Matthias Ellmer and Torsten Mayer-Gürr
Institute of Theoretical Geodesy and Satellite Geodesy
Graz University of Technology

GRACE Follow-On Sensor Noise with Realistic Background Models

Introduction

We performed three gravity recovery simulations modeled on real orbit and K-Band ranging (KBR) data.

We artificially degraded the dealiasing product used in the recovery step, resulting in observation of a synthetic time variable signal.

We determined the combined effect of this time variable gravity signal, accelerometer accuracy, and the improved range rate measurements of the proposed laser ranging instrument (LRI) aboard GRACE Follow-on on gravity recovery.

Methods

Our simulations are based on real observations for the 30 days of April 2006. The data was synthesized from reduced dynamic orbits fitted to GRACE kinematic orbits. Data gaps were synchronized.

We recovered the gravitational signal from d/o 2 to 120 using the variational equation approach with range rates as observables. The full AOD1B dealiasing product was used in the simulation step. For the recovery step, we degraded the AOD1B product with partial atmosphere (A), ocean (O), and hydrology (H) components of the updated ESA ESM [1].

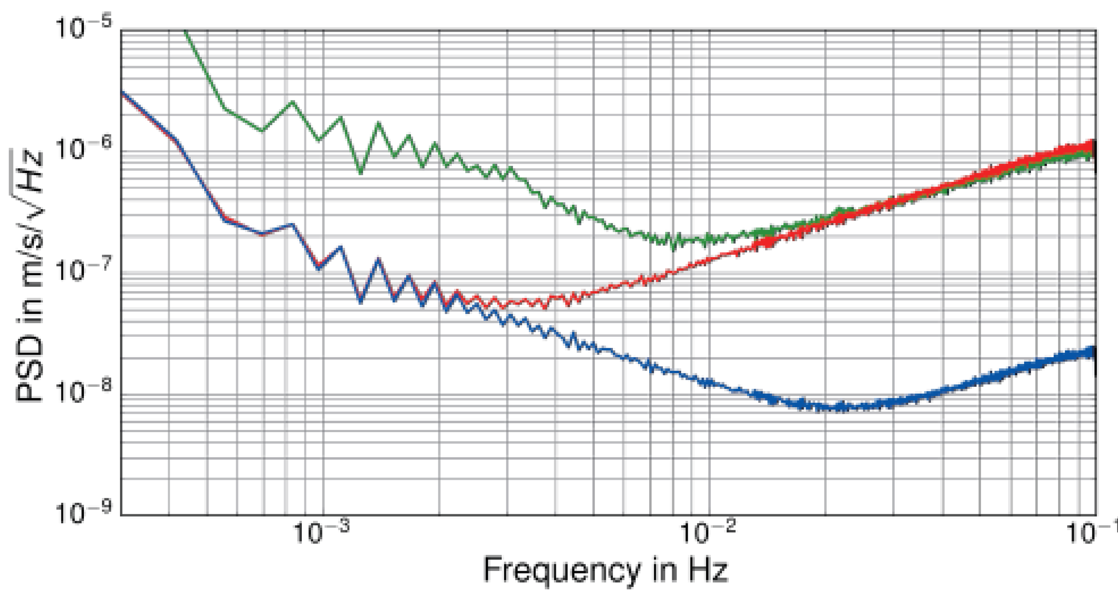
KBR measurements were degraded by ~1/f noise (Applying a differential filter to white range noise $\sigma = 4.5\ \mu m$). LRI is modeled as an improvement of factor 50 with regards to KBR measurements ($\sigma = 90$ nm) [2]. The white accelerometer noise set for the most sensitive axis is $\sigma = 0.17\ nm/s^2$ [3] (Scenario 1,2) and $1.5\ nm/s^2$ (Scenario 3).The kinematic satellite orbits used as observations were degraded with white noise at $\sigma = 2$ cm.

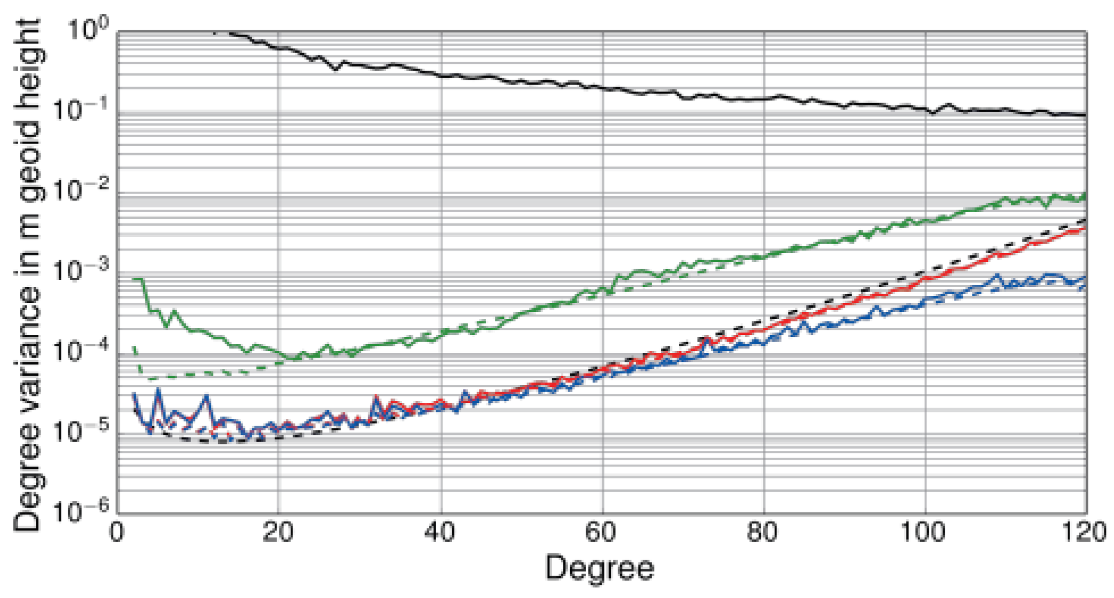
All spatial plots are given in terms of geoid height (300 km Gaussian filter).

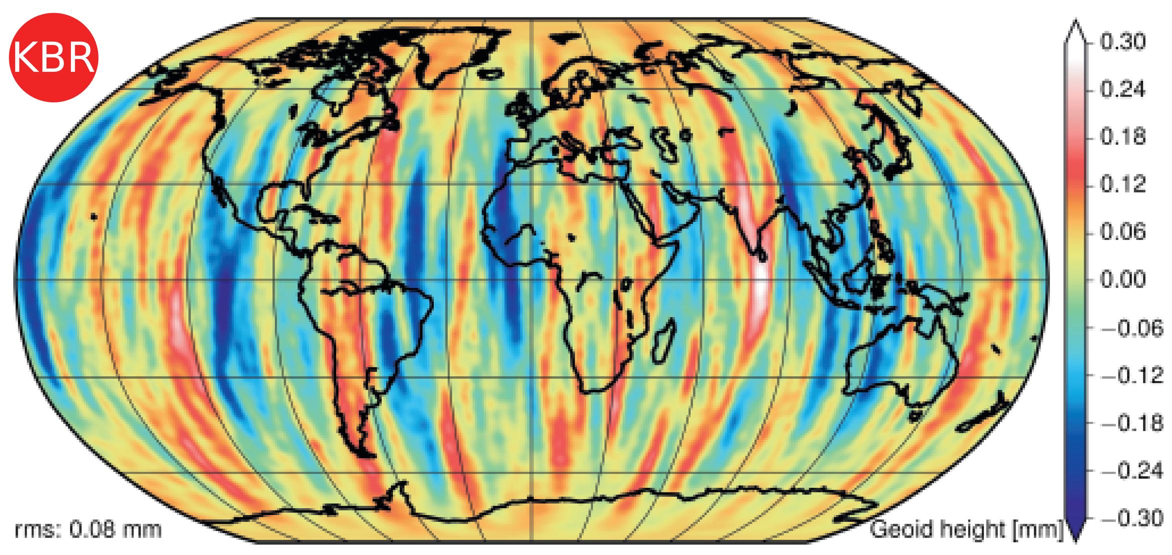
Scenario 1

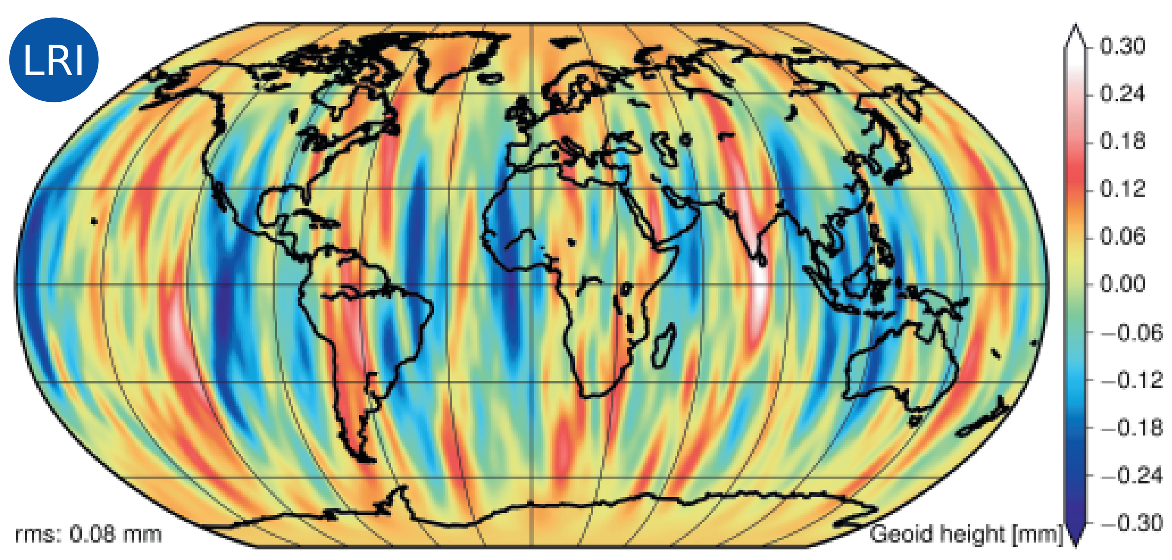
- Accelerometer noise as per specification
- Complete dealising product in restore step

► Solution comparable to GRACE baseline. LRI gives improvement above d/o 60.





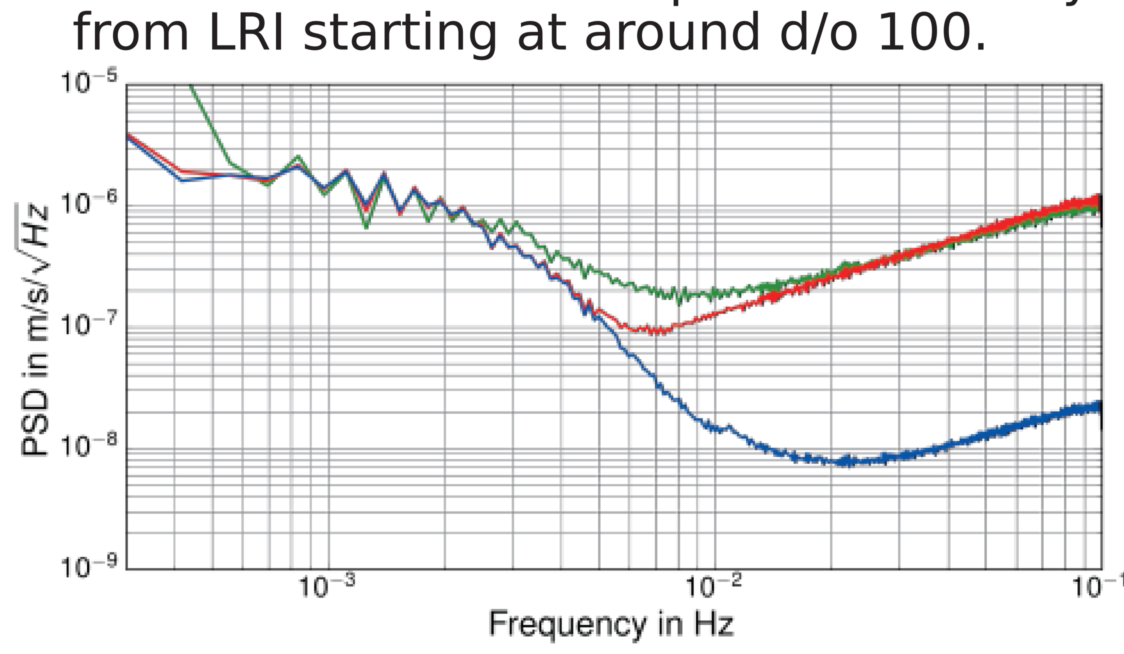


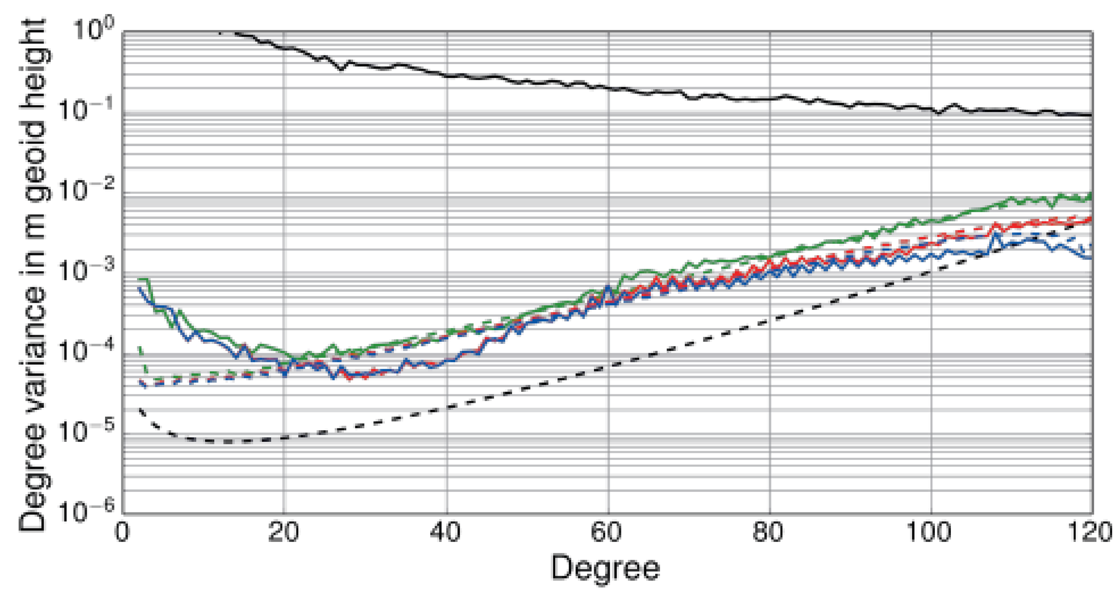


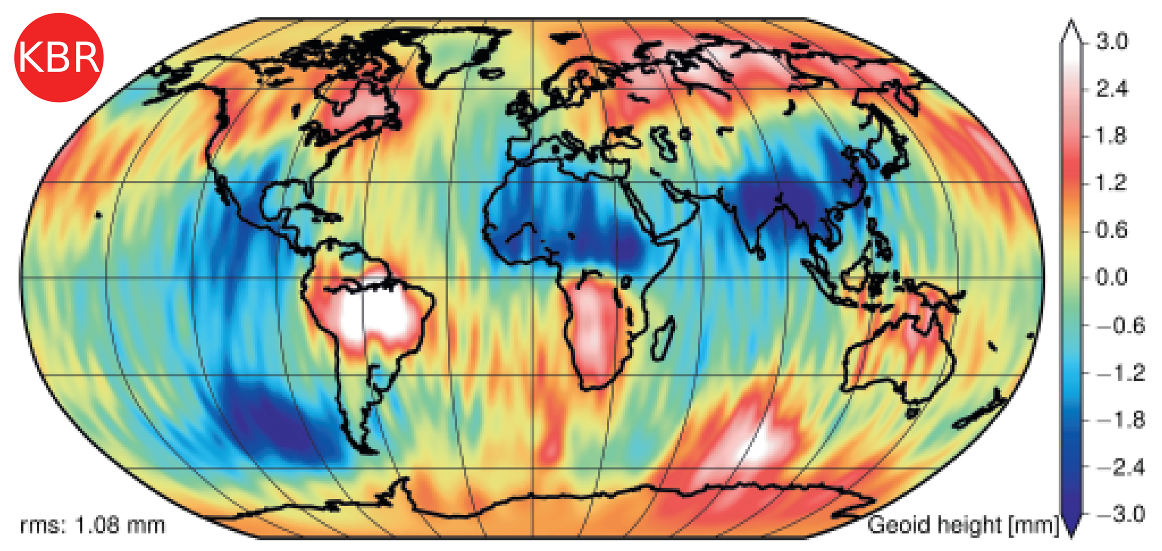
Scenario 2

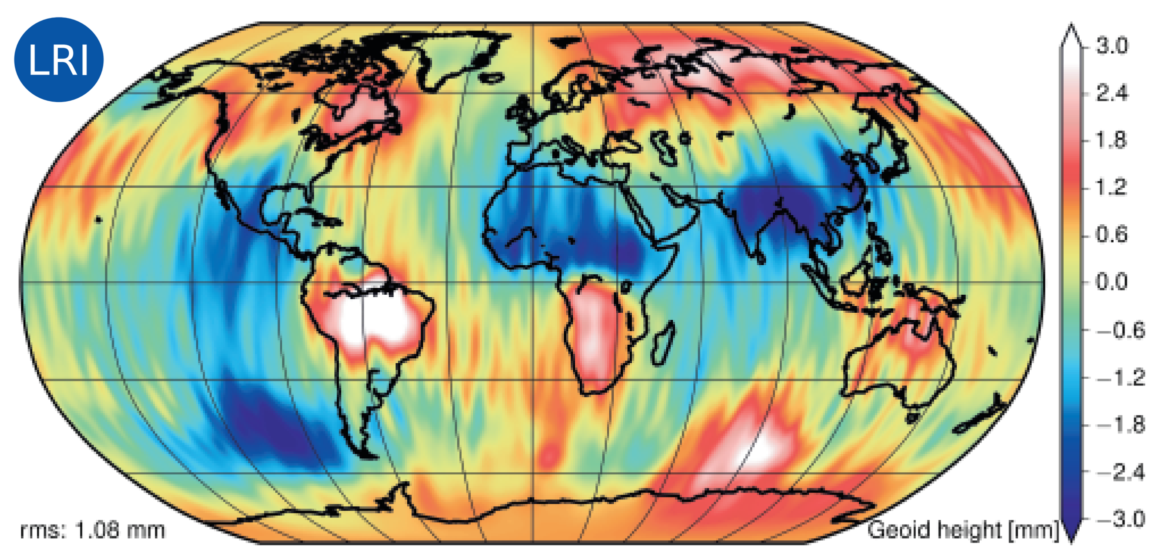
- Accelerometer noise as per specification
- Degraded dealising product based on AOD1B and ESA ESM (AOH components)

► Residual time variable signal resembles that of real solution. Improved accuracy from LRI starting at around d/o 100.





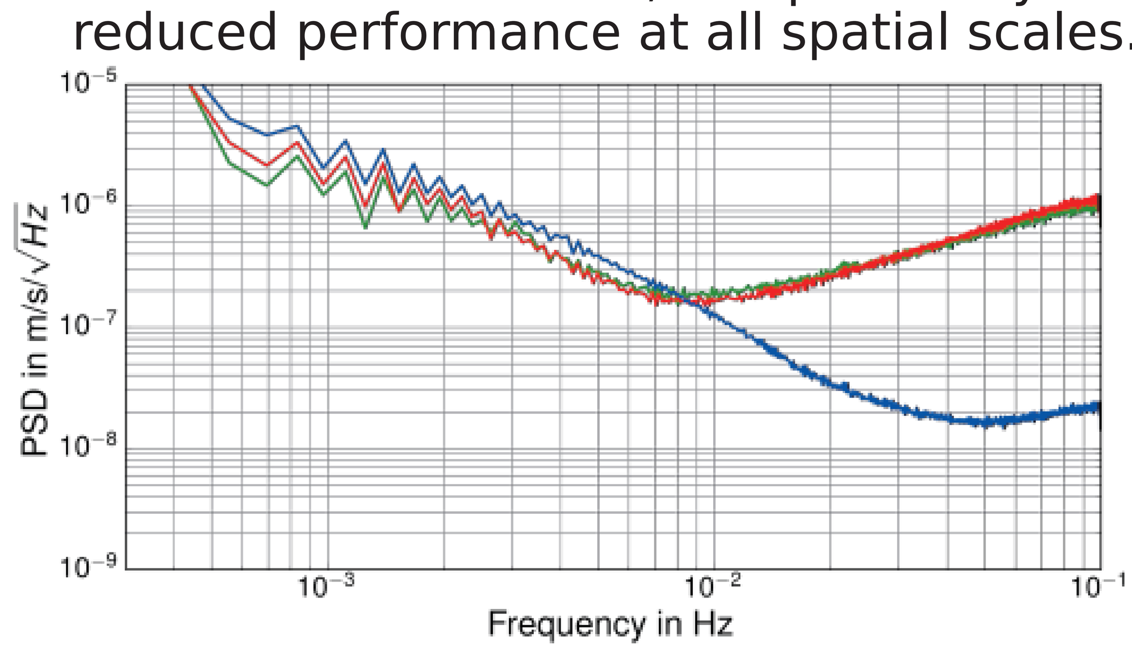


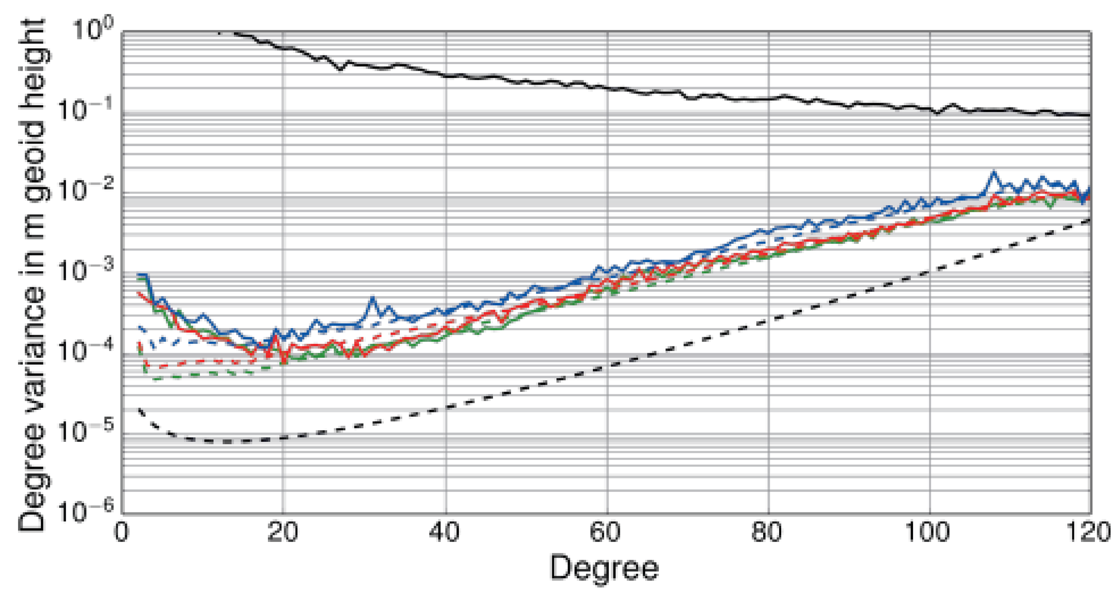


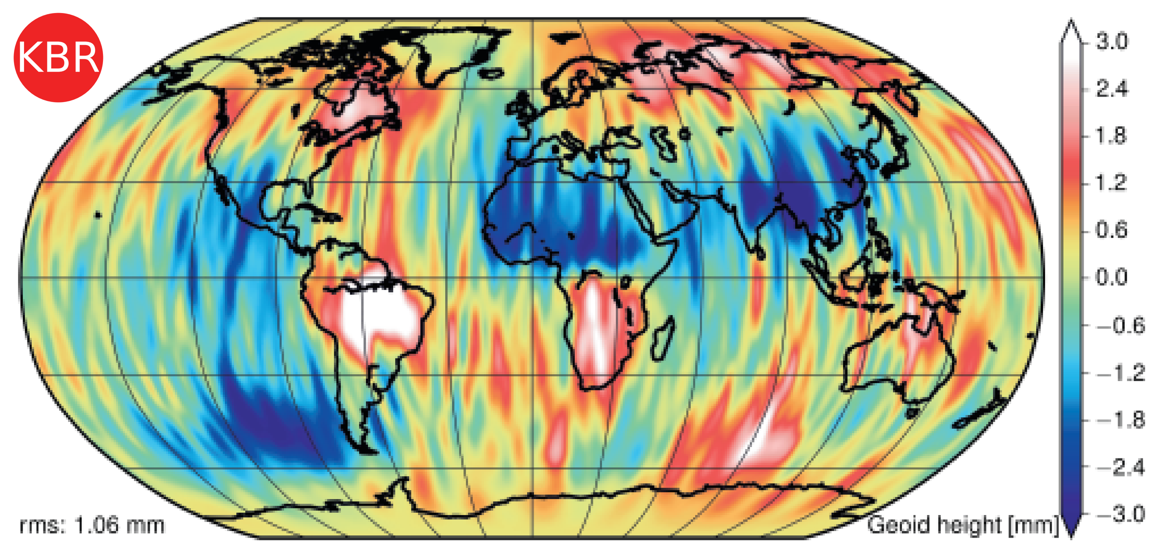
Scenario 3

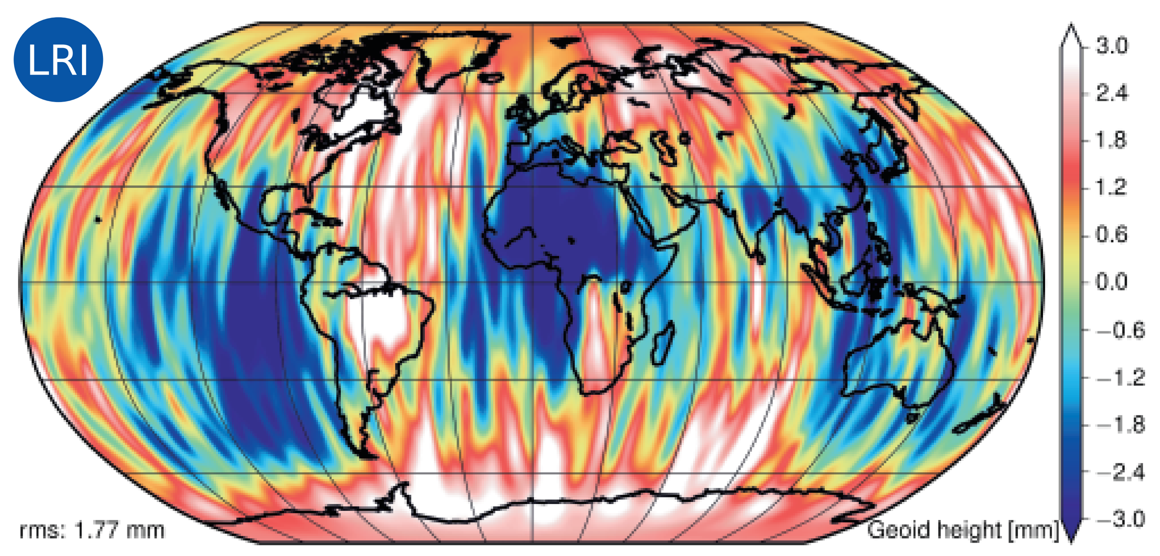
- Accelerometer noise increased by factor 9
- Degraded dealising product based on AOD1B and ESA ESM (AOH components)

► KBR matches real solution well. LRI suffers more than KBR, comparatively reduced performance at all spatial scales.





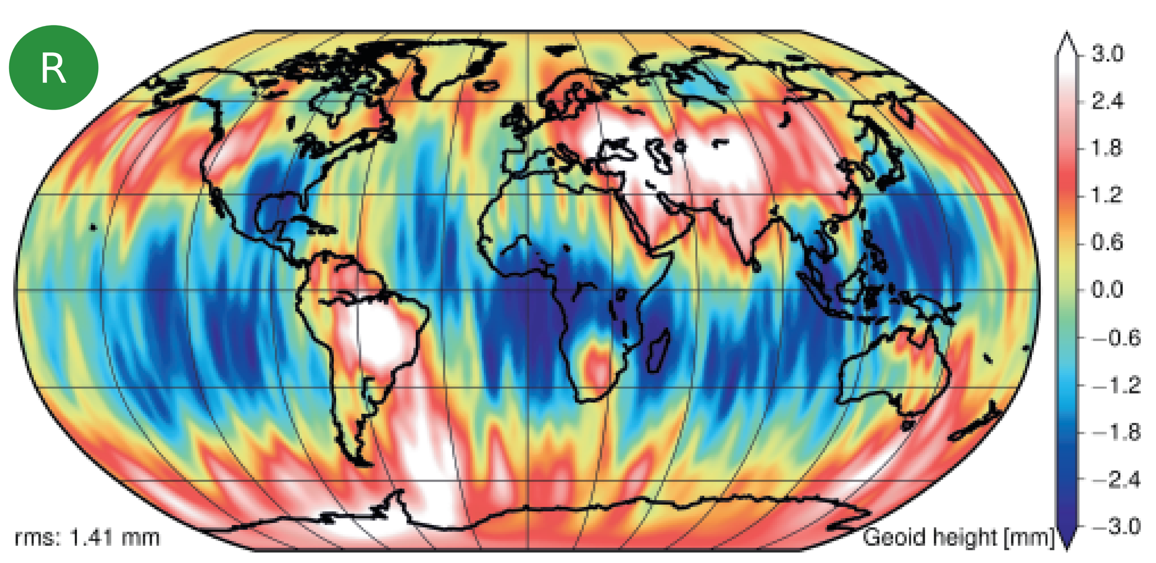




Real monthly data — K-Band instrument — Laser interferometer — GOCO03s — Baseline

Real solution April 2006

- Difference to GOCO03s
- Time variable signal remains



Results

We observed that our modelling of instrument noise only led to performance similar to GRACE baseline (Scenario 1), with LRI outperforming the KBR measurements at small spatial resolutions.

We were able to partially, but not fully, reconstruct the spectral and spatial characteristics of a real monthly solution using components of the updated ESA earth system model to synthesize a realistic time variable gravity signal (Scenario 2).

The remaining gap between the real solution and the KBR simulation could be closed by increasing accelerometer noise (Scenario 3). This impacted the LRI performance more than the KBR result, actually leading to comparatively worse performance from the new instrument.

[1] Dobslaw et al. (2014): Updated ESA Earth System Model. ESAESM mid-term review meeting, presentation, Potsdam.
[2] Flechtner et al (2012): Status of the GRACE Follow-on Mission. Joint GSTM/SPP final Colloquium, presentation, Potsdam.
[3] Flury et al (2008), Precise Accelerometry Onboard the GRACE Gravity Field Satellite Mission, Advances in Space Research 42 (8): pp 1414–23.

Matthias Ellmer
email: ellmer@tugraz.at
phone: +43 316 873 6347

Torsten Mayer-Gürr
email: mayer-guerr@tugraz.at
phone: +43 316 873 6359