AGU FALL MEETING
San Francisco | 14–18 December 2015

Analysis of GRACE range-rate residuals with emphasis on reprocessed star camera datasets

Sujata Goswami[1], Beate Klinger[2], Torsten Mayer-Gürr[2], Tamara Bandikova[1], Jakob Flury[1], Majid Naeimi[1]
[1]Institute of Geodesy, Leibniz University Hanover, Germany
[2]Institute of Geodesy, Graz University of Technology, Austria

1. Introduction

The goal of the GRACE mission is determination of the Earth's time-variable gravity field. Still, accuracy of the gravity solutions has not reached the GRACE baseline. The major error sources are the GRACE sensor errors, imperfections in the ocean and atmospheric models and orbit modeling. These errors are absorbed by the post-fit range-rate residuals obtained after gravity field parameter estimation. Their analysis provides valuable insight into the contribution of the individual error sources to the overall error budget. Hence, we focus here on the residuals obtained from the gravity solutions. Four different gravity field solutions are computed using four different processed GRACE attitude sensor datasets individually to study its contribution to the overall error budget. The four different star camera datasets are for the month of December 2008:(a.)Official Level-1B (b.)reprocessed at Institute of Geodesy (IfE) Hannover Germany (c.)reprocessed at Institute of Geodesy (IfG) Graz Austria (d.)combination of IfE and IfG reprocessed dataset. First, we compare the differences in the antenna offset corrections computed using these different attitude datasets. Then, we compare the range-rate residuals in spectral domain. To see the ground-track variability of residuals we plot the differences between the set of residuals obtained from the solutions computed using different star camera datasets individually. Also, we compute the differences in the spherical harmonics of different solutions to see the impact of changing star camera data on spherical harmonics coefficients.

2. Attitude datasets

The different datasets are described below:

(a.) Level-1B

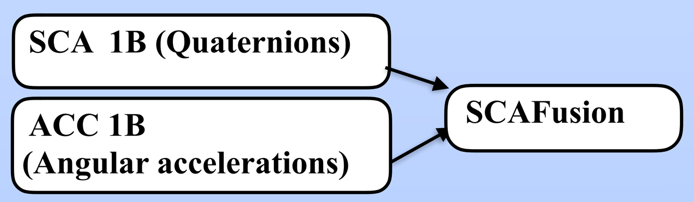
Official Level-1B star camera data (SCA1B RL02): generated by JPL using the standard processing routines which is described in (Wu et al., 2006).

(b.) IfE

Reprocessed star camera data (SCAIfE): the standard JPL processing routines have been used for reprocessing, but with the correct implementation of the quaternion combination method. That means proper weighting strategy has been applied to process the data (Bandikova et al., 2014) which was not correctly implemented in the official version.

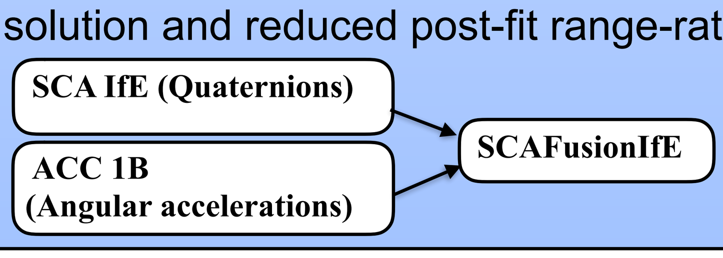
(c.) Fusion

Reprocessed star camera data (SCAFusion): The official Level-1B star camera data (SCA1B) has been combined with angular accelerations present in accelerometer data (ACC1B) using the approach which is explained in (Klinger & Mayer-Gürr, 2014). The high frequency noise is effectively reduced.



(d.) FusionIfE

Reprocessed star camera data (SCAFusionIfE): SCAIfE has been combined with the angular accelerations from accelerometer using the sensor fusion approach explained in step(c). Here we expect improvement in the gravity field solution and reduced post-fit range-rate residuals.



3. Results

I. Impact on KBR antenna offset correction

The inter-satellite KBR observations are corrected for the imperfect inter-satellite pointing (Bandikova et al., 2012) by applying the KBR antenna offset corrections (AOC). The effect of the reprocessed attitude data on the AOC for range-rates is shown in Fig.1.

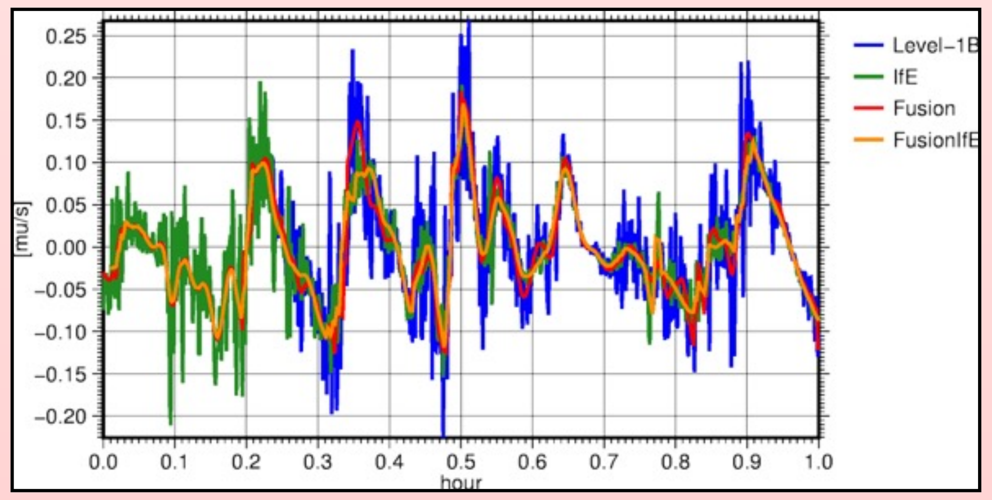


Figure 1. Comparison of KBR antenna offset corrections for range-rate (for 1 hour of 2008-12-01) derived from the SCA1B data (green), SCAIfE data (blue), SCAFusion data (red) and SCAFusionIfE data (orange)

II. Power Spectral Density

Gravity field solutions are computed individually from the four different attitude datasets using the least squares approach. Power Spectral Densities (PSD) of the post-fit range-rate residuals are displayed in Fig.2. The plot shows that noise is reduced in high frequency band when using the reprocessed attitude datasets (SCAIfE, SCAFusion, SCAFusionIfE); the biggest reduction in noise is achieved with SCAFusionIfE. Also, the rms value of range-rate residuals of individual solutions are: 0.506(Level-1B), 0.535(IfE), 0.504(Fusion), 0.359(FusionIfE) which again shows the significant reduction in attitude errors.

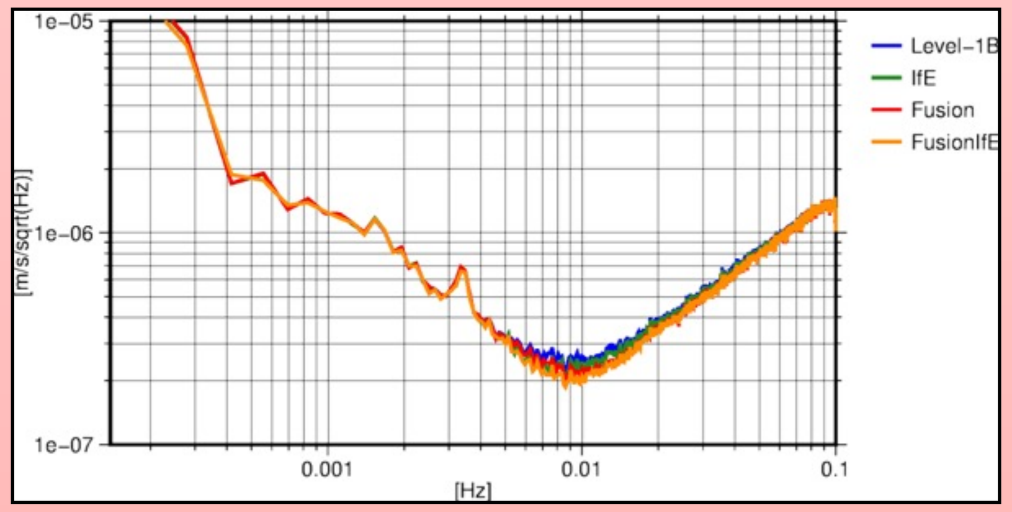


Figure 2. PSD of post-fit range-rate residuals

III. Range-rate residuals in spatial domain and spherical harmonic triangles

Here, we take the difference between range-rate residuals from solutions computed from different reprocessed dataset and range-rate residuals from the solution computed by considering Level-1B data individually which are shown in fig. 3, 4 & 5. Root mean square values of the differences between the solutions is specified along with figures. The biggest differences in the range-rate residuals occur for FusionIfe, shown in fig.5. The differences between the individual solutions are more clearly visible in the spherical harmonic triangles, showing the differences in spherical harmonic coefficients between the reprocessed attitude data and Level-1B data individually. In fig.3 & 4 mainly the zonal coefficients (highlighted in red box) are affected, which is attributed to the reduced inter-satellite pointing noise. Whereas in fig.5, the combined effect of IfE and Fusion becomes visible.

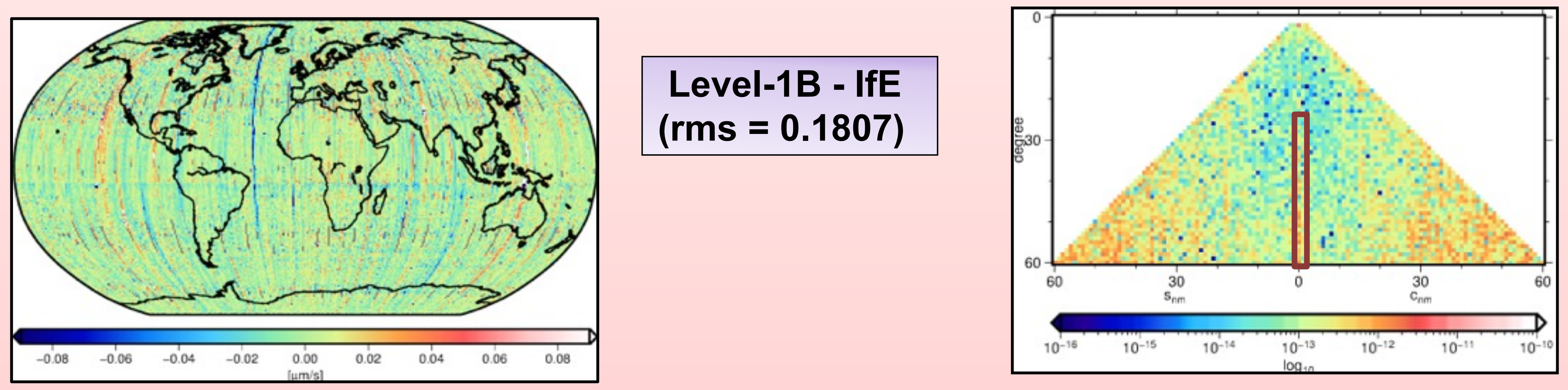


Figure 3 (Left) Differences between range-rate residuals on the ground-track, (Right) Differences in Spherical Harmonics are spread across spectrum

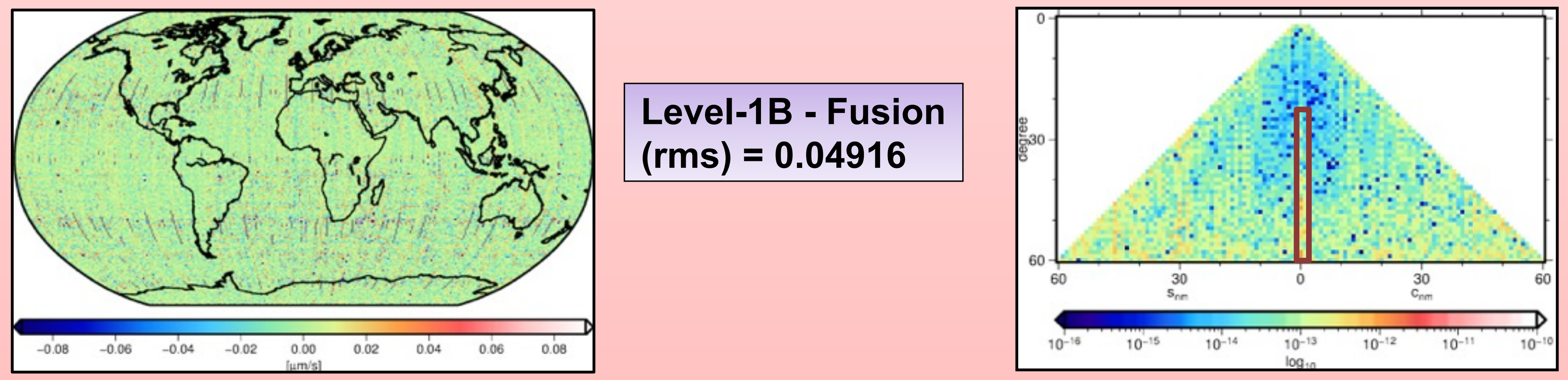


Figure 4. (Left) Differences between range-rate residuals on the ground-track, (Right) Differences are mainly high in the zonal coefficients region

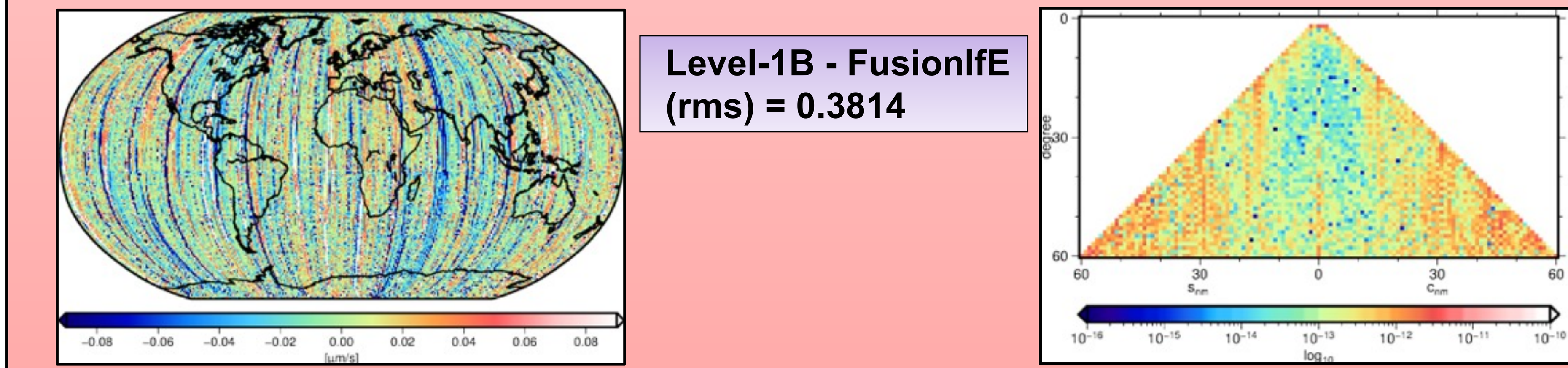


Figure 5. (Left) Differences between range-rate residuals on the ground-track, (Right) Differences in Spherical Harmonics are spread across the spectrum

4. Conclusions

(a.) The noise of the AOCs has been reduced significantly by using the reprocessed star camera data (SCAIfE, SCAFusion, SCAFusionIfE).
(b.) FusionIfE dataset improves the gravity solution although it is so small. Degree variances of the two solutions are compared in fig.6.
(c) Range-rate residuals has been lower down when the solution is computed from FusedIfE dataset.
(d) Major errors are not coming from attitude, still we can achieve little improvement in gravity field by improving the attitude information.

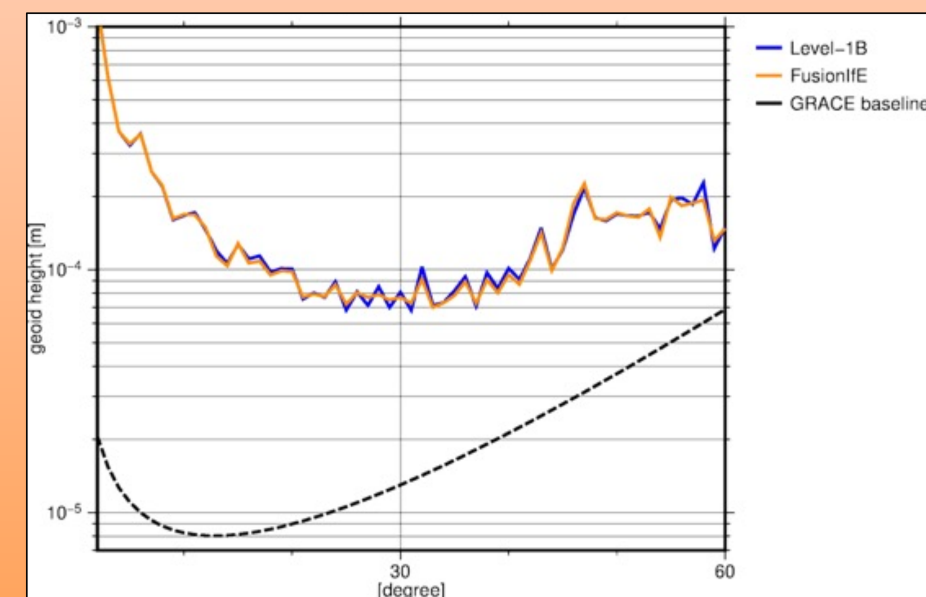


Figure 6. Degree variances compared for the two solutions

5. References

- Bandikova et. al (2012) - Characteristics and accuracies of GRACE inter satellite pointing, Adv. Space Res.
- Bandikova & Flury (2014) - Improvement of GRACE star camera data based on the revision of the combination method, Adv. Space Res.
- Klinger & Mayer-Gürr (2014) - Combination of GRACE star camera and angular acceleration data: Impact on gravity field models, GSTM 2014, Potsdam
- Wu S.C., Kruizinga G., Willy B. (2006) - Algorithm Theoretical Basis Document for GRACE Level-1B data Processing V1.2

6. Acknowledgement

- We thank the Geo-Q project for providing the funding to support this work
- We also thank IP@Leibniz (promoted by DAAD) and Graduate Academy Hannover for providing the research stay and travel support for Graz, Austria
- We thank to EGSIEM and Austrian Space Research Agency for funding support