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Inter-system weighting for improved multi-GNSS real-time ZTD estimation

Tomasz Hadas, Anna Turbanska-Guzniczak, Kamil Kazmierski, and Krzysztof Sosnica

Institute of Geodesy and Geoinformatics, Wroclaw University of Environmental and Life Sciences, Wroclaw, Poland (tomasz.hadas@upwr.edu.pl)

Remote sensing of the atmosphere using Global Navigational Satellite Systems (GNSS), so called GNSS meteorology, provides homogenous products of spatial and temporal resolution higher than any other troposphere sensing technique. A dynamic development of GNSS constantly increases the number of operational spacecraft and the amount of provided frequencies, therefore more and more signals are sensing the troposphere. The zenith troposphere delay (ZTD), horizontal gradients and slant troposphere delays can be obtained directly using the Precise Point Positioning (PPP) technique. Since real-time products have become available for GPS, GLONASS, Galileo and BeiDou, it is now possible to estimate troposphere products taking advantage of the almost complete quad-system constellation. However, the quality of real-time products, that affects directly the accuracy of parameters estimated with the PPP technique, is not homogenous among systems. Although it was already demonstrated, that improper inter-system weighting may lead to degradation of position precision and accuracy, the impact on troposphere products has not been yet investigated.

In our study we used multi-GNSS data from 14 stations distributed worldwide and estimated real time ZTDs for two periods, one week long each. We obtained GPS only solution and three quad-system solutions by applying three different inter system weighting strategies: 1) equal weights for all systems, 2) taking into account the signal in space range error (SISRE) and 3) taking into account SISRE and observation noise. Estimated real-time ZTDs were validated against final products of the International GNSS Service (IGS).

We noticed that the equal weighting of multi-GNSS observations significantly worsened the quality of estimated ZTD, and the obtained ZTD-time series were very noisy. On the other hand, when SISRE was used to differentiate weights among various GNSS, 14% of improvement in the accuracy of ZTD was obtained compared to the GPS-only solution. Even though the carrier-phase observation were down weighted with respect to GPS by the factor of 3, 3, 3.5 and 4 for GLONASS, Galileo, BeiDou MEO and BeiDou IGSO, respectively, they still contributed to improving ZTD. On the other hand, a very limited impact on the ZTD accuracy was observed, when the observation noise was additionally taken into account.