

## ***Interactive comment on “Instrument Data Simulations for GRACE Follow-on: Observation and Noise Models” by Neda Darbeheshti et al.***

### **Anonymous Referee #1**

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#### General Comments

The GRACE mission has yielded much advancement in Earth system science thanks to the availability of a more than 15 years time series of mass transport data. Unfortunately, due to increasing problems with the battery on GRACE-2 the mission will shortly end and the hope is that GRACE Follow-on (GRACE-FO), due for launch early 2018, will be a worthy successor. As the name already says the prime objective of GRACE-FO will be to extend the GRACE time series using the same instruments and also data streams/formats. This would enable the users directly to start analyzing the new data.

The innovative addition on GRACE-FO will be a Laser Ranging Interferometer (LRI) which shall increase the accuracy of the inter-satellite measurement. In order to pre-

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pare for GRACE-FO it is of high interest for a) gravity field processing centers to have a set of realistic instrument test data, especially for the new LRI, and b) for the user community to get a projection what the new LRI could provide for scientific applications when flown on GRACE-FO and what could be achieved on Next Generation Gravity Missions. Therefore the work done by the authors is of high interest especially for gravity field processing centers to prepare for using the GRACE-FO data.

The simulated instrument data set described in this paper is very significant, unique, useful, complete and worth to be published. Nevertheless, I provide some additional specific and technical comments as well as suggestions and some corrections which have to be taken into account in the next revision.

### Specific Comments

- In the introduction section it is mentioned that the LRI data also provide information on attitude (pitch and yaw). I am not sure if this data is used/provided in the nominal GRACE-FO SDS Level-1B data processing. Some background information should be given.

- Same section: The authors mentioned Kim (2000) as a realistic pre-launch simulation of GRACE but forgot to mention Flechtner et al. (2016): What Can be Expected from the GRACE-FO Laser Ranging Interferometer for Earth Science Applications? - Surveys in Geophysics, 37, 2, p. 453-470. <http://doi.org/10.1007/s10712-015-9338-y>. Also here a simulation of the possible impact of the LRI on the GRACE-FO gravity field results and various applications is performed. In this paper 5 years of realistic instrument data and background model errors have been simulated (but not been made public).

- Also a hint to the plans of the GRACE-FO Science Data System to provide a set of simulated GRACE-FO data to the user community within the so called "Grand Simulation" shall be mentioned. E.g. taking the GRACE-FO status reports / abstracts of presentations in Kobe (IUGG) or Vienna (EGU). Nevertheless, it has to be mentioned that this activity is much behind schedule and therefore the provided data set is very

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useful to start just now!

- It is not 100% clear what the time period of the simulated data is. I assume (without check by downloading the data) that it is one month. There are also later sentences such as “we simulated one month of data”. This general information should be given at the very beginning.
- If it is just a month then analysis of trends or seasonal/sub-seasonal signals are not in the focus, but more a check if the simulated data can be read by the processing centers and how good the recovered field fits to the gravity field used for simulation. This points to question b) in the general comments. Should be discussed.
- Also I suggest that the authors provide some results at the end that they were successful with their own software (if existing?) to recover the noise-free and noisy data with such and such error (e.g. by degree variance plots). This would be close-loop verification before external users test the data.
- Page 3, Line 14: ...and a GPS error is added to each...: see comment below for KBR and SCA
- Page 3, Line 16: ...with added KBR errors...: I think here it should be already mentioned what is included in the error budget or at least a clear statement that the errors are all discussed in chapter 6.
- Page 4, Line 2: similar comment for the SCA1B errors
- Page 4, Line 3: For the Accelerometer data it looks like if they do not contain errors (but have as shown in Figure 2 and discussed later)
- Page 4, Line 7: same comment as for KBR1B
- Page 4, Figure 2: Imprecise, as quaternions here do not contain errors
- Page 5, Line 11: Don't understand “a static gravity field of d/o between 75 and 90”. What has been used for simulation? Is this description a hint what is stated in line 18

namely that the user shall try to solve for the right degree and order which fits best to the simulated field? I would more expect that they used a fixed degree and order (e.g. 90) with coefficients which are unknown to the user and provide this max d/o to the user.

- Page 5, Line 10: It should be discussed that other gravitational forces such as atmosphere and ocean short term mass variations or an ocean pole tide model are not used (for simplicity) and this simulation data set focuses on impact of instrument data errors.

- Page 5, Line 12/13: Reference for eot11a and DE405 missing

- Page 6, Line 1ff: information on used altitude, eccentricity and inclination missing, also on length of the simulation (1 month?)

- Page 7, Line 12: Would be good to know (and also the reference) how large the GRACE noise level is for RPY angles.

- Page 10, Line 6: The authors mentioned ACC biases and scales. The value of the bias is known from Horwath et al (2011), but the values chosen for the scale factors are not known to the user. Some lines below it is only mentioned that certain constant values for each axis were chosen. As both have to be adjusted during gravity field determination it would be interesting to compare the simulated and adjusted values. The authors should mention if these scale factors will be made available.

- Page 10, Line 12ff: Here a first hint is given that one month of data was simulated (see comments above)

- Page 22, Line 2: This statement is not complete as the quality of GRACE-FO models also depends on knowledge of short-term tidal and non-tidal mass variations (which have also large influence on the adjusted gravity model; in contrast to Flechtner et al. was not simulated). Nevertheless, it is highly appreciated that such a well described set of simulated GRACE-FO instrument data is now being available to the different gravity

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field processing centers.

#### Technical Corrections

- Page 6, Line 19: More importantly, even though the KBR will be the primary science instrument and the LRI, a technology demonstrator, a threshold: This sentence shall likely read: More importantly, even though the KBR will be the primary science instrument, for the LRI, a technology demonstrator, a threshold of. . .

- Page 11, Line 11: As the abbreviation is  $\delta$ SO I suggest to write . . . is dominated by system and oscillator noise. . .

- Page 20, Line 9: Therefore, the angle determination is quantization limited shall read Therefore, the angle determination quantification is limited – or?

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