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Empirical corrections for atmospheric neutral density derived from thermospheric models

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Accurately predicting satellite positions is a prerequisite for various applications from space situational awareness to precise orbit determination (POD). Given the fact that atmospheric drag represents a dominant influence on the position of low-Earth orbit objects, an accurate evaluation of thermospheric mass density is of great importance to low Earth orbital prediction. Over decades, various empirical atmospheric models have been developed to support computation of density changes within the atmosphere. The quality of these models is, however, restricted mainly due to the complexity of atmospheric density changes and the limited resolution of indices used to account for atmospheric temperature and neutral density changes caused by solar and geomagnetic activity. Satellite missions, such as Challenging Mini-Satellite Payload (CHAMP) and Gravity Recovery and Climate Experiment (GRACE), provide a direct measurement of non-conservative accelerations, acting on the surface of satellites. These measurements provide valuable data for improving our knowledge of thermosphere density and winds. In this paper we present two empirical frameworks to correct model-derived neutral density simulations by the along-track thermospheric density measurements of CHAMP and GRACE. First, empirical scale factors are estimated by analyzing daily CHAMP and GRACE acceleration measurements and are used to correct the density simulation of Jacchia and MSIS (Mass-Spectrometer-Incoherent-Scatter) thermospheric models. The evolution of daily scale factors is then related to solar and magnetic activity enabling their prediction in time. In the second approach, principal component analysis (PCA) is applied to extract the dominant modes of differences between CHAMP/GRACE observations and thermospheric model simulations. Afterwards an adaptive correction procedure is used to account for long-term and high-frequency differences. We conclude the study by providing recommendations on possible contributions of satellite measured density estimations to improve model simulations.