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Estimation of LEO Phase Center Variations using onboard GPS and BDS observations

Qian Zhang, Keke Zhang, Wei Zhang, Hongmin Zhang, and Yujie Qin
Wuhan University, School of Geodesy and geomatics, China (qianzhang23333@whu.edu.cn)

Nowadays, the GPS-based precise orbit determination (POD) has become the primary source providing orbit information for low earth orbit (LEO) satellites. When recovering the high precise orbit of LEO from GPS observations, the phase center variations (PCV) of the onboard antenna is an important factor and cannot be neglected. Usually, the nominal PCV patterns of LEO antenna can be obtained through the field calibration before launch, but it can not reflect the real phase center variations in-flight because of the deformation and complex space environment. Therefore, it is necessary to estimate and recalibrate the PCV of LEO in-flight. In this study, we focus on the PCV estimation of two new Chinese meteorological satellites, Fengyun-3C (FY-3C) and Fengyun-3D (FY-3D), which carry a BDS and GPS dual-system receiver, to investigate the influence of BDS PCV on LEO POD and discuss the possibility of using GPS PCV to correct phase variations of BDS signals. The $5^\circ \times 5^\circ$ PCV maps for GPS and BDS are estimated respectively using about one-month carrier phase residuals. The result shows that the orbit of the GPS-only solution present a better consistency between two adjacent 30-h arcs after correcting GPS PCV. The carrier phase residuals of GPS observations are reduced from 11mm to 9mm for FY-3C, and from 7mm to 6mm for FY-3D. With correction of BDS PCV, the GPS and BDS combined (GC) POD presents a better orbit precision than that of solution neglecting BDS PCV, which indicates that BDS PCV correction need to be taken into consideration in high precise orbit determination. The precision improvement of the GC solution for FY-3C is 4% and FY-3D achieves a slight precision improvement of about 2% when considering BDS PCV. For FY-3C, the carrier phase residuals of GEO, IGSO and MEO observations are respectively decreased by 6%, 12% and 12% and that for FY-3D are reduced by 4%, 10% and 2%. When using GPS PCV to correct the phase variations of BDS signals, the orbit of the GC solution can achieve a similar precision with the solution applying BDS PCV, which demonstrates it is feasible to apply GPS PCV corrections to onboard BDS signals like the ground stations when the BDS PCV is not available.