Extended troposphere delay model dedicated to Satellite Laser Ranging

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Motivation

Satellite Laser Ranging (SLR) is the only space geodetic technique in which troposphere models do not consider horizontal asymmetry of the atmosphere above the station. Due to low number of observations, poor geometry, and weather conditions the estimation of horizontal gradients from laser observation provide to deterioration of weekly solutions. To model this effect in sufficient way we propose to use the ray-trace mapping function coefficients and the horizontal gradients dedicated for laser observations.

PMF products

The time series of mapping function coefficients derived from Mendes–Pavlis model (red) and NWM solution (green) are shown in figure 1. The a1 coefficient derived from NWM is smoother in comparison to a1 MP coefficient. Moreover, the coefficients a2 and a3 show characteristic offset at the level of 3% to 6%.

The differences between coefficients from PMF and Mendes-Pavlis models is transformed to differences of the slant total delay estimation at the level of 5 mm for the elevation angle equal to 10 degrees (fig. 2).

Methodology

The solutions with horizontal gradients improve the horizontal asymmetry above SLR station. The differences between linear gradients can reach even 3 mm.

Differences of geocenter coordinates

Figure 7 presents the differences between pole coordinates including PMF models and Mendes-Pavlis approach. The solutions with horizontal gradients characterize offsets at the level of 20 µas. The consistency of the pole coordinates between SLR solutions with horizontal gradients and the IERS-14-C04 series is improved and reduced from 22 µas and 38 µas to 2 µas and 14 µas for X and Y pole coordinates, respectively.

The differences of the geocenter coordinates are shown in figure 8. The mean shift in the solution PMF+O1 and O2 is up to 0.04, 0.13, and 0.04 mm for the X, Y, and Z components respectively. It suggests that the currently used origin of the ITRF realization may be affected by neglect of horizontal gradients in the SLR solutions.

References:


Figures:

1. Comparison of mapping function coefficients, a1, a2, a3 derived from PMF (red) and from PMF mapping functions. For year 2003: For station CGR (CGR) and Yarragadee (YAR).

2. Impact of the first (green dashed line) and second degree (red dotted line) of PMF horizontal gradients for 10° elevation angle, at the 14 January 2007. The second degree of horizontal gradients improves the horizontal asymmetry above SLR station. The differences between linear gradients can reach even 3 mm.

3. Residuals statistics

4. Differences of Earth rotation parameters

5. Differences of coordinates repeatability

6. Differentials of Earth rotation parameters, between the standard solution and solutions with PMF

7. Differences of geocenter coordinates between standard solution and PMF solutions

Conclusions

We propose to extend the currently used troposphere delay model by linear horizontal gradients derived from NWM. The mapping functions coefficients give the same results as the mapping function coefficient derived from FCULzd proposed by Mendes and Pavlis 2002. The horizontal gradients improve the consistency between SLR and other space geodetic techniques. The nonlinear horizontal gradients bring measurable results in dynamic weather conditions however the SLR stations provide observations only in good cloudless conditions so the second degree of horizontal gradients could be neglected to simplify the troposphere model.