TOMOREF operator for assimilation of GNSS tomography wet refractivity fields in WRF DA system

Natalia Hanna¹, Estera Trzcina², Maciej Kryza³, and Witold Rohm²

¹TU Wien, Department of Geodesy and Geoinformation, Vienna, Austria (natalia.hanna@geo.tuwien.ac.at)
²Wroclaw University of Environmental and Life Sciences, Institute of Geodesy and Geoinformatics, Wroclaw, Poland
³University of Wroclaw, Department of Meteorology and Climatology, Wroclaw, Poland

The amount of water vapor in the atmosphere is highly variable and not easy to measure. One of the methods to provide reliable information about the amount and distribution of the humidity in the troposphere is GNSS (Global Navigation Satellite Systems) tomography. The GNSS tomography uses the observations of signal delays between satellites and ground-based receivers over the field covered by a GNSS network. This method enables deriving the 3D distribution of wet refractivity at a low cost in all weather conditions, with high temporal and spatial resolution.

The first applications of the GNSS tomography data in the Weather Research and Forecasting Data Assimilation (WRF DA) system were performed by the adaptation of the GPSREF observation operator. In this study, we present a new tool, namely the TOMOREF observation operator, which consists of three parts: forward, tangent linear, and adjoint operators. As the input data in the assimilation process, the wet refractivity fields from two tomographic models (TUW, WUELS) are used. The analysis is carried out for a 2-week long period (May 29 – June 14, 2013) in Central Europe when severe weather conditions occurred, including heavy precipitation events. The data assimilation results are verified against radiosonde observations, synoptic data, and ERA5 reanalysis. Moreover, the performance of the TOMOREF and GPSREF operators is examined. For the forecasts of relative humidity (RH) at a pressure level of 300 hPa, the implementation of the TOMOREF operator vanishes the negative impact caused by the GPSREF operator. Additionally, the improvement of the root mean square error of the forecasts of RH up to 0.5% is observed. Comparing to the assimilation of Zenith Total Delay observations, the application of the tomographic data has overall a greater influence on the WRF model. Consequently, the GNSS tomography data can be valuable in operational weather forecasting.