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Development of High-precision Thermosphere Models for Improving Precise Orbit Determination of Low-Earth-Orbiting Satellites - TIPOD

Lea Zeitler (1), Michael Schmidt (1), Jürgen Kusche (2), Claudia Stolle (3), Chao Xiong (3), Urs Hugentobler (4), Christoph Bamann (4), Klaus Börger (5), Ehsan Forootan (6), and Maike Schumacher (6)

(1) Deutsches Geodätisches Forschungsinstitut, Technische Universität München, Munich, Germany (lea.zeitler@tum.de), (2) Institut für Geodäsie und Geoinformation, Universität Bonn, Bonn, Germany, (3) Deutsches GeoForschungsZentrum GFZ, Potsdam, Germany, (4) Forschungseinrichtung Satellitengeodäsie, Technische Universität München, Munich, Germany, (5) German Space Situational Awareness Centre (GSSAC), Uedem, Germany, (6) Institut für Physik und Meteorologie, Universität Hohenheim, Stuttgart, Germany

The motion of a satellite depends on gravitational and non-gravitational accelerations. A major problem in precise orbit determination (POD) of low-Earth orbiting (LEO) objects such as satellites or space debris is modelling the thermospheric drag. It is the largest non-gravitational acceleration for objects with altitudes lower than 1000 km and decelerates their movement. In case of the Swarm satellites with an altitude of around 460 km not considering the drag within the POD would cause an error of around 3 meters per revolution in the along-track direction.

The knowledge of the thermospheric density is of crucial importance in many geo-scientific applications such as remote sensing, satellite altimetry and satellite gravity missions, where orbits with an accuracy of a few millimetres are required. Yet, today's usage of thermosphere models, often based on data collected at times with different solar conditions and altitudes, may provide only limited accuracy in POD. Therefore, we initiated the project TIPOD for the second phase of the Special Priority Programme (SPP) 1788 Dynamic Earth funded by the German Research Foundation (DFG). The project aims on improving the POD of LEO satellites by applying further developed thermosphere models. For this purpose, data from various satellite tracking techniques (SLR, accelerometer, GNSS, DORIS, RADAR and TLE) will be assimilated into a physical coupled thermosphere-ionosphere model, namely TIE-GCM (Thermosphere-Ionosphere-Electrodynamics General Circulation Model). Since these data are rather heterogeneous, an empirical model will be interposed between the observations and the physical model in the first step of the project. After calibrating the empirical model, its output will be assimilated into the physical model within the second step of the project.

TIPOD addresses two main scientific questions: (1) how close can the physical model recover the empirical one within the investigated time span of recent satellite missions such as CHAMP, GRACE and Swarm, and (2) how far can the LEO-POD be improved by the application of both models?