[EGU2017-15532]
Effect of the Accelerometer Calibration Method on AIUB's GRACE Monthly Gravity Field Solution

Yoomin Jean, Ulrich Meyer, Daniel Arnold, Katrin Bentel, and Adrian Jäggi

Astronomical Institute
University of Bern

UNIVERSITÄT BERN

EGU General Assembly 2017
23-28 April, 2017
Vienna, Austria

European Commission

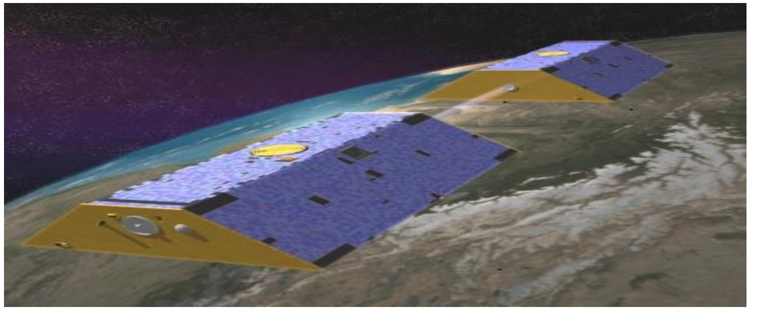
Contents

Please click or touch the button to view the detailed contents.

Introduction

Y. Jean et al.: Effect of the improved accelerometer calibration method on AIUB's GRACE monthly gravity field solution
EGU General Assembly 2017, 23-28 April, 2017, Vienna, Austria

GRACE Mission by NASA/DLR



↓

- **GPS Measurements + K-band Measurements + other Measurements**

↓

- **Monthly Gravity Field Solutions**

One of the Methods to Improve the Quality is

Accelerometer Data Calibration

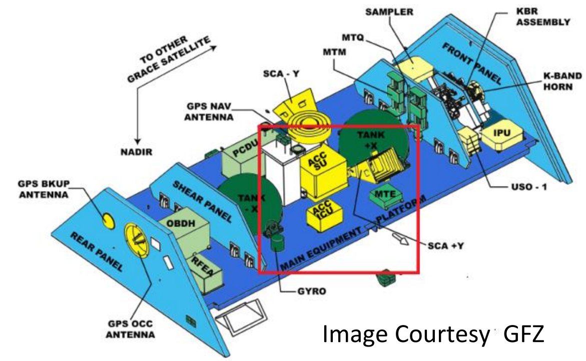
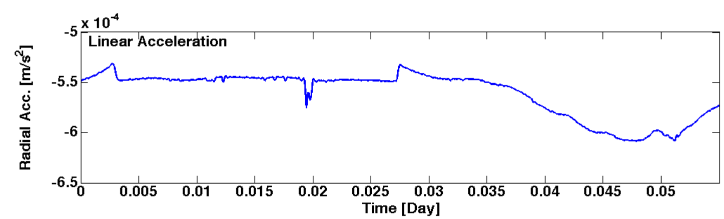


Image Courtesy GFZ

- **On-board Accelerometer**
  - Measuring nongravitational forces acting on the satellites (e.g. perturbing forces by air drag, ...)

- **Official GRACE ACC1B Data**
  - contain instrument scale and bias in the linear accelerations

    → Calibration is required.



Y. Jean et al.: Effect of the improved accelerometer calibration method on AIUB's GRACE monthly gravity field solution
EGU General Assembly 2017, 23-28 April, 2017, Vienna, Austria

To the Main Slide

Objective

GRACE monthly gravity field solutions by the *AIUB Processing Center*

- estimates the scaling factors in three directions since the release 2 monthly gravity field solutions (Meyer et al. 2016) using Celestial Mechanics Approach (Beutler et al. 2010a, 2010b)

- To investigate the effect of the accelerometer data calibration in the Celestial Mechanics Approach using the stochastic pulses/piece-wise constant accelerations
  - Interactions between the stochastic parameters and the scaling factors for the accelerometer data calibration

Method: Accelerometer Data Calibration

- Calibration equation: $\mathbf{a}_{Calibrated} = \mathbf{S} \cdot \mathbf{a}_{Measured} + \mathbf{b}$

$\mathbf{a}_{Calibrated}$: *Calibrated Acceleration*

$\mathbf{a}_{Measured}$: *Measured Acceleration by the GRACE accelerometers*

$\mathbf{S}$: *Scale matrix*

$\mathbf{b}$: *bias*

- Scaling Matrix:

$$\mathbf{S} = \begin{bmatrix} S_x & S_{xy} & S_{xz} \\ S_{yx} & S_y & S_{yz} \\ S_{zx} & S_{zy} & S_z \end{bmatrix}$$

  – Main diagonals: estimated once per day
  – Usually, the off-diagonal terms are assumed to be 0:

$$S_{xy} = S_{xz} = S_{yx} = S_{yz} = S_{zx} = S_{zy} = 0$$

Celestial Mechanics Approach (CMA)

- A processing method to produce gravity field solutions as well as satellite orbits (Beutler et al. 2010a, 2010b)
- Used at the AIUB processing center via the Bernese GNSS Software
- Stochastic parameters

Stochastic Pulse/Piece-wise Constant Accelerations

- CMA-specific parameters:
  - *Instantaneous velocity changes* in three directions at particular epochs

  or
  - *Piece-wise constant accelerations* in three directions over a certain time interval

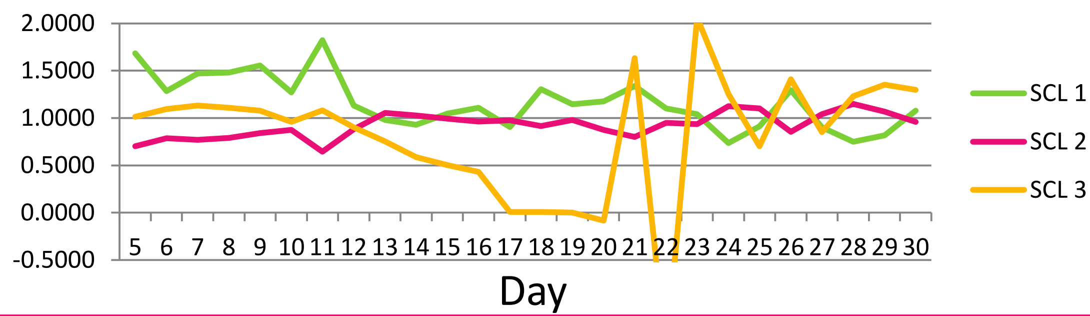
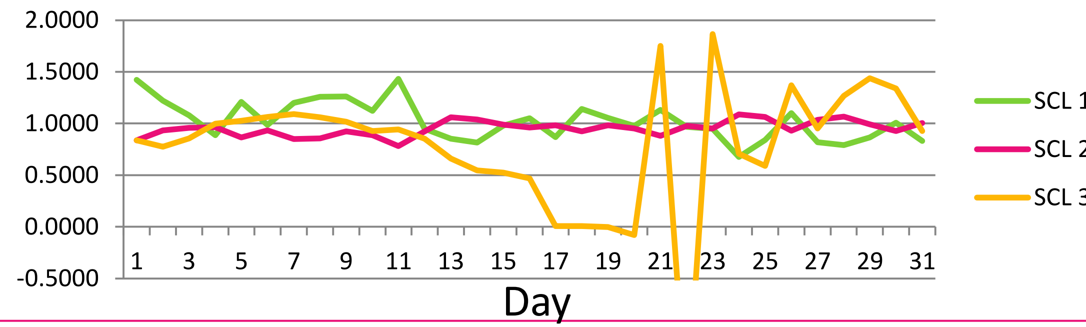
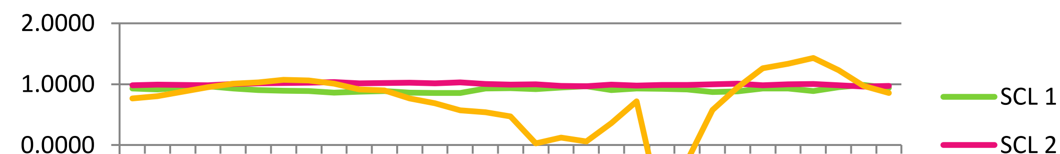
- Stochastic pulse/Piece-wise constant acceleration is varied by *contraint of RMS* and *frequency* (every 15 minutes for the GRACE orbits)

To the Main Slide

Processing Details

Type/Models	Details
Reference Frame	• Satellite RSW frame • GRACE Instrument (Accelerometer) frame • ECI J2000
Processing Strategy (SW)	Celestial Mechanics Approach (Bernese GNSS Software)
Estimated Parameters	• GRACE Orbital Elements • 3-dimensional Scaling Factors (Once per day) and Offsets (Once per day) for Accelerometer Data Calibration • Stochastic Pulses (every 15 minutes)
Input Data and Models	(Identical to AIUB GRACE Monthly Gravity Fields Release 2: *Meyer et al. 2016*)
Solid Earth Tide	TIDE2000
Ocean Tide	EOT11A (100)
Ocean Pole Tide	Desai (100)
AOD Dealiasing	AOD1B (RL05)
Ephemeris (3rd bodies)	DE405
Nutation Model	IERS2010
Subdaily Pole Model	IERS2010
a priori Gravity Field	AIUB's a priori Model (AIUB-GRACE03S)
Accelerometer Measurement	GRACE ACC1B Data
Time Span	January 2007 (1 Month)

Stochastic Pulses ⇔ Estimated Scaling Factors (1 Month)

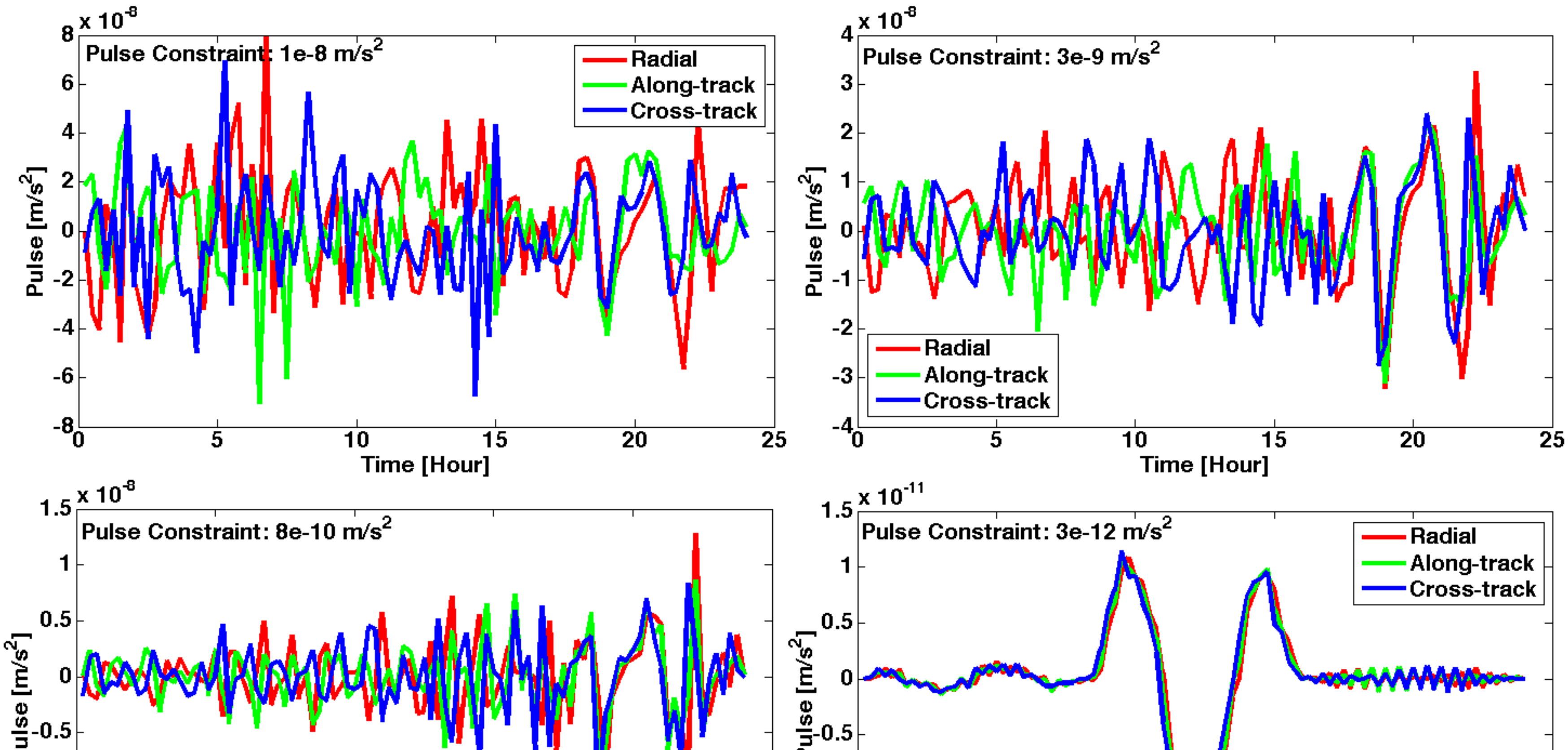
Pulse Constraints (m/sec)	Estimated Scale Factor (Daily in January 2007)
1×10^{-8}	
3×10^{-9}	
8×10^{-10}	

- Smaller constraints to control overall RMS of the stochastic pulses result in the estimated scale factors which are closer to the nominal value, 1.

Y. Jean et al.: Effect of the improved accelerometer calibration method on AIUB's GRACE monthly gravity field solution
EGU General Assembly 2017, 23-28 April, 2017, Vienna, Austria

To the Main Slide

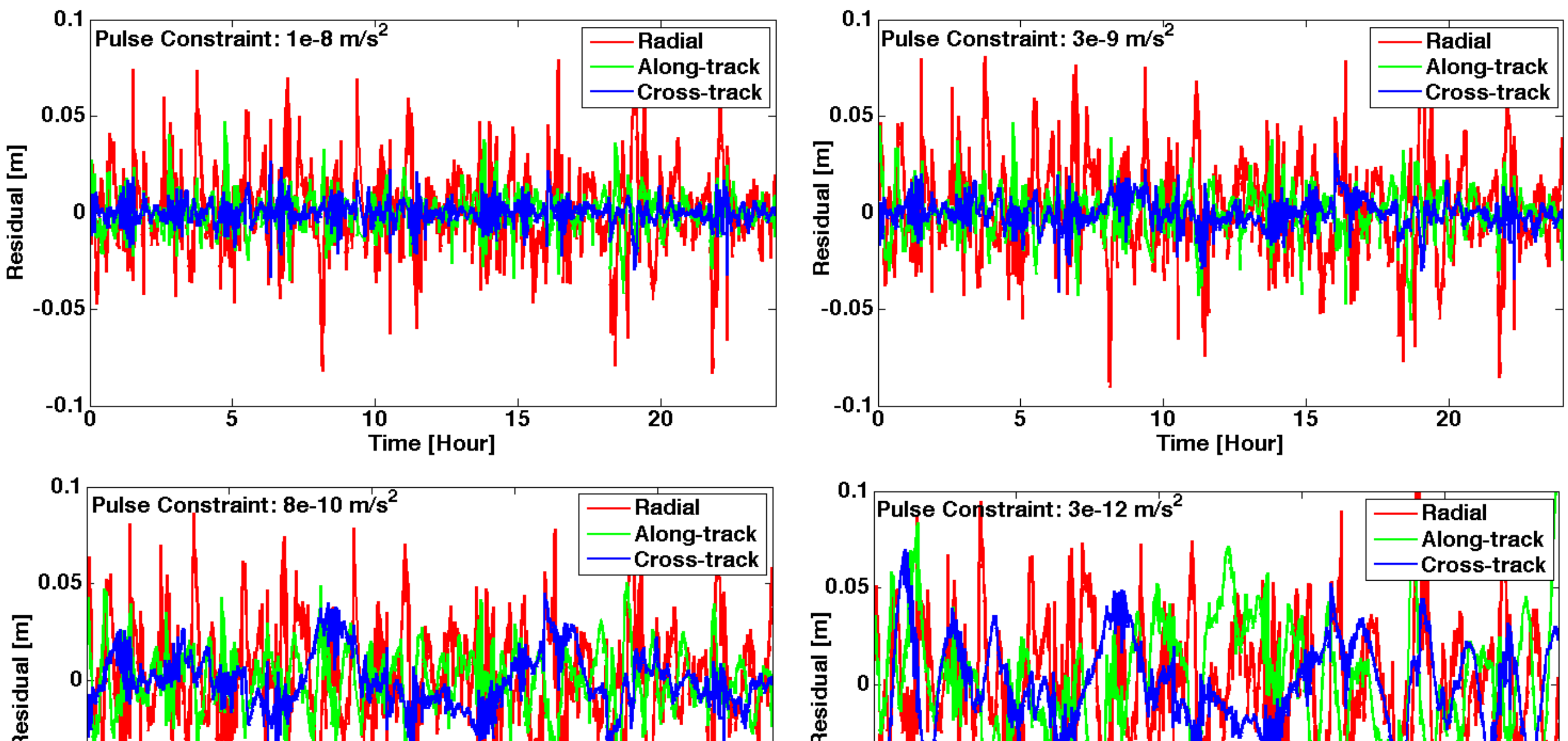
Stochastic Parameters (01 January 2007)



- Four different RMS constraints for the stochastic parameters: 1×10^{-8}, 3×10^{-9}, 8×10^{-10}, 3×10^{-12} [m/s^2]
- Magitude of the stochastic parameters (piece-wise constant accelerations) are constrained by the pre-defined constraints.

Y. Jean et al.: Effect of the improved accelerometer calibration method on AIUB's GRACE monthly gravity field solution
EGU General Assembly 2017, 23-28 April, 2017, Vienna, Austria

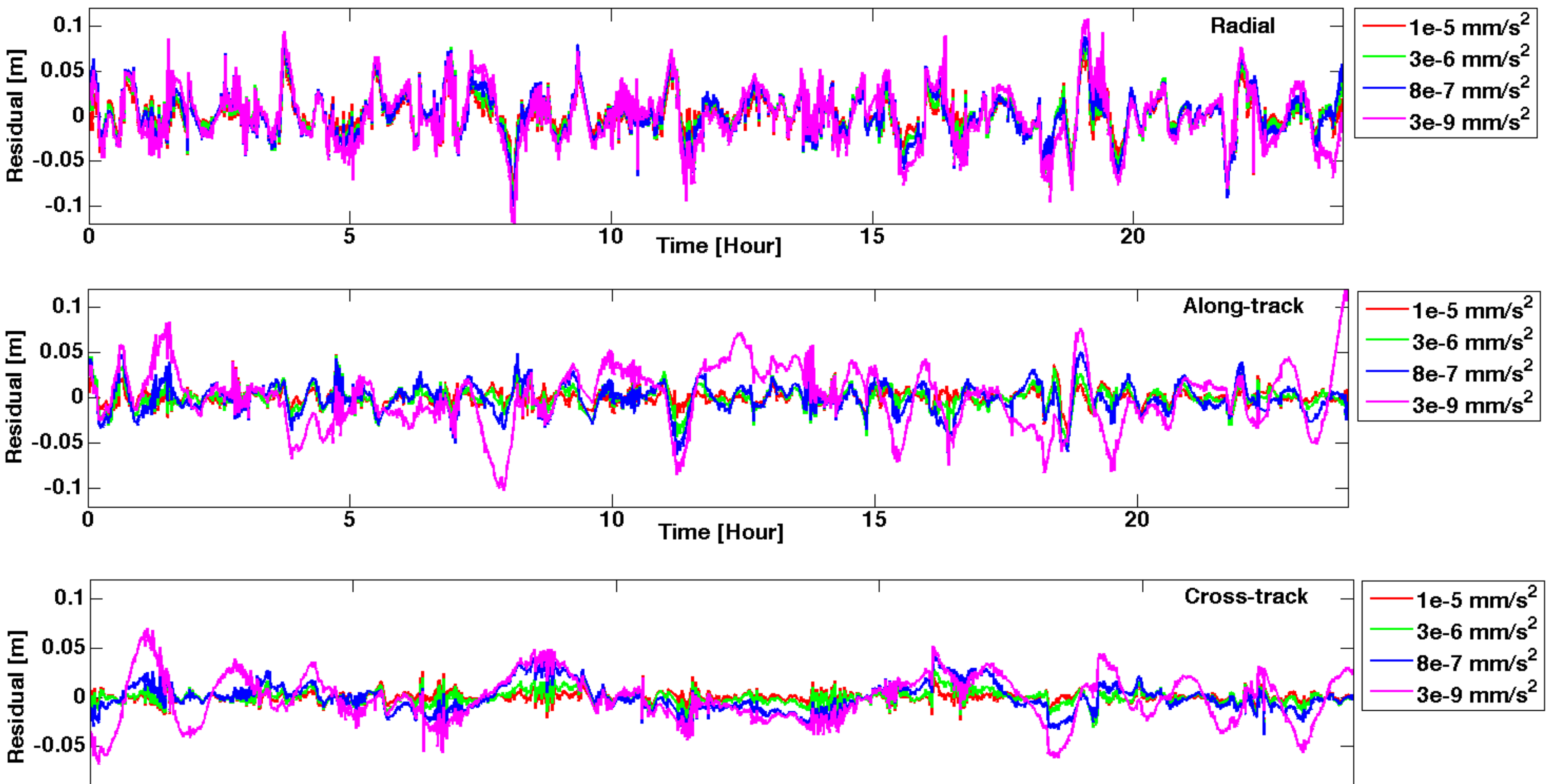
Residuals (1): by Pulse Constraints (01 January 2007)



- When the pulse constraints decreases, the residuals increases.

  → The pulse constraints cannot be very small, but should be adjusted: $1\text{x}10^{-9}$ ~$3\text{x}10^{-9}$ m/s^2 is reasonable level of the piece-wise constant accelerations.

Residuals (2): by each Direction (01 January 2007)



- Radial direction shows larger residuals than the other directions
  → related to the estimated scale factor in the radial direction closer to 1 than those in other directions

Conclusions

- In the Celestical Mechanice Approach to produce GRACE gravity field solutions, the magnitudes of contraints to the RMS of the stochastic pulses affect the estimated scaling factors for the accelerometer data calibration directly.

- Considering the reasonable levels of the residuals and the stochastic pulses to absorb the model deficiencies in the orbit determination, a value in the range $1 \times 10^{-9} \sim 3 \times 10^{-9}$ m/s^2 has to be selected for the constraints of the RMS of the stochastic parameters.

- Further improvements in the method of the estimation of the scaling factors used for the accelerometer data calibration are expected to improve at least certain coefficients of the monthly gravity field solutions in the gravity field using the Celestial Mechanics Approach.

Reference

- G. Beutler, A. Jäggi, L. Mervart, U. Meyer, "The celestial mechanics approach: theoretical foundations", *Journal of Geodesy*, 84(10):605–624, 2010.
- G. Beutler, A. Jäggi, L. Mervart, U. Meyer, "The celestial mechanics approach: application to data of the GRACE mission", *Journal of Geodesy*, 84(11):661–681, 2010.
- U. Meyer, A. Jäggi, Y. Jean, G. Beutler, " AIUB-RL02: an improved time-series of monthly gravity fields from GRACE data ", *Geophys. J. Int.* 205, 1196–1207, 2016. doi: 10.1093/gji/ggw081

- **Thank you for your interest in this study.**

This research was supported by the European Union's Horizon 2020 research and innovation program under the grant agreement No. 637010.

EGSIEM

European **G**ravity **S**ervice for **I**mproved **E**mergency **M**anagement

www.egsiem.eu

Contact Address

Yoomin Jean
Astronomical Institute, University of Bern
Sidlerstrasse 5, 3012 Bern, Switzerland
yoomin.jean@aiub.unibe.ch

EGSIEM Project

- **E**uropean **G**ravity **S**ervice for **I**mproved **E**mergency **M**anagement
- A Horizon 2020 Project (2015-2017)
- Consortium
- Main Objectives:
  - Combination Service of GRACE Gravity Field Solutions
  - Near-real time Service of GRACE Gravity Field Solutions
  - Early Warning Service of Hydrological Events
- For more information: visit the website

EGSIEM www.egsiem.eu