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How precisely can we monitor climate signals with GNSS and VLBI? A simulation study

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As of 2018, several stations of global navigation satellite systems (GNSS) and very long baseline interferometry (VLBI) will have been observing for over 25 and 35 years, respectively. Since these periods span closely to the climate normals, occasionally exceeding them, it is high time to address the precision of the climate signals estimated by the established space geodetic techniques, in an absolute sense. The comparison of climate signals from sufficiently long series of different observing systems such as GNSS, VLBI and numerical weather models (NWM) cannot provide a ground truth on which is the most accurate system for this purpose. To this end, we have carried out a number of Monte Carlo simulations employing the actual observation geometry i.e. GNSS satellite orbits and the actual VLBI schedules. The simulation setup comprises of a turbulence model for the troposphere, random walk plus integrated random walk for the clocks, and an elevation-dependent and system-dependent white noise for the observations. For the first time, the simulator is additionally driven by ray-traced delays in ECMWF's fifth-generation reanalysis NWM, ERA5. Utilizing our ray-traced delays at every epoch and at every station, we have estimated mapping functions (MF), gradient components, and zenith hydrostatic and wet delays (ZHD and ZWD). In a subsequent geodetic adjustment, it is important to assess the resilience of the estimated parameters to lacking tropospheric modeling. We compared the results of our approach with the GFZ-PT, an empirical model with which zenith hydrostatic delays and mapping functions can be computed. Four solutions were performed alternating the tropospheric parameterization: (1) MF and ZHD both from ray-tracing, (2) MF from ray-tracing and GFZ-PT ZHD, (3) GFZ-PT MF and ZHD from ray-tracing, and (4) GFZ-PT MF and GFZ-PT ZHD. The estimated zenith wet delays and gradient components are compared epoch-wise with those stemming from the ray-traced delays. Afterwards, the rates thereof are compared to those from ERA5.