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BDS orbit determination with combined GNSS and SLR observations

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Abstract: Beidou Navigation Satellite System (BDS) has made great progress these years with more than six-year service for the Asian-Pacific region by the BDS-2. The BDS-3 provided initial service at the end of last year, and it will serve global users in 2020. In this paper, validation and evaluation on the orbit accuracy of the BDS-2 using long-term satellite laser ranging (SLR) measurements are conducted firstly. For this purpose, BDS precise orbits from three Multi-GNSS EXperiment analysis centers (MGEX ACs), that is WUM, COM and GBM, and the fourth one ISC of the international GNSS continuous Monitoring and Assessment System (iGMAS), are validated from the year of 2013 to 2018. In addition, the performances of the BDS orbits during non-eclipse, eclipse and yaw maneuver (YM) period are evaluated, and the relationships of the SLR residuals with regard to the Sun elevation angle β, the satellite nadir angle, the SLR site elevation angle, as well as the satellite orbit angle $\Delta\mu$ are analyzed in detail. Secondly, BDS orbit determination with combined GNSS and SLR observations is performed and assessed. Different orbit determination strategies related to the selection of arc length, weight ratio between SLR and GNSS observations and the estimated dynamic parameters are studied and compared. GNSS-only, SLR-only and GNSS+SLR orbit determination are conducted and compared. The range residuals are further analyzed to show whether there is any systematic difference between the GNSS and SLR system. The results show that the inclusion of SLR data can bring significant improvement for the combined orbit compared to the GNSS-only orbit especially for those BDS satellites with SLR observations. Finally, the accuracy of BDS kinematic precise point positioning (PPP) using the combined GNSS+SLR orbit and clock is tested.
Keywords: GNSS; SLR; BDS; orbit determination; PPP.

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