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Unified theory for atmospheric propagation effects of geodetic space techniques

D. D. Wijaya and F. K. Brunner

Institute of Engineering Geodesy and Measurement Systems, Graz University of Technology, Steyrergasse 30/II, 8010 Graz, Austria (dudy.d.wijaya@student.tugraz.at & fritz.brunner@tugraz.at).

The accuracy of geodetic space measurements is limited by the atmospheric propagation delays, which consist of the delays related to the total density and the water vapor density of air. Usually, calculations of the propagation delays for geodetic microwave and optical measurements are carried out independently. We propose a unified theory to calculate the propagation delays affecting all geodetic space measurements.

We have developed a unified atmospheric correction formula based on the theory of two frequency range measurements. All integrations are carried out along the known chord of the propagation path. Gradients of the horizontal density are incorporated in the integrations. The curvature effect is evaluated separately. The chord elevation angle is used instead of the unknown apparent elevation angle. The unified formula is applicable to Global Navigation Satellite Systems (GNSS), Very Long Baseline Interferometry (VLBI) and Satellite Laser Ranging (SLR).

The unified formula represents a new model for the accurate calculation of the zenith propagation delays as well as a new mapping function for all geodetic space techniques. Furthermore, it allows the elimination of the propagation delays by combining the possible simultaneous measurements of different geodetic space techniques. Therefore, the availability of SLR and GNSS measurements at all SLR stations can be an advantage for conducting the co-located observation of single SLR system and GNSS, which is useful to estimate the water vapor effects of SLR observations.