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Author: Mr. Florian Wöske
Center of Applied Space Technology and Microgravity, Germany, Florian.Woeske@zarm.uni-bremen.de

Dr. Takahiro Kato
ZARM, University of Bremen, Germany, takahiro.kato@zarm.uni-bremen.de
Dr. Meike List
ZARM, University of Bremen, Germany, meike.list@zarm.uni-bremen.de
Dr. Benny Rievers
ZARM, University of Bremen, Germany, benny.rievers@zarm.uni-bremen.de

GRACE ACCELEROMETER CALIBRATION BY HIGH PRECISION NON-GRAVITATIONAL FORCE MODELLING AND ITS VALIDATION

Abstract

The demand for highly accurate non-gravitational force modeling is steadily increasing. The high quality of measurement methods and sensors available nowadays, like GNSS, laser ranging, inter-satellite ranging or atomic clocks, imposes the need for exact models of all physical effects. This includes not only the gravitational forces but also all other forces acting on a satellites. The non-gravitational effects lay in the range of measurement precision and are expected to be the limiting factor of the measurement improvement. These forces originate from radiation of Sun, Earth and the satellite itself, as well as residual atmosphere. Concerning modeling capabilities provide the basis for a variety of tasks like precise orbit determination. Nevertheless, it is a common strategy to apply and estimate numerical and stochastic parameters to compensate for modeling deficiencies. With the development of precise models for all non-gravitational forces, we try to reduce these stochastic parameters and enhance scientific results.

In this study we present a novel simulation-based approach for accelerometer calibration of GRACE (Gravity Recovery And Climate Experiment). We use our in-house developed satellite dynamics simulation tool to produce simulated accelerometer data as reference for instrument calibration. The work is twofold, first we analyze the resulting residuals to quantitatively validate different non-gravitational model approaches. In a second step, we compare the results to different calibration methods, based on precise orbit determination, gravity field recovery and GPS-based calibration.

The comparison shows good agreement of all approaches, nevertheless, all methods show advantages and disadvantages which turned out in this analysis by having detailed models to distinguish different sources of effects. Calibration parameters are estimated and compared for the whole time span of the GRACE mission from 2003 to 2017, covering different environmental conditions.

The applied non-gravitational forces modeling is based on a detailed finite element (FE) model of the satellite. We consider atmospheric forces and winds, as well as radiation forces due to solar radiation pressure, albedo, Earth infra-red (IR) and thermal radiation (TRP) of the satellite itself. For TRP we apply a transient heat calculation of the satellite surfaces with radiation input from the aforementioned sources. Albedo and IR forces are based on one hourly CERES data with one-degree spacial resolution. For each force the FE model is utilized, considering the orientation of each element with respect to the disturbance source, material properties as well as shadowing conditions. A brief overview of the modeling and theoretical background will be given.