48** (d/o: 300) [1]
Third Bodies (*DT*)	– Direct and indirect terms for the Sun and Moon – Ephemerides: **DE405** [2] – Celestial bodies are considered as point masses
Solid Earth Tide (*SET*)	– Sun and Moon (d/o: 4) [3] – Frequency dependent part from IERS Conventions 2010 [4]
Ocean Tide (*OT*)	– **EOT11a** (d/o: 80) [5] – 18 main waves, minor waves are interpolated based on admittance theory
Relativistic Effects (*REL*)	– IERS Conventions 2010 [4]
Solid Earth Pole Tide (*SEPT*)	– IERS Conventions 2010 (d/o: 2) [4]
Ocean Pole Tide (*OPT*)	– IERS Conventions 2010 (d/o: 60) [4]
Atmospheric Tide (*AT*)	– Not applied yet
Non-Tidal (*NT*)	– **AOD1B RL05** (d/o: 100) [6] – Linear interpolation of SHC
Non-Gravitational	– Linear accelerometer measurements [7] – Scale factors are held fixed to a-priori values [8] – Corrections to a-priori biases [8] are estimated per direction and arc

C – Parametrization

step 1:

Orbit pre-adjustment

9 local parameters / 3h arc

- initial state (6)
- accelerometer bias (3)

3 iterations

step 2:

Orbit adjustment and gravity field recovery

9 local parameters / 3h arc

- initial state (6)
- accelerometer bias (3)

8 common parameters / 3h arc

- empirical KBR (8)

6561 global parameters / month

- normalized spherical harmonic coefficients of the Earth's geopotential (d/o: 80)

1 iteration

GRACE-SIGMA software consists of two main processing steps. In a pre-adjustment L1B reduced-dynamic orbits are improved by estimating corrections to the initial satellite states and a priori accelerometer biases. Pre-adjusted orbits are used as initial orbits in step 2. In this step, GRACE-SIGMA recovers the gravity field using batch least squares. Local parameters and common parameters are eliminated and the normal matrices containing spherical harmonic coefficients are stacked.

Fig. 1: Parametrization of the LUH-GRACE2018 solutions.

D – Comparison of Degree Standard Deviations

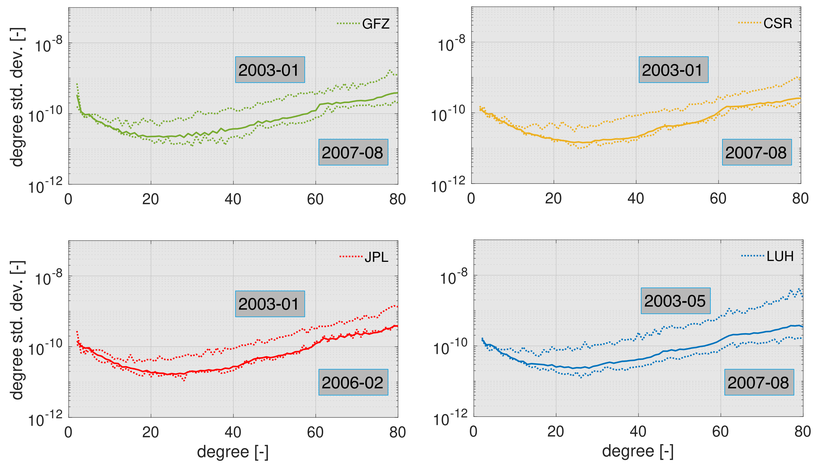

Fig. 2: Comparison of degree standard deviations. Minimum, maximum and mean degree standard deviations for the period 2003-2009 are shown.

Solutions of the three analysis centers and the LUH solutions have comparable degree standard deviations. The CSR and JPL solutions show a good consistency because the mean degree standard deviations are close to the minimum degree standard deviations. The consistency of the LUH solutions is comparable to the GFZ solutions. A more advanced data screening method can be applied in order to minimize the maximum degree standard deviations of the LUH solutions.

E – Comparison of Equivalent Water Heights

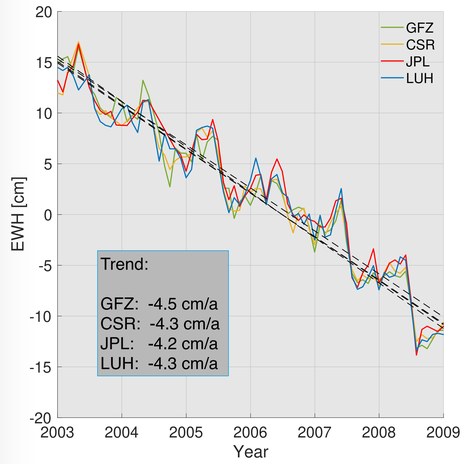

Fig. 3: Mean equivalent water heights (EWH) in Greenland, 2003-2009.

To compare the quality of our solutions, we compare the equivalent water heights (EWH) time series in Greenland. The area of Greenland was approximated by a rectangle with following limits: latitude: 60°–85°, longitude: -70°–-20°. The EWH values were computed on a 0.25° x 0.25° grid. The figure shows the corresponding mean values.

The C_{20} coefficients were replaced by values obtained with SLR. The mean gravity was subtracted. The differences of spherical harmonic coefficients were smoothed using the Gauss filter (300 km).

F – Outlook

For a second release, several new aspects will be considered, e.g.:

- GRACE L1B RL03 data
- AOD1B RL06
- Testing of different parametrizations
- Analysis of range rate residuals
- Atmospheric tides
- Accelerometer scale estimation
- More advanced data screening

GRACE-SIGMA will be extended, to take into account GRACE-FO LRI observations.

References

[1] ***Ries et al.*** **(2011):** Mean background gravity fields for GRACE processing, GRACE Science Team Meeting Austin, TX, August 8-10. [2] ***Standish*** **(1998):** JPL planetary and lunar ephemerides, DE405/LE405, Jet Propulsion Laboratory Interoffice Memorandum IOM 312.F-98-048. [3] **Kudryavtsev (2011):** Precise analytical calculation of the effect of solid Earth tides on satellite motion, Proceedings of the Journées 2011 "Systèmes de référence spatio-temporels", H. Schuh, S. Böhm, T. Nilsson and N. Capitaine (eds), Vienna University of Technology, 2012. [4] ***Petit and Luzum*** **(2010):** IERS Conventions (2010), IERS technical note 36, Verlag des Bundesamts für Kartographie und Geodäsie, Frankfurt am Main. [5] ***Rieser et al.*** **(2012):** The ocean tide model EOT11a in spherical harmonics representation, Technical report. [6] ***Flechtner et al.*** **(2015):** AOD1B product description document for release 05, GRACE 327-750 (GR-GFZ-AOD-0001), Technical report. [7] ***Case et al.*** **(2010):** GRACE level 1B data product user handbook (JPL D-22027), Technical report. [8] ***Bettadpur*** **(2009):** Recommendation for a-priori bias & scale parameters for level-1B acc data (version 2), (GRACE TN-02), Technical report.

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