Comparison of neutral density using different empirical thermosphere models
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Introduction
- In the first phase of SPP 1788, studies related to the investigation of thermospheric density were carried out within the INSIGHT project.
- Thermospheric density was estimated from SLR observations to spherical Low-Earth-Orbiting (LEO) satellites ANDE-Castor (ANDE-C), ANDE-Pollux (ANDE-P) and SpinSat.
- Four empirical thermosphere models CIRA86, NRLMSISE00, JB2008 and DTM2013 have been used as background models to test the sensitivity of SLR observations to thermospheric density variations.
- The four models present density values of significantly different magnitudes.
- To compensate these differences, the drag acceleration was scaled by an additional factor \( f_D \) estimated during the Precise Orbit Determination (POD). See Figure 1.

Further investigations
- First results of DGFI-TUM in context of the work in TIPOD (Development of High-Precision Thermosphere Models for Improving Precise Orbit Determination of Low-Earth-Orbiting Satellites) will be presented here.
- Figure 2 shows the four different thermosphere models mentioned above and their horizontal density variations as a global map on a quiet day (12.03.2015 15:00:00 UTC) at a single altitude of 400 km.

Figure 2: Four different empirical thermosphere models and their density variations on a quiet day at an altitude of 400 km.

- Differences between the models are clearly visible and show the importance of further investigations.
- Figure 3 shows a similar representation in form of time series for a single location (lon 5°, lat 15°) for the four empirical thermosphere models.
- It can be stated that the magnitude of the DTM2013 model is significantly larger than the magnitude of the other models.
- Also important: The density change vs. the height: Figure 4 shows the modelled density of JB2008 on March 12, 2015 at 15:00:00 UTC.
- Figure 5 illustrates a 2D plot of the density change along the height for the four different models for a quiet and a storm day (left) and the respective differences (right).
- First step in WP 130 is done: Processing of DORIS data has been implemented in DOGS (DGFI-TUM Orbit and Geodetic parameter estimation Software) and is being tested for the next step (e.g. extraction of thermospheric density).

Figure 3: Time series of the above mentioned models for a single location (lon 5°, lat 15°) for a period of 15 days.

Figure 4: Maps of modeled density (JB2008) on March 12, 2015 at 15:00:00 UTC. The different height levels are normalized for the visualization. The minimum values are marked in blue, the maximum values in red. The corresponding values are provided alongside the maps.

Figure 5: Representation of the variation of density with height at a single location for a quiet and a storm day for the four different models (left) and their differences (right).

Next steps
- Generation of a uniform representation (e.g. spherical harmonic expansion) of all models used in order to allow for comparisons on the basis of key parameters (see figures below).
- Assimilation of thermospheric density data from SLR (WP 110) and DORIS (WP 130) observations into the spherical harmonic representation.

Reference