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PRECISE ORBIT DETERMINATION (POD) WITH FOCUS ON PHYSICAL ACCELEROMETER CALIBRATION OF THE GEODETIC SATELLITES GRACE AND GRACE-FO FOR THERMOSPHERIC DENSITY ASSESSMENT

Abstract

The ultra-sensitive accelerometers onboard geodetic satellites are affected by low frequency bias and drift. Therefore, a calibration of the data is indispensable. Usually time dependent bias and scale factors are estimated. For the intended application in Gravity Field Recovery (GFR), these calibration parameters are estimated together with other empiric parameters as well as the gravitational field coefficients. The focus is on obtaining an optimal gravitational field solution, which does not necessarily lead to realistic or physical accelerometer calibration parameters. Particularly on short time scales and for the less sensitive axes, the estimated calibration may be quite unrealistic in a physical sense. Due to not impacting on GFR accuracy, the estimated calibration (involving the potential unphysical parameters) is considered as a mere side product and not of further interest.

However, the motivation of the presented study is the determination of the neutral mass density of the upper atmosphere (thermosphere) by using the measured non-gravitational accelerations from the accelerometers of geodetic satellites. For this application a physical accelerometer calibration is fundamental.

In this contribution we use dynamic POD and investigate different parametrization strategies tailored for an accurate and physical accelerometer calibration. For example, we investigate the effect of constraining the accelerometer calibration parameters such that a continuous calibration over all arcs is achieved, where normally each arc is treated locally separated from all other arcs, leading to jumps in the calibration parameters. The scale factor, which is highly correlated to the estimated bias, is concurrently estimated but over a longer batch of arcs. Furthermore, different calibration equations, initial parameters and pre-processing of the accelerometer data are considered. We compare different bias parametrizations, arc lengths, as well as the combination of different observation data (GNSS and highly accurate inter-satellite ranging) and weighting strategies.

We validate the resulting calibrations with an approach based on high precision non-gravitational force modeling. The modeling is very accurate for the radiative forces. The aerodynamic drag forces are much more challenging and less accurate due to lack of precise atmospheric data and the complexity of the underlying physical processes. Because of the dedicated attitude of the GRACE satellites these two types of forces are distinctly distinguished in the accelerometer axes. This allows for a good validation of the cross-track and radial axes, from which conclusions can be drawn to the along-track axis, as well.