Preparing for GRACE-FO: Level-1A and Level-1B data handling and processing in the framework of the project MAGIC

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Introduction - The project MAGIC

The project MAGIC focuses on the handling and processing of the future GRACE-FO instrument data to allow for a continuation and improvement of the GRACE derived gravity field time series.
In addition to pre-processed data products (Level-1B) as available from GRACE, raw observations (Level-1A) will be publicly available for the first time. This enables a more detailed analysis of the instrument data, which is not only essential for improving gravity field solutions, but also for preparing next generation gravity field missions. Therefore, it is necessary to meet the challenges of the new data, to incorporate new observation types into the gravity field recovery (e.g., LRI) and to enhance both Level-1A and Level-1B data processing methodologies.
In summary, a processing chain tailored to the data and requirements of GRACE-FO is envisaged, providing a continuous and highly-accurate data record for climate change research.

Major goals

- GRACE-FO Level-1A and Level-1B data handling & processing capability
- Improved processing methodologies based on the use of Level-1A data products (e.g., enhanced sensor fusion approach, independent Level-1B data products)
- Extension of the gravity field time series
- Publication and validation of GRACE-FO derived gravity field solutions (Level-2 & user-friendly Level-3 data products)

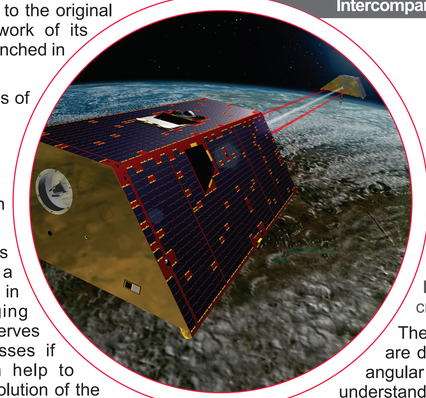
GRACE-Follow-On (GRACE-FO)

The GRACE-FO mission - successor of the original GRACE mission - carries on the work of its predecessor and is expected to be launched in spring 2018 [2].

Onboard GRACE-FO evolved versions of the following instruments will be used:

- KBR ranging instrument
- GPS receiver
- SuperSTAR accelerometer
- Attitude determination based on three star camera (SCA) heads

A secondary objective of GRACE-FO is to demonstrate the effectiveness of a Laser Ranging Interferometer (LRI) in improving the inter-satellite ranging performance [3]. Therefore, the LRI serves as a technical demonstration to asses if precision laser interferometry can help to improve the spatial and temporal resolution of the derived gravity field models.



Level-1A to Level-1B data processing - GRACE

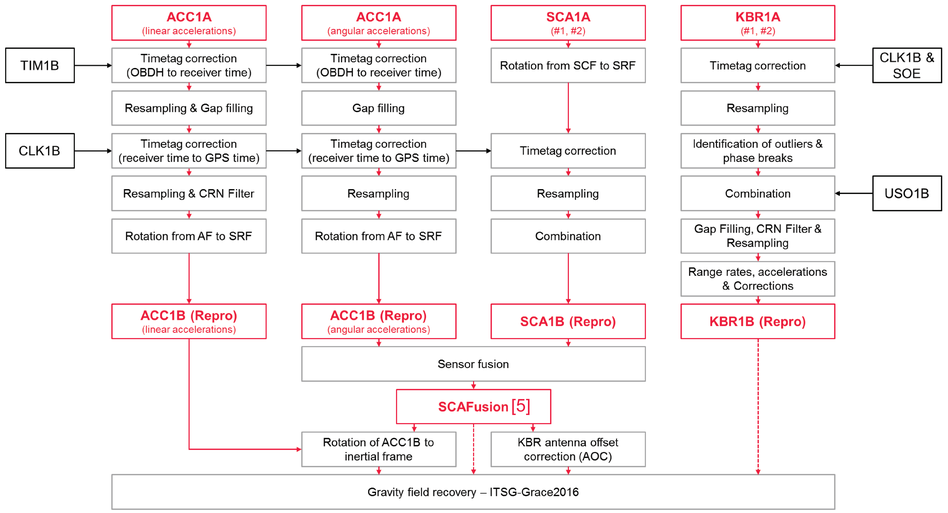


Fig. 1: Illustration of the GRACE Level-1A to Level-1B processing scheme according to [8], and use of the re-processed ACC1B, SCA1B and KBR1B (Repro) data within the ITSG-Grace2016 processing chain.

Intercomparison of data products - Level-1B (RL02) vs. Repro

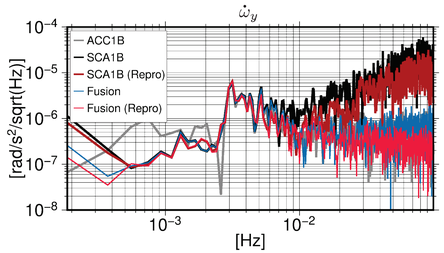


Fig. 2: Comparison of the PSD of the angular accelerations in cross-track direction for different data products for a 1.5 h interval.

The differences w.r.t the official Level-1B data products (cf. Tab. 1) are due to data processing differences [8]. The origin of the larger angular acceleration differences - especially for GRACE-B - is not fully understand yet. The SCA differences are caused by both processing differences and the correct combination of the SCA heads (cf. Fig. 2).

Instrument		RMS (GRACE-A)	RMS (GRACE-B)
ACC [m/s²]	a_x	3.9e-16	3.3e-16
	a_y	6.2e-16	9.6e-16
	a_z	3.9e-15	4.8e-15
ACC [rad/s²]	$\dot{\omega}_x$	1.4e-11	1.9e-09
	$\dot{\omega}_y$	8.2e-12	8.4e-10
	$\dot{\omega}_z$	2.7e-12	4.4e-10
SCA [-]	q_0	3.4e-05	3.4e-05
	q_1	3.5e-05	3.3e-05
	q_2	3.3e-05	3.6e-05
	q_3	3.2e-05	3.2e-05

Tab. 1: RMS differences between Level-1B and Repro data products for one sample month (September 2011).

Implementation of user-friendly Level-3 data products

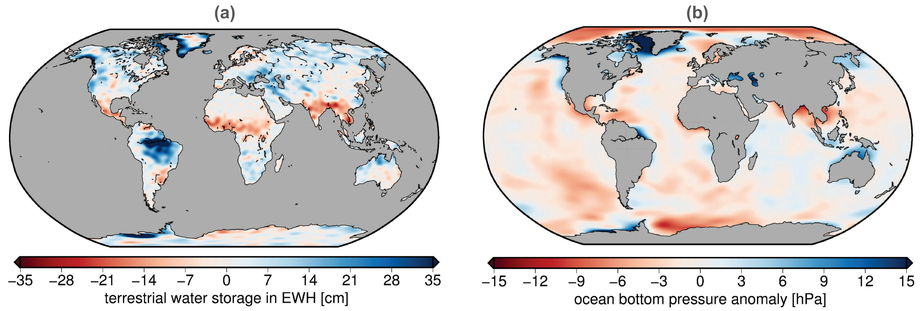
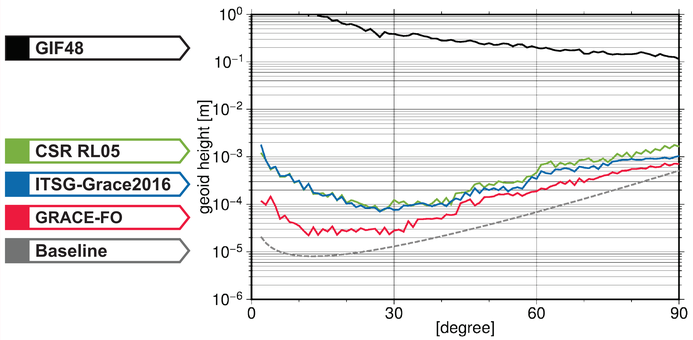


Fig. 3: Gridded mass anomalies from GRACE gravity field solutions for (a) hydrological and (b) oceanographic applications. For each subsystem, a tailored post-processing filter based on the expected signal-to-noise ratio was implemented. The noise model for the filter is based on the time-varying formal error of the GRACE monthly solutions.

Gravity field recovery based on simulated GRACE-FO data



Recovery of the monthly gravity field solution for August 2008 based on the ITSG-Grace2016 processing standards [4,6] using the GRACE-FO Simulation Data Set [1].
Due to the simulation scenario no accelerometer calibration parameters are co-estimated.

⇨ Overall, the data handling and ITSG-Grace processing routines work for the simulated GRACE-FO data!

Fig. 4: Difference degree amplitudes of the recovered monthly gravity field solution (Red) for August 2008; computed with respect to the GIF48 reference model (Black) [7].

Outlook

Next steps:

⇨ Completion of GRACE Level-1A processing routines & Inter-comparison with existing Level-1B data products (RL02 & RL03)
⇨ Extension of sensor fusion approach to 3 SCA heads for GRACE-FO

Further research within the project MAGIC:

- Mock Data Challenge (MDC) gravity field recovery (if corrected data sets are available!)
- Introduction of new observation type: Implementation of data handling & processing routines for LRI data
- GRACE-FO real data analysis & gravity field recovery as soon as GRACE-FO data products are available!

Acknowledgements

This poster is presented in the frame of the project MAGIC (Mass redistributions from GRACE-FO using Laser Interferometry and Microwave ranging based on tailored data processing) funded by the Austrian Research Promotion Agency (FFG) in the framework of the Austrian Space Applications Programme (ASAP) 13.
We also want to thank Dr. Srinivas Bettadpur from the UTCSR for providing us the GRACE Level-1A test datasets.

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