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

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Abstract

GNSS troposphere tomography technique provides a 3D distribution of wet refractivity (Nw) based on GNSS-derived tropospheric delay. The recent studies show a good agreement of the tomographic estimations with radiosonde and synoptic data. Although the first tries of assimilation of the tomographic outputs into the numerical weather prediction (NWP) models showed an improvement in the forecasts of humidity and temperature during heavy precipitation events, they were performed using observation operators not adjusted to the characteristics of the GNSS tomography data. In this work, we present a new observation operator TOMOREF, designed for assimilation of the tomography-derived Nw fields in the Weather Research and Forecasting Data Assimilation system.

The study presents forward, tangent linear, and adjoint parts of the TOMOREF operator. Verification of the proposing tool is performed based on the Nw fields derived using two tomographic models during a 14-day period, including a heavy precipitation event. For the comparison, assimilation using GPSREF and GPSZTD operators was carried out. Validation was based on radiosonde data, synoptic observations, and ERA5 reanalysis. Comparing the performance of the GPSREF and TOMOREF operators, the latter shows a better adjustment to the quality of the tomographic data at particular height levels in terms of the percentage of assimilated observations. Also, a larger impact on the relative humidity forecasts was noticed for assimilation of the Nw fields compared to the ZTD data (by 1% rmse). Moreover, another assimilation experiment using TOMOREF is presented, focused mainly on forecasting wind parameters.