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Empirical Solar Radiation Pressure Modelling of Satellites with Orbit Normal Attitude

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The Center for Orbit Determination in Europe (CODE) is contributing to the IGS MGEX (Multi-GNSS Extension) since its start in 2012 with an orbit and clock solution. The CODE MGEX (COM) solution currently considers the satellite systems GPS, GLONASS, Galileo, BeiDou2 (BDS2), and QZSS.

Most BDS2 spacecraft as well as QZS-1 are oriented according to the orbit normal (ON) attitude at times when the elevation of the Sun over the respective orbital plane (the so-called beta angle) is low. During the ON-mode the well-established Empirical Code Orbit Models (ECOM) are not sufficient for properly modelling the SRP (Solar Radiation Pressure). Therefore, some groups developed (semi-) analytical SRP models that perform well - at least for QZS-1. However, most of these models cannot cover the SRP effect entirely. Hence, they still need to be supported by an empirical model.

We did the effort to develop a family of empirical SRP models that could – in theory – be applied to every satellite with ON attitude (including spacecraft in geostationary orbits). Different versions of the resulting ECOM-TB (ECOM using a terminator reference frame and considering the beta angle) were verified with MGEX data and have been activated in the COM solution in summer 2018. Like older ECOM models, ECOM-TB can not only be used stand-alone, but also together with an a priori SRP model.

Our validations show that ECOM-TB is able to significantly improve the estimated orbits and clock corrections of QZS-1. This is also confirmed by comparisons with external QZS-1 solutions in the frame of the IGS MGEX. The benefits are less pronounced for BDS2 spacecraft - in particular not for BDS2 IGSOs when solving for long orbital arcs. We addressed this issue by developing a modified version of the model retaining a minimum number of SRP parameters supported by empirical parameters.