Machine learning algorithms for global modelling of Zenith Wet Delay based on GNSS measurements and meteorological data

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Abstract

Global Navigation Satellite Systems (GNSS) are nowadays not only indispensable for global positioning and navigation, but find also application in atmospheric research. This is related to the fact that GNSS signals, as they traverse the atmosphere, are subject to various phenomena introducing a time delay. By estimating and analysing these delays, measurements of atmospheric properties can be performed.
The tropospheric delay in the zenith direction is referred to as Zenith Total Delay, which is typically divided into a zenith hydrostatic delay (ZHD) and a non-hydrostatic (wet) delay (ZWD). While ZHD can be modelled with sufficient accuracy using surface pressure, ZWD is challenging to model and is therefore typically estimated. ZWD mainly depends on the water vapour content in the atmosphere which is highly variable. Thus, the quantification of ZWD with high accuracy can be utilized for precise weather forecasting or climate research.
In this work, we apply several machine learning (ML) algorithms with a special focus on Random Forest and Extreme Gradient Boosting (XGBoost) to model ZWD globally. The investigated ML models are trained based on over 10.000 globally distributed geodetic GNSS stations for which ZWD estimates are available as well as on meteorological data (ECMWF Reanalysis v5 (ERA5)) such as pressure, temperature and humidity. The predictions are then validated against ZWDs from approximately 2600 additional GNSS stations. Preliminary results indicate a model accuracy characterized with a ZWD Root Mean Squared Error of approximately 18 millimeters.