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Calibrating GRACE accelerometer data and its impact on thermospheric neutral density estimation

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Satellite gravity missions such as the Gravity Recovery And Climate Experiment (GRACE) are equipped with ultra-sensitive space-borne accelerometers to measure non-gravitational forces acting on the surface of the satellite. These forces consist of the Earth radiation pressure, the solar radiation pressure and the atmospheric drag, where the latter is related to the thermospheric neutral density. Due to systematic errors, the accelerometer observations need to be calibrated before their use in gravity recovery or thermospheric neutral density estimations.

Here, we calibrate GRACE accelerometer data using three different procedures: (1) a multi-step numerical estimation approach based on the numerical derivation of the kinematic orbits, (2) a calibration of accelerometer observations within the dynamic precise orbit determination procedure, and (3) a comparison of observed to modeled forces acting on the satellite's surface. Our results indicate that time series of calibration parameters (bias and scale factor) derived from the three calibration approaches are found to be different in short time-scales (few days to months). Results are more similar when considering longer data periods, from which the results of approach (1) and (2) are found to be closer compared to (3).

Calibrated GRACE accelerometer observations are then applied to estimate thermospheric neutral densities. A comparison of accelerometer-based density estimations to simulations of empirical neutral densities, e.g., NRLMSISE-00, shows differences of 22% of the simulated densities on average. Therefore, daily corrections are estimated for neutral densities derived from NRLMSISE-00. These corrections are found to improve model-based density simulations particularly during the period of high solar/magnetic activity, e.g., during St. Patrick's Day storm.