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ASSESSING ACCURACY OF DIFFERENT ATMOSPHERIC MODELS THROUGH ORBITAL PREDICTIONS FOR NEAR REAL TIME APPLICATIONS

Abstract

Atmospheric forces are one of the perturbations with the greatest impact on orbital predictions of low-altitude orbits. An inaccurate modelling of the aerodynamic drag, as a consequence of miss-modelling of the atmosphere, leads to significant errors in the orbital propagation of these orbits.

The objective of this study is to compare orbital predictions using different atmospheric models among those most commonly used: MSISE-90, NRLMSISE-00, DTM-2013 and Jacchia-Bowman 2008. The methodology consists in comparing the precise orbits of several low-altitude satellites (ESA's Sentinel and Swarm satellites) against the orbits calculated by numerical propagation using the different atmospheric models. The precise orbits of these satellites are GNSS-based kinematic orbits (i.e. not based on any dynamical model), and are used as reference in the two scenarios of the process: first one, a pseudo-orbit determination, where the precise orbit is used to perform an orbital fitting, giving an initial estimate of the drag; and second one, the propagation, where the previously estimated initial state vector is propagated and the calculated orbit is compared against the reference.

These comparisons allow not only to determine the most accurate atmospheric model in both scenarios (orbit propagation and determination), but also to characterise the errors associated to the use of such models in both of them. Since these applications are often required in near-real time, the accuracy of the prediction of the solar proxies used as input in the atmosphere models has also an important impact, even preventing accurate orbital propagations at certain altitudes. Apart from the accuracy of the prediction itself, other factors, such as their availability or resolution, are decisive to consider or discard atmospheric models as suitable for the near-real time applications.

The different cases analysed focus on the above-mentioned atmospheric models and their most common proxies. The results determine that none of the models produce high errors even when using predicted proxies. As example, for the case of the Sentinel satellites (with orbital altitudes between 700 and 800 km), the RMS errors are always below 50 meters after 7 days of propagation, regardless of the model used. According to the results of this study, the Jacchia-Bowman 2008 and DTM-2013 models seem to be the most realistic ones. Nonetheless, the lack of public availability in real time of the proxies used by Jacchia-Bowman model renders the DTM-2013 and MSISE models the most suitable for use in this type of near-real time applications.