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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 I 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 accerleration was scaled by an additional factor f_s estimated during the Precise Orbit Determination (POD). See Figure 1.

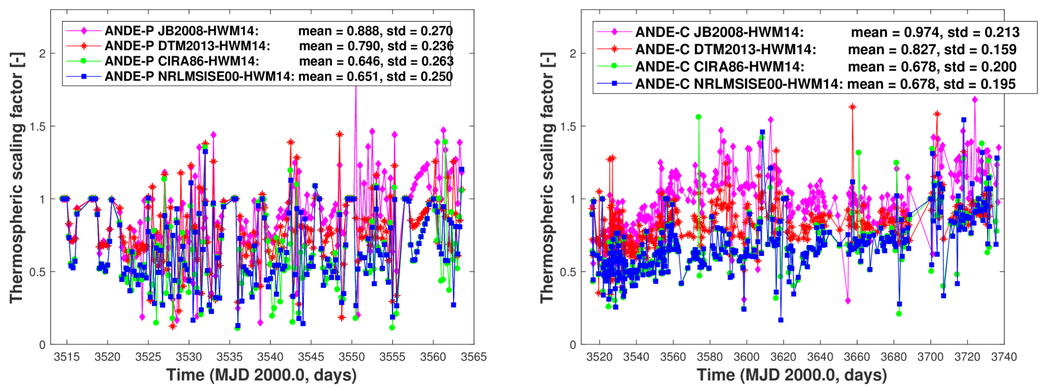


Figure 1: Scale factors f_s estimated from SLR measurements of ANDE-P from 16 August 2009 to 3 October 2009 (left) and ANDE-C from 16 August 2009 to 26 March 2010 (right).

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

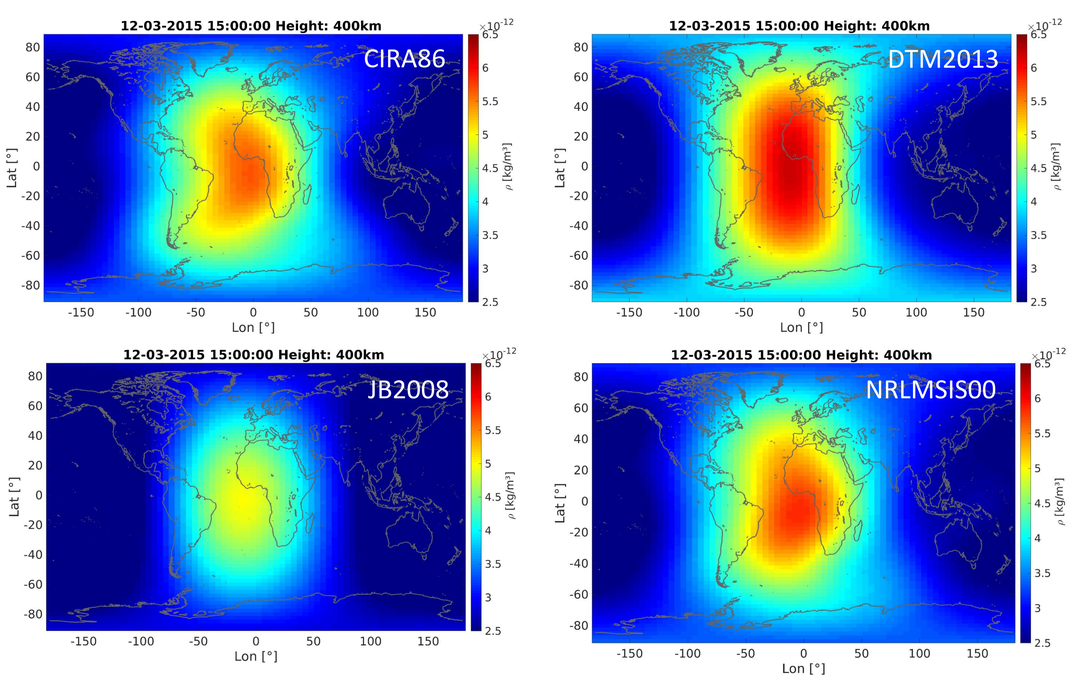


Figure 2: Four different empirical thermosphere models and their density variations on a quiet day at an altitude of 400 km

- 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 been 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)

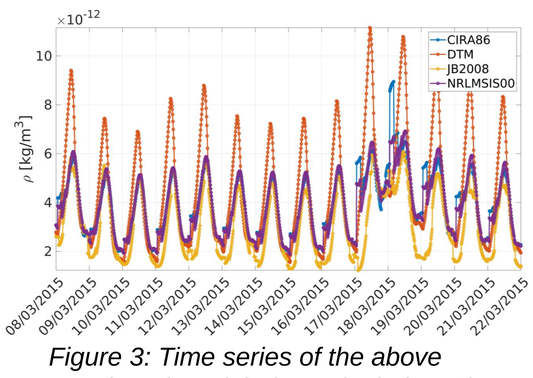


Figure 3: Time series of the above mentioned models for a single locartion (lon 5°, lat 15°) for a period of 15 days

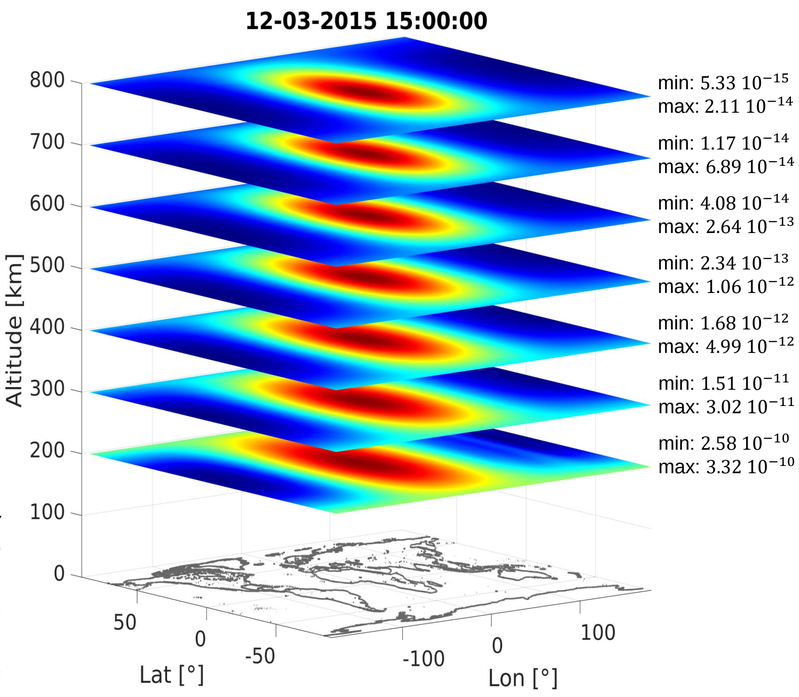


Figure 4: Maps of modelled density (JB2008) on March 12, 2015 at 15:00:00 UTC. The different height levels are normalized for the visualization. The minimum values are marked in blue, the maximum values in red. The corresponding values are provided alongside the maps.

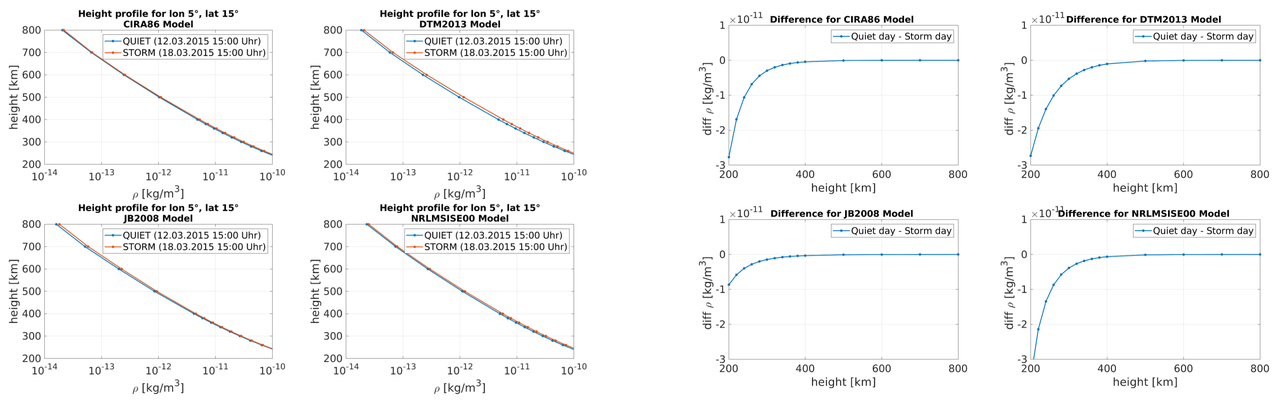
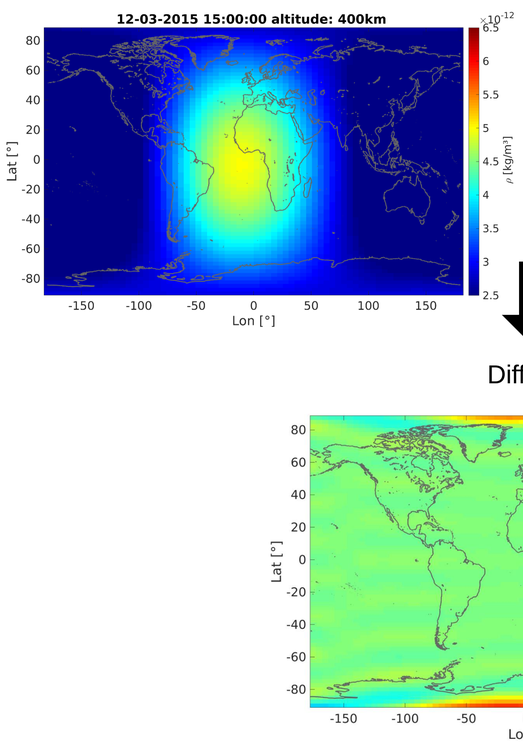
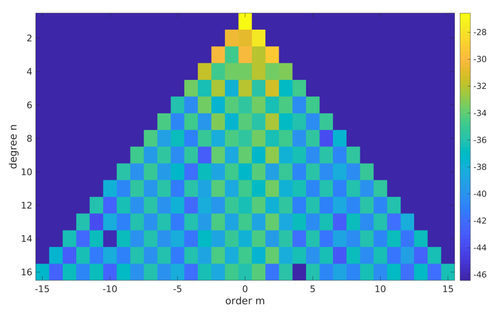


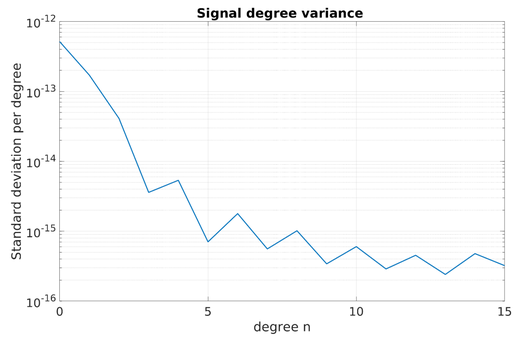
Figure 5: Representation of the variation of density with height at a single location for a quiet and a storm day for the four different models (left) and their differences (right)

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

Rudenko et al. (2018): Calibration of Empirical Models of Thermospheric Density Using Satellite Laser Ranging Observations to Near-Earth Orbiting Spherical Satellites. In: Freymueller J., Sánchez L. (eds) International Symposium on Advancing Geodesy in a Changing World. International Association of Geodesy Symposia, vol 149. Springer, Cham

DFG SPP colloquium 2019, Bad Aibling, Germany, 04. June – 06. June 2019