University of Bremen

CENTER OF APPLIED SPACE TECHNOLOGY AND MICROGRAVITY
ZARM

Master thesis

Thermospheric density estimation by Precise Orbit Determiantion (POD) with GRACE/-FO and LEO satellites

The density of the thermosphere is of high relevance for the propagation and determination of satellite trajectories in Low Earth Orbit (LEO). The drag acceleration, results in a change of trajectory and an orbital decay. This has implications for active satellites, where a precise orbit or position knowledge might be crucial for the mission success (e.g. altimetry, gravimetry, remote sensing), for maneuver planning and satellite lifetime prediction, as well as for space debris, where position determination is important for collision avoidance and reentry calculations. Furthermore, in atmospheric sciences, thermospheric density data can help to restrict, develop and validate complete physics-based thermosphere-ionosphere models.

The density of the upper atmosphere can be determined by orbit and accelerometer data from LEO satellites as insitu measurements along the orbit. Within a DLR project we do this with data from GRACE/-FO. These kind of data are actually the most accurate data source for thermospheric density. Nevertheless, satellites with precise accelerometers are rare. Therefore we want to develop a method without accelerometers, just based on GNSS tracking data, to have a bigger data source.

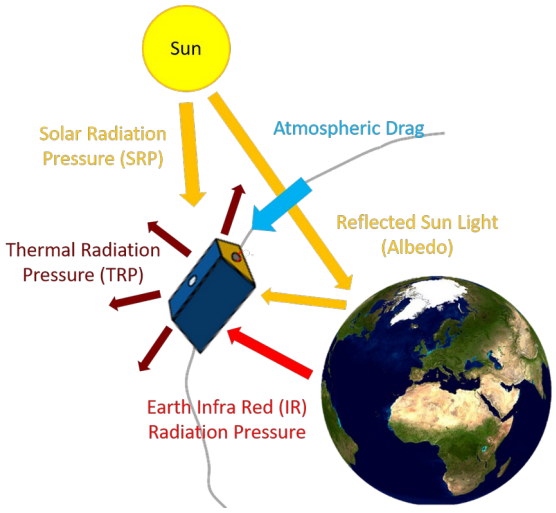

Figure 2: Non-gravitational accelerations acting on a satellite.

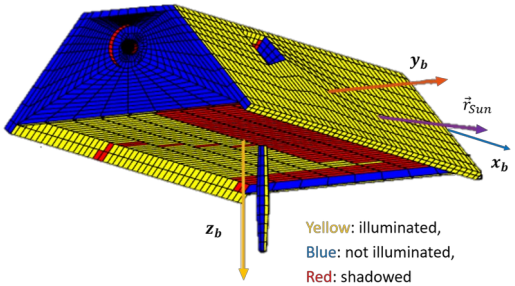

Figure 1: Finite element model of a GRACE-FO satellite for the radiative non-gravitational force computation.

As a first step, in the POD for GRACE/-FO the accelerometer data should be replaced by modeled data. Subsequently, a density model parametrization should be implemented to consider the atmospheric density/ drag and to estimate the respective parameters in this model. First this should be applied to GRACE/-FO, where it is possible to compare the resulting density with the accelerometer based method. After a validation, the method could be applied to another scientific LEO a satellites without accelerometer, but with good GNSS data. There are several candidates. Based on the previous findings some research need to be done which is the most suitable candidate with the best data, orbit, epoch, etc. for the developed approach.

The general POD method is already implemented, and used for several projects in our working group, for example also for the accelerometer calibration. The non-gravitational force models (see Fig. 1) are implemented in our MATLAB/Simulink orbit and satellite simulation toolbox XHPS (eXtended Hybrid simulation Platform for Space systems) based on detailed Finite Element (FE) Models (Fig.2) and are already available for GRACE/-FO

The exact work schedule can be discussed in a personal meeting, depending on preferences and type of thesis.

We are looking for students with:

- Background in physics or space engineering, preferably with programming skills and basic knowledge of orbital mechanics
- Interested in satellite data evaluation, processing and simulation
- No fear of some satellite related mathematical estimation theory

We can offer:

- Interesting topics in the field of satellite simulation, force modeling, orbit and gravitational field determination and analysis of satellite data
- Close scientific supervision and integration in our research group (Space Science, MSAMM, Benny Rievers)

A thesis is possible in **English** or **German**. If you are interested you are welcome to contact us for further information and/ or send us an application.

This topic could also be adapted to a Master project with maybe two people.

Contact:

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