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Publication date:
2024-04-17

Permanent link:
https://doi.org/https://doi.org/10.3929/ethz-b-000669900

Originally published in:
EGUsphere, https://doi.org/10.5194/egusphere-egu24-10250

EGU24-10250, updated on 29 Apr 2024
https://doi.org/10.5194/egusphere-egu24-10250
EGU General Assembly 2024

Assimilating UAV-based GNSS ZTDs for Numerical Weather Predictions

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In recent decades, various studies have demonstrated that assimilating tropospheric parameters from ground-based GNSS receivers benefits numerical weather predictions (NWPs). However, the achieved performance is limited by the spatial resolution of GNSS, especially in the vertical direction. With the rapidly developing and growing market of unmanned aerial vehicles (UAVs) and the facilitates of integrating low-cost GNSS hardware into various autonomous systems over the last years, there is a potential to address this problem by utilizing UAVs to collect airborne GNSS data and generate zenith total delays (ZTDs). The airborne GNSS ZTDs can act as a potential complementary source to radiosonde data for obtaining vertical profiles of the troposphere, making it promising to investigate the impact of assimilating GNSS ZTDs of high spatio-temporal resolution in NWPs.

In this study, we explored the use of GNSS data collected by a vertically ascending UAV, with ZTDs processed using the software CamaliotGNSS. Based on the airborne GNSS ZTDs, we conducted not only data assimilation but also weather predictions using the Weather Research and Forecasting Model (WRF). With the onboard meteorology observations as references, we found that assimilating airborne GNSS ZTDs positively impacted humidity and temperature forecasts, with their forecasting root-mean-square errors decreasing by about 19% and 29%, respectively. Moreover, by selecting and comparing different subsets of data, we found that better forecasts can be obtained with airborne GNSS ZTDs of higher spatio-temporal resolution. The positive results invite further exploration of applications of airborne platforms such as UAVs in the field of GNSS meteorology.