Gravity field models derived from Swarm GPS data

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Introduction

The Swarm satellites continue to provide high-quality hl-SST data. We use these data to derive the time-varying **gravity field of the Earth** at **1500km resolution**, on a **monthly basis** since December 2013. We combine the gravity field solutions computed with the data of all three satellites, as provided by the Astronomical Institute (ASU), Astronomical Institute of the University of Bern (AIUB) and Institute of Geodesy (IfG) and demonstrate that this **uninterrupted time series** of gravity field models are **in good agreement** with the temporal variations observed by the **GRACE satellites**.

The **hl-SST data** gathered by the **Swarm satellites** can be used to study **large-scale mass changes** globally, e.g. i) in the context of **low-latency applications**, such as the European Gravity Service for Improved Emergency Management project (http://egsiem.eu), ii) in those months where **GRACE solutions are not available**, and iii) as an important source of **independent information for mitigating the GRACE/GRACE Follow-On gap**.

Swarm gravity field models

Inst.	Location	Approach	Orbits	Ref. Gravity Field	Reference
AIUB	Bern, Switzer-land	Celestial Mechanics Approach (Beutler et al., 2010)	AIUB	AIUB-GRACE03S	Jäggi et al. (2016)
ASU	Prague, Czech Rep.	Acceleration approach (Bezděk et al., 2014)	IfG	ITG-Grace2010s	Bezděk et al. (2016)
IfG	Graz, Austria	Short-arc approach (Mayer-Gürr, 2006)	IfG	GOCO05S	Zehentner and Mayer-Gürr (2015)

Gravity field model pre-processing

- Truncation to degree 20
- C_{20} replaced with value from *GRACE Technical Note 07*
- Temporal variations relative to GGM05G
- Low-pass smoothing with 750km radius (≈ degree 13)

Gravity field model combination

We combine the models described using **simple arithmetic averaging**:

$$\overline{C}_{\ell m}^{(\mathrm{AIUB+ASU+IfG})} = \frac{1}{3}\sum_{i} \overline{C}_{\ell m}^{(i)}, \quad i = \mathrm{AIUB, ASU, IfG} \qquad (1)$$

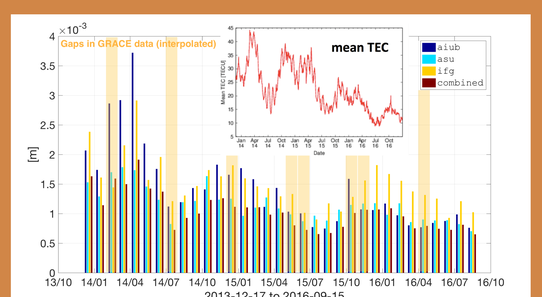
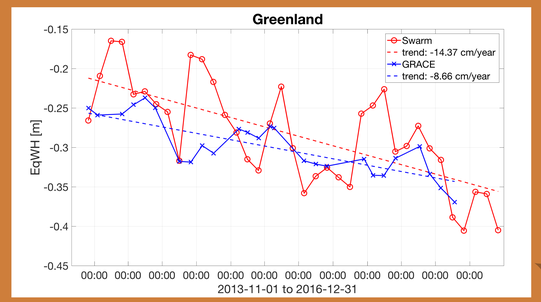
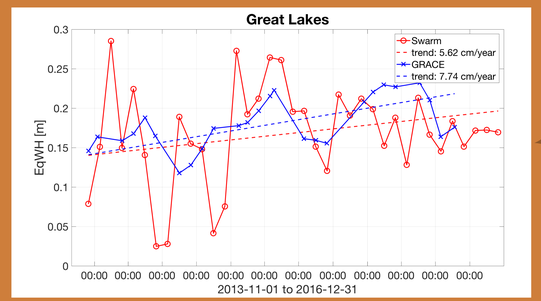
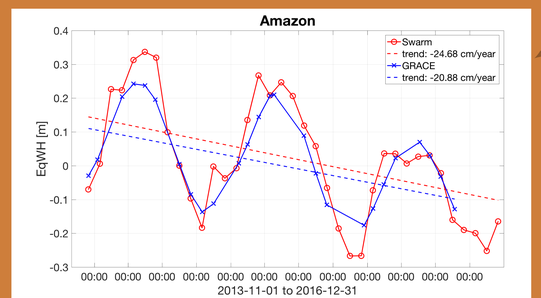
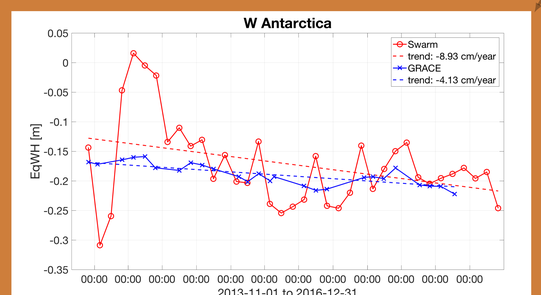


Figure 1 – Indivdual and combined solutions degree-RMS difference relative to GRACE GFZ RL05.









Signal RMS

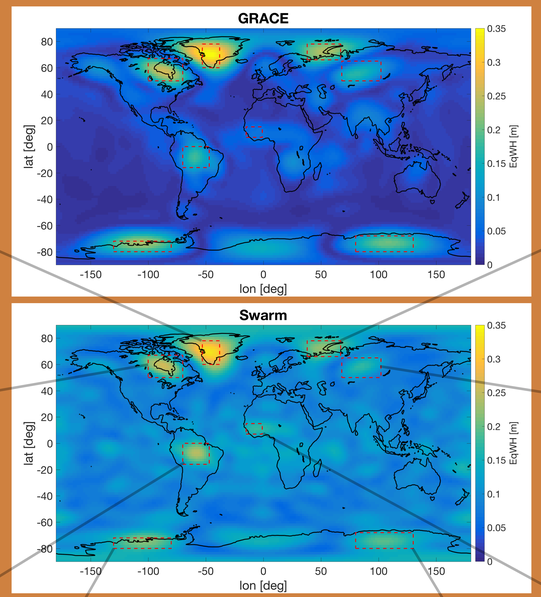


Figure 2 – Signal RMS for 26 GRACE solutions (Dec 2013 to Aug 2016, top) and 37 Swarm solutions (Dec 2013 to Dec 2016, bottom)

Conclusions

- Capable to detect large mass transport processes at ≈ 1500km scale
- Long-term trends differ from GRACE by ≈ factor of 2
- Large scatter (in "smaller" catchments) distort water storage history
- Unreliable in the first 5 months of the mission, due to high ionospheric activity and sub-optimal GPS receiver settings
- Later months with ≈ 1 cm geoid height difference w.r.t. GRACE
- Likely remain with comparable accuracy during GRACE/GRACE-FO gap

References

João Teixeira da Encarnação, Daniel Arnold, Aleš Bezděk, Christoph Dahle, Eelco Doornbos, Jose van den IJssel, Adrian Jäggi, Torsten Mayer-Gürr, Josef Sebera, Pieter Visser, and Norbert Zehentner. **Gravity field models derived from Swarm GPS data**. *Earth, Planets and Space*, 68(1):127, dec 2016. DOI 10.1186/s40623-016-0499-9

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