

COST-G gravity field predictions for operational satellite orbit determination

Precise orbit determination (POD) of Earth observation satellites at orbit altitudes below 2000 km, so-called Low Earth Orbiters (LEOs), critically depends on the precise knowledge of the Earth's gravity field and its variations with time. On a global scale, the time-variable gravity field is determined by the analysis of observations of the two satellites of the dedicated GRACE-FO mission (or its predecessor GRACE). In the frame of the Combination Service for Time-variable Gravity fields (COST-G) the Astronomical Institute of the University of Bern (AIUB) collects the monthly gravity field solutions of the GRACE / GRACE-FO analysis centers worldwide and derives combined solutions.

But the latency of the monthly gravity fields amounts to 2-3 months and thus in operational POD of other LEOs the monthly GRACE-FO solutions cannot be used. Instead, operational POD is commonly based on long-term mean gravity field models with high resolution, occasionally complemented by seasonal variations and long-term trends, which are derived by the common analysis of several years of GRACE / GRACE-FO data. These models of secular and seasonal variations allow for the prediction of gravity field variations for operational POD. But the effort for the generation of such multi-year models is much higher than for the generation of the monthly snapshot solutions, and consequently it may take years unless an update based on the latest GRACE-FO data becomes available. When using a long outdated gravity field model for LEO POD, the prediction errors of the gravity field variations and consequently also the orbit errors reach critical size.

To reduce the prediction errors, a model of time-variable gravity based on the monthly GRACE-FO solutions has been developed at AIUB in collaboration with PosiTim UG in the frame of COST-G. It is foreseen to quarterly update the model to allow for gravity field predictions during the following three months that are always based on the newest GRACE-FO observations. In experimental POD of the Copernicus Earth observation satellites Sentinel-2B and -3B the use of the COST-G model lead to a gain in consistency between successive orbital arcs of 30-50% when compared to orbits based on the standard long-term model. The GPS phase residuals could be reduced by up to 20%, and the orbit validation by independent satellite laser ranging (SLR) observations confirmed an absolute quality gain in radial direction of up to 10%.

The new model of gravity field variations is freely available to all users at the International Center for Global Earth Models (ICGEM):

http://icgem.gfz-potsdam.de/series/02_COST-G/DSM/quarterly