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Enhanced troposphere delay model for SLR

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The currently recommended troposphere delay model for Satellite laser ranging (SLR) assumes a full symmetry of the atmosphere above stations. The microwave-based techniques of space geodesy contributing to the realizations of the international reference frames, i.e. Global Navigation Satellite Systems, Very Long Baseline Interferometry or Doppler Orbitography and Radiopositioning Integrated by Satellite, consider horizontal gradients in the process of the observation analysis. As a result, SLR is the only space geodetic technique that disregards horizontal asymmetry in the troposphere delay model. This limitation has been addressed as an unresolved issue by the International Earth Rotation and Reference Systems Service (IERS) Conventions 2010.
We present the impact of the application of new mapping function coefficients and horizontal gradients of the first and second order derived from numerical weather models (NWM) on products derived from SLR observations to passive geodetic satellites LAGEOS-1, LAGEOS-2 as well as from SLR observations to low Earth orbiting satellite Sentinel-3A. The results show differences in SLR mapping functions at the level of 5 mm for the slant delays projected to the elevation angle of 10 degrees during the winter time in the Northern hemisphere. Moreover, the impact of horizontal gradients projected to 10-degrees elevation angle can reach 14 mm. When considering the horizontal asymmetry in SLR solutions, the mean offset between SLR-derived pole coordinates and the combined solution IERS-14-C04 series is reduced from 22 to 2 μas and for 38 to 14 μas for the X and Y components of pole coordinates, respectively from the 10-year analysis of LAGEOS data.
In the second step, we analyze the impact of the new mapping function and horizontal gradients on SLR observations to a LEO satellite, that is Sentinel-3A. The SLR observations to LEO satellites are performed mostly at low elevation angles, thus considering horizontal gradients is crucial to reduce systematic effects. The results show that the standard deviations of the observation residuals can be improved by about 4 mm for high-performing SLR stations, such as Zimmerwald, Mt Stromlo, or Graz. Summarizing the result described above, we propose to extend the currently used troposphere delay model by adding horizontal gradients to improve the consistency between SLR and other space geodetic techniques and to reduce substantially systematic errors in the SLR solutions.