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Extending the GPS satellite antenna patterns of the IGS to nadir angles beyond 14° using LEO data

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The absolute phase center model adopted by the International GNSS Service (IGS) in 2006 is based on robot calibrations for a number of terrestrial GNSS receiver antennas and consistent correction values for the GNSS transmitter antennas estimated from data of the global IGS tracking network. As the calibration of the satellite antennas is solely based on terrestrial measurements, the estimation of their phase patterns is limited to a nadir angle of 14°. This is not sufficient for the analysis of spaceborne GPS data collected by low Earth orbiting (LEO) satellites that record observations at nadir angles of up to 17°. Moreover, phase center variation (PCV) estimates for nadir angles close to 14° derived from terrestrial measurements might be affected by uncertainties in the troposphere modeling. This drawback may also be overcome by the use of LEO data.

We use GPS tracking data from the LEO missions Jason–2, MetOp–A, GRACE, and GOCE to extend the IGS satellite antenna patterns to nadir angles beyond 14°. In order to achieve estimates that are consistent with the PCVs currently used within the IGS, GPS and LEO orbits are fixed to solutions obtained by adopting the IGS conventional values. Due to significant near-field multipath effects in the LEO spacecraft environment, it is necessary to solve for GPS (nadir–dependent only) and LEO (azimuth– and elevation–dependent) antenna patterns simultaneously. We analyze the separability of these parameters and discuss appropriate constraints. We assess the contribution of the different LEO missions to a combined solution and analyze the impact of the extended PCVs on LEO precise orbit determination results.