DFG Research Unit 2736

New Refined Observations of Climate Change from Spaceborne Gravity Missions (NEROGRAV)

Dataset

Stochastic models for GRACE/GRACE-FO accelerometers and inter-satellite ranging instruments

Version 1.0 (28 November 2022)

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Individual Project	**Work Packages**
IP4	WP4.100

Introduction

This document describes the main outcomes of WP4.100 of Individual Project IP4 and of the Deliverable D4.1 of the research unit NEROGRAV summarizing the analyses of the GRACE and GRACE-FO accelerometer (ACC) and satellite-to-satellite tracking data (Microwave instrument (MWI) or Laser Ranging Interferometer (LRI)) in order to derive a characterization of the instrument performance and a stochastic model. A detailed description and discussion focusing on the GRACE data is given in Murböck et al. (2023a).

Data description

The first version of the combined ACC+MWI/LRI noise models is provided with the ASCII-file NEROGRAV_Dataset_GRACE_ GRACE-FO_ACC-MWI-LRI_StochasticModel_V01.dat containing header information (17 lines) and the square root power spectral densities (PSDs), i.e. the amplitude spectral densities (ASDs) for the combined accelerometer and ranging observations in terms of range-rates (cf. Fig. 1). It is given for 21600 frequencies from 1/86400 Hz up to 0.25 Hz. Above 0.1 Hz (Nyquist frequency of the 5 s sampled MWI data) the columns for the ACC+MWI models are zero. The five columns consist of the frequency in Hz (col. 1), the combined ACC+MWI models for GRACE 2007 (col. 2), GRACE 2014 (col. 3), GRACE-FO 2019 (col. 4) and the combined GRACE-FO 2019 ACC+LRI model (col. 5) in $\mathrm{m/s}/\sqrt{\mathrm{Hz}}$.
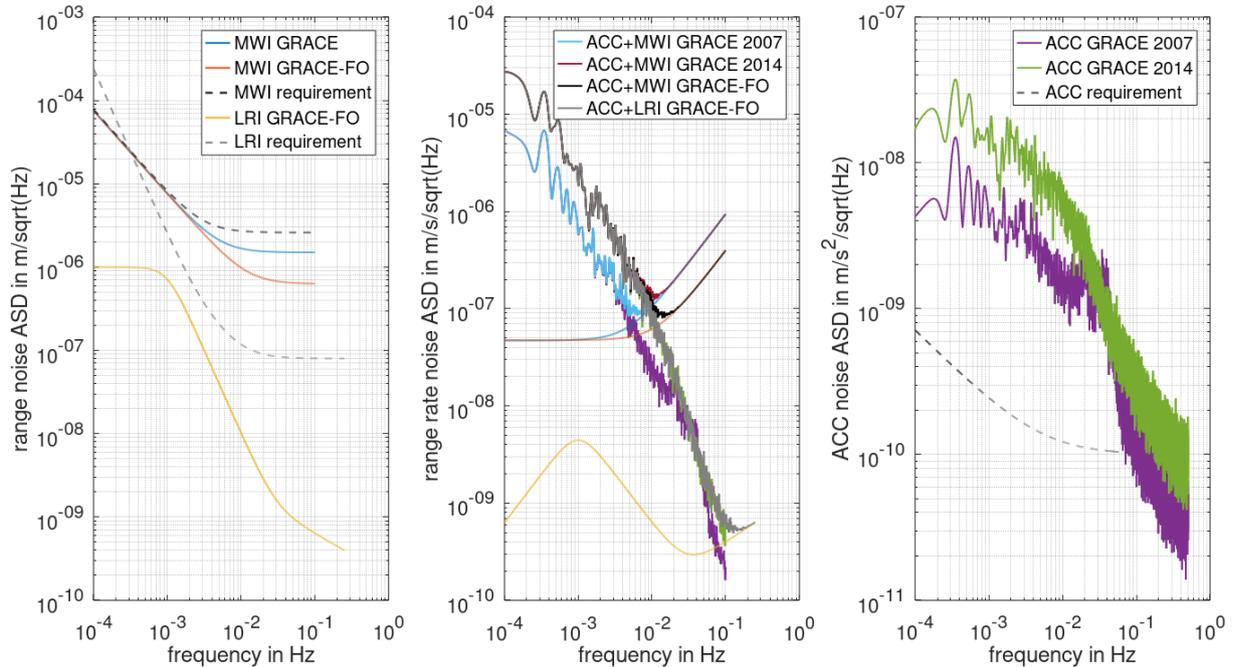

Fig. 1: Noise models in terms of ASDs of the key GRACE/GRACE-FO instruments; left: GRACE/GRACE-FO MWI (blue/red) and GRACE-FO LRI (yellow) noise models and requirements in terms of range ASDs in m/sqrt(Hz); right: GRACE ACC noise models for 2007 (purple) and 2014 (green) with requirements in terms of acceleration ASDs in m/s²/sqrt(Hz); center: combined GRACE/GRACE-FO ACC+MWI/LRI noise models in terms of range-rate ASDs in m/s/sqrt(Hz).

The analytical noise models for the ranging instruments in terms of range ASDs (cf. Fig. 1, left) read

$$\delta_{\mathrm{GRACE-MWI}} = 1.5 \times 10^{-6} \cdot \sqrt{1 + (5\ \mathrm{mHz}/f)^2}\ \mathrm{m}/\sqrt{\mathrm{Hz}}$$

$$\delta_{\mathrm{GRACE-FO-MWI}} = 0.6 \times 10^{-6} \cdot \sqrt{1 + (12\ \mathrm{mHz}/f)^2}\ \mathrm{m}/\sqrt{\mathrm{Hz}}$$

$$\delta_{\mathrm{GRACE-FO-LRI}} = \sqrt{\left(2 \times 10^{-10}/\sqrt{f}\right)^2 + (10^{-12}/f^2)^2}\Big/\sqrt{1 + (10^{-3}/f)^4}\ \mathrm{m}/\sqrt{\mathrm{Hz}}.$$

The ACC noise models (cf. Fig. 1, right) are assessed from a transplant approach described in Murböck et al. (in preparation). For frequencies below 10 mHz they can be approximated in terms of acceleration ASDs by

$$\delta_{\mathrm{GRACE-ACC-2007}} = 1.3 \times 10^{-10}/\sqrt{f}\ \mathrm{m}/\mathrm{s}^2/\sqrt{\mathrm{Hz}}$$

$$\delta_{\mathrm{GRACE-ACC-2014}} = 4.7 \times 10^{-10}/\sqrt{f}\ \mathrm{m}/\mathrm{s}^2/\sqrt{\mathrm{Hz}}.$$

The combined noise models in terms of range-rates (cf. Fig. 1, middle) are derived from the square root of the squared sum of these two contributions. Hence, we have

$$\delta_{\mathrm{ACC+MWI/LRI}} = \sqrt{(\delta_{ACC}/2\pi f)^2 + \left(\delta_{MWI/LRI} \cdot 2\pi f\right)^2}.$$

The presented noise models in terms of ASDs can be used to assess a full variance covariance matrix for the range-rate observations considering the stochastic properties of the accelerometer and ranging observations for GRACE and GRACE-FO gravity field determination.

References

Murböck, M.; Flechtner, F.; Abrykosov, P.; Pail, R. (2023): Stochastic models for GRACE/GRACE-FO accelerometers and inter-satellite ranging instruments. GFZ Data Services. https://doi.org/10.5880/nerograv.2023.001

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