EGU2020-18361
https://doi.org/10.5194/egusphere-egu2020-18361
EGU General Assembly 2020

Recent Advances in Galileo and BeiDou Precise Orbit Determination

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To produce Global Navigation Satellite System (GNSS) orbits and clocks with high accuracy and for all constellations, the ESA's Navigation Support Office (NSO) continually strives to keep abreast and improve its precise orbit determination (POD) strategies. In this presentation, we report on NSO's recent developments and progress in Galileo and BeiDou POD. We first discuss the approach of improving Galileo POD solutions through a prudent combination of radiometric and satellite laser ranging (SLR) measurements at the observation level. For this technique to be effective, SLR normal point (NP) data from the Galileo SUCCESS campaign are used. Launched by the European Laser Network (EUROLAS) in the middle of May 2019, this three-week tracking campaign provided over 1000 NPs for two selected Galileo spacecraft: GSAT0102 and GSAT0220. We show that the precision of the GSAT0102 and GSAT0220 orbits is more than 10 percent better than that produced by solutions without SLR data. In this performance evaluation, we also discuss the presence of station-specific SLR biases, taking advantage of near-simultaneous SLR tracking by two or three separate laser sites. Additionally, we demonstrate that the SLR full-rate data from a single kHz laser system can be used to determine the Galileo satellites' yaw state during eclipse maneuvers. This approach takes advantage of the 1.0 m distance between a Galileo spacecraft's laser retroreflector array (LRA) and rotation axis to estimate the yaw angle in a recursive least-squares algorithm epoch by epoch. The method may serve as an interesting alternative to reverse kinematic point positioning (RPP), particularly for LRA-equipped satellites without significant transmit antenna phase center offsets. Finally, we present the first centimeter-quality orbit solutions for BeiDou's third-generation series of medium Earth orbit (MEO) spacecraft. We discuss the POD strategy underlying these orbits and evaluate its performance by way of several metrics including laser range residuals, day-to-day orbit overlaps, satellite clock residuals, as well as RPP estimates as measure for the attitude model accuracy. Challenges pertaining to the satellite antenna phase center and radiation force modeling are addressed. The results on the overlap and SLR residuals suggest that our BeiDou-3 MEO orbits are accurate to better than 5 cm in all three components. Therefore, the new BeiDou constellation is fully integrated into our operational multi-GNSS routine, bringing the total number of daily processed GNSS satellites to more than 110 (http://navigation-office.esa.int/products/gnss-products).