

Machine learning and meteorological data for spatio-temporal prediction of tropospheric parameters

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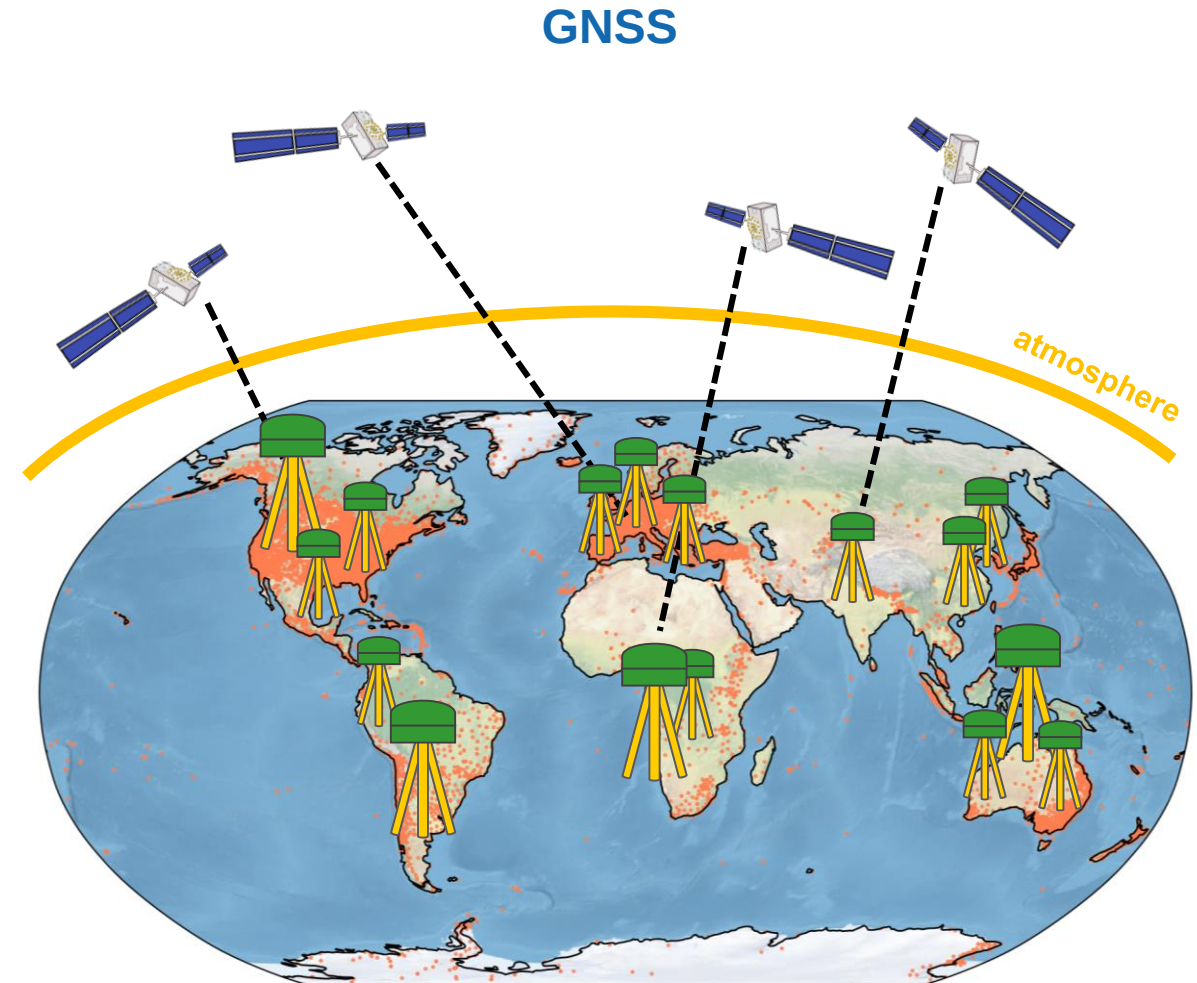
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Motivation

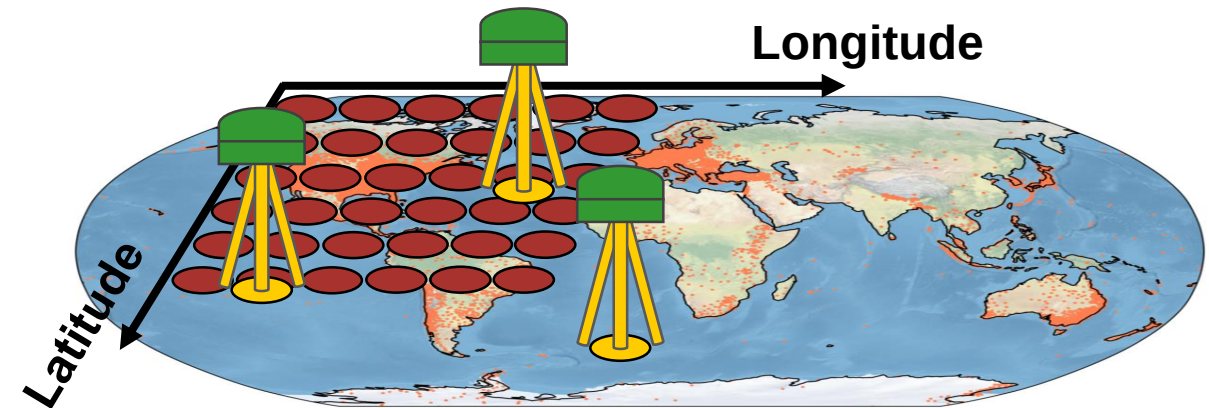
- Global Navigation Satellite System (GNSS)
 - a suitable tool for studies of the atmosphere
- Radio signals transmitted by GNSS propagate through the atmosphere – atmospheric parameters can be estimated
- Make use of thousands of GNSS stations
 - model **tropospheric parameters** based on meteorological data using Machine Learning (ML)



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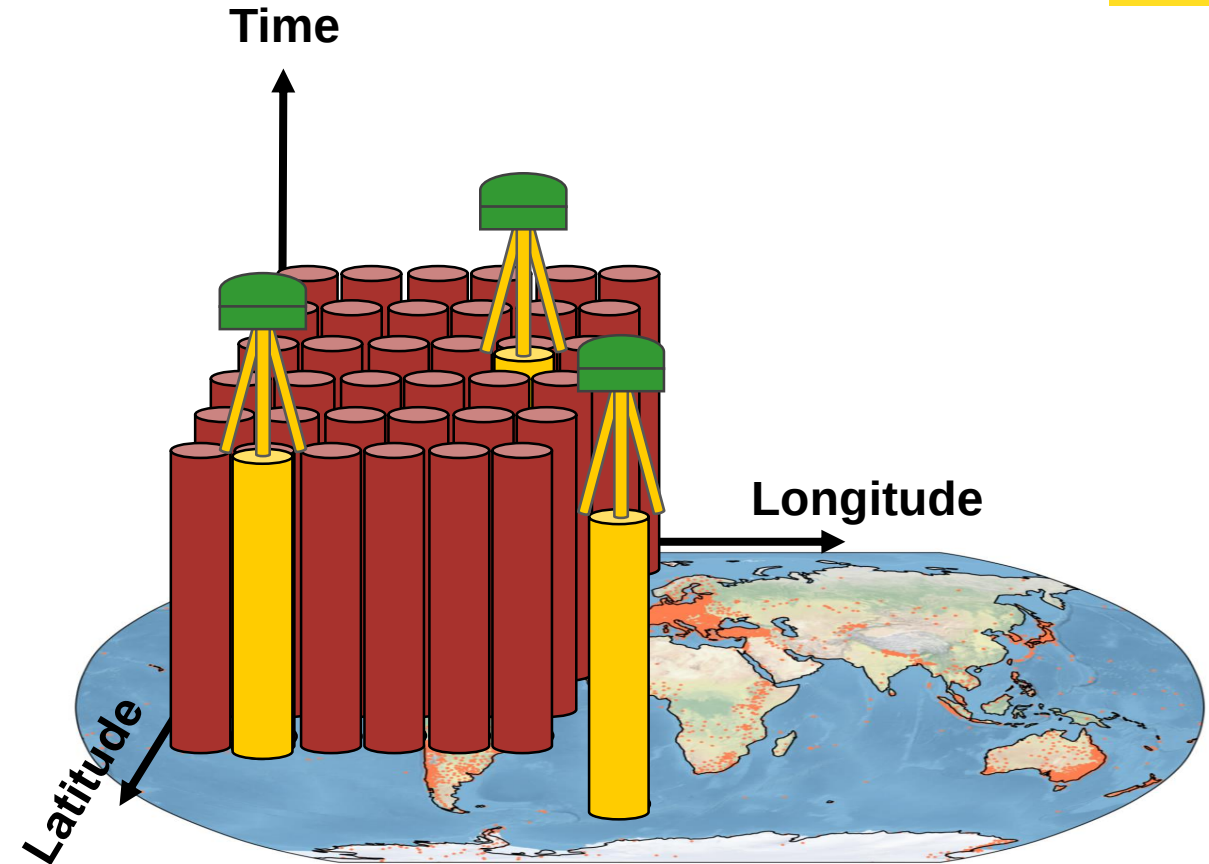
Zenith Wet Delay (ZWD)



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Zenith Wet Delay (ZWD)



Data



Zenith Wet Delay (ZWD)

- Source: Nevada Geodetic Laboratory (NGL)
 - More than 19.000 GPS stations available
- Temporal resolution: 5 min → hourly resolution
- Spatial resolution: stations distributed globally
- Time span: year 2019

Meteorological data

- Source: ECMWF ERA5
- Temporal resolution: hourly
- Spatial resolution: 0.25°
- Time span: year 2019
- Several variables:
 - Specific humidity
 - Relative humidity
 - Temperature
 - Surface pressure
 - Total precipitation
 - Geopotential
 - Wind speed

Data



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FEATURES

- Latitude
- Longitude
- Height
- Time

Data



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- Aim: predict ZWD in space (and time) using ML algorithms



Meteorological data

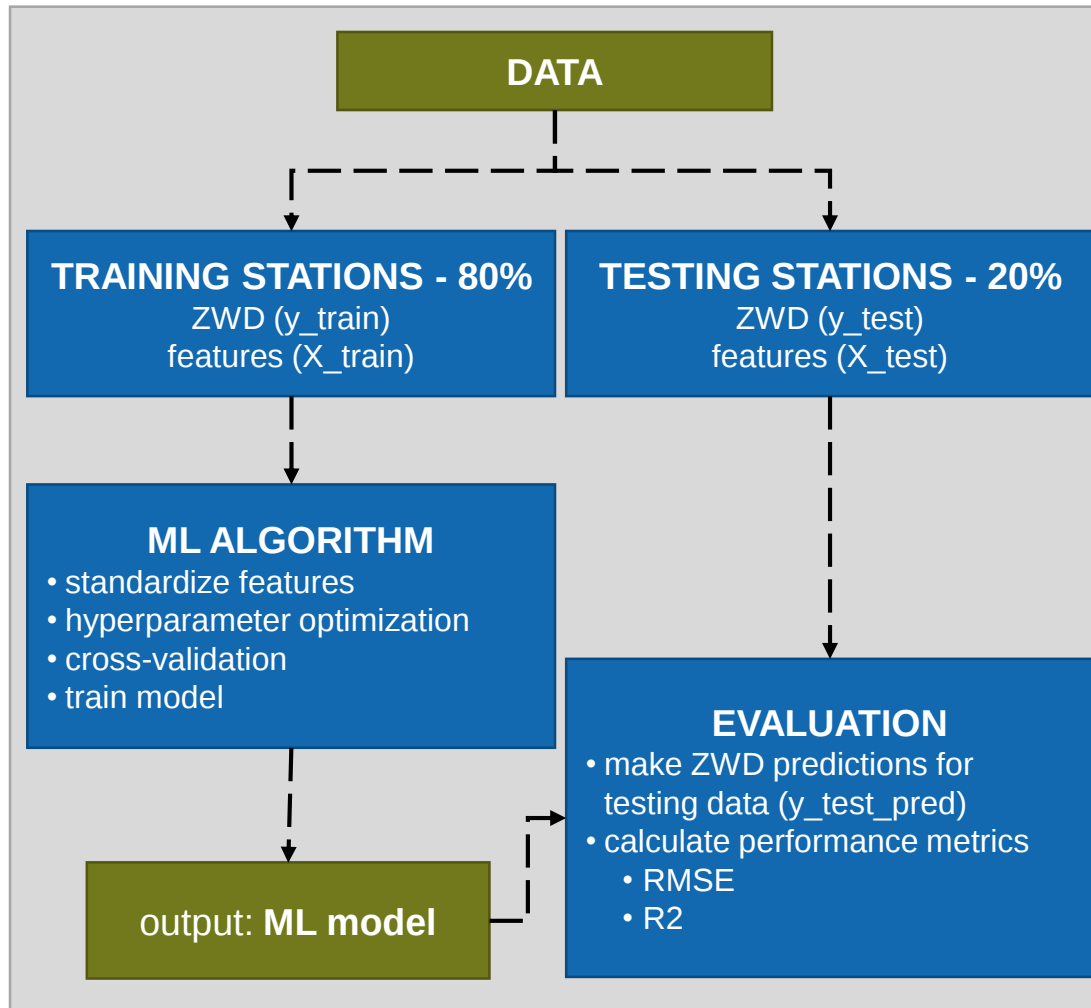
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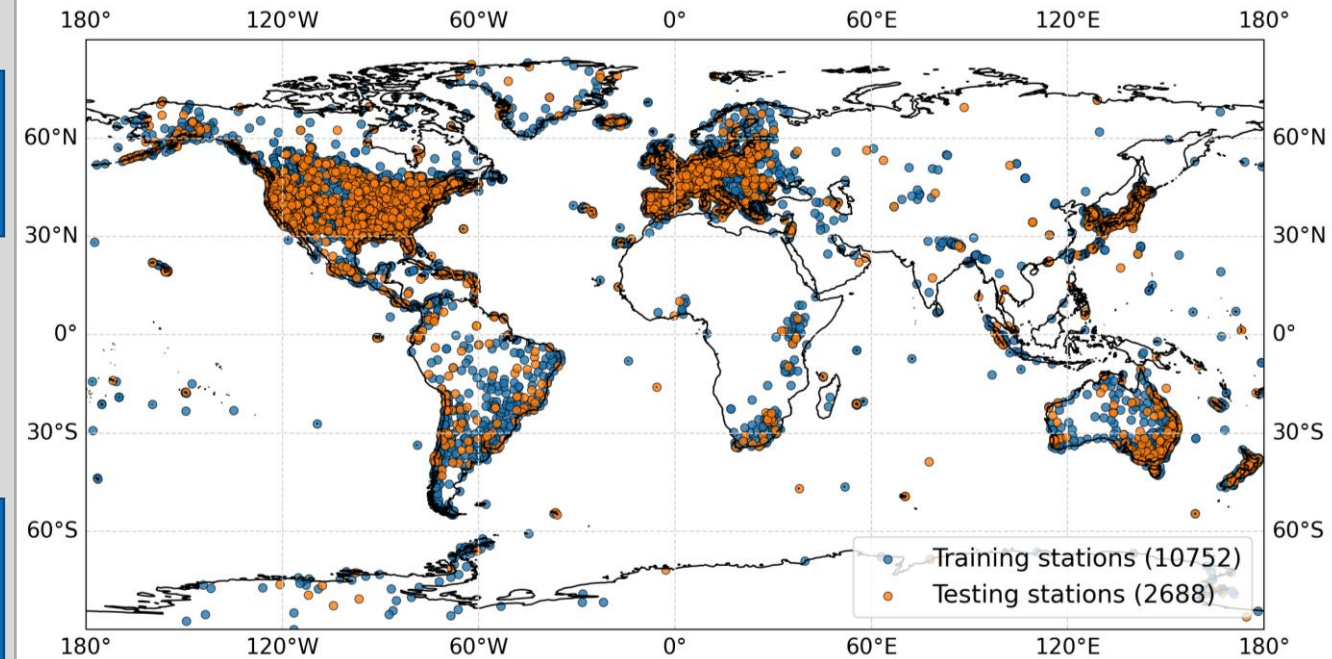
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- Height
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Setup



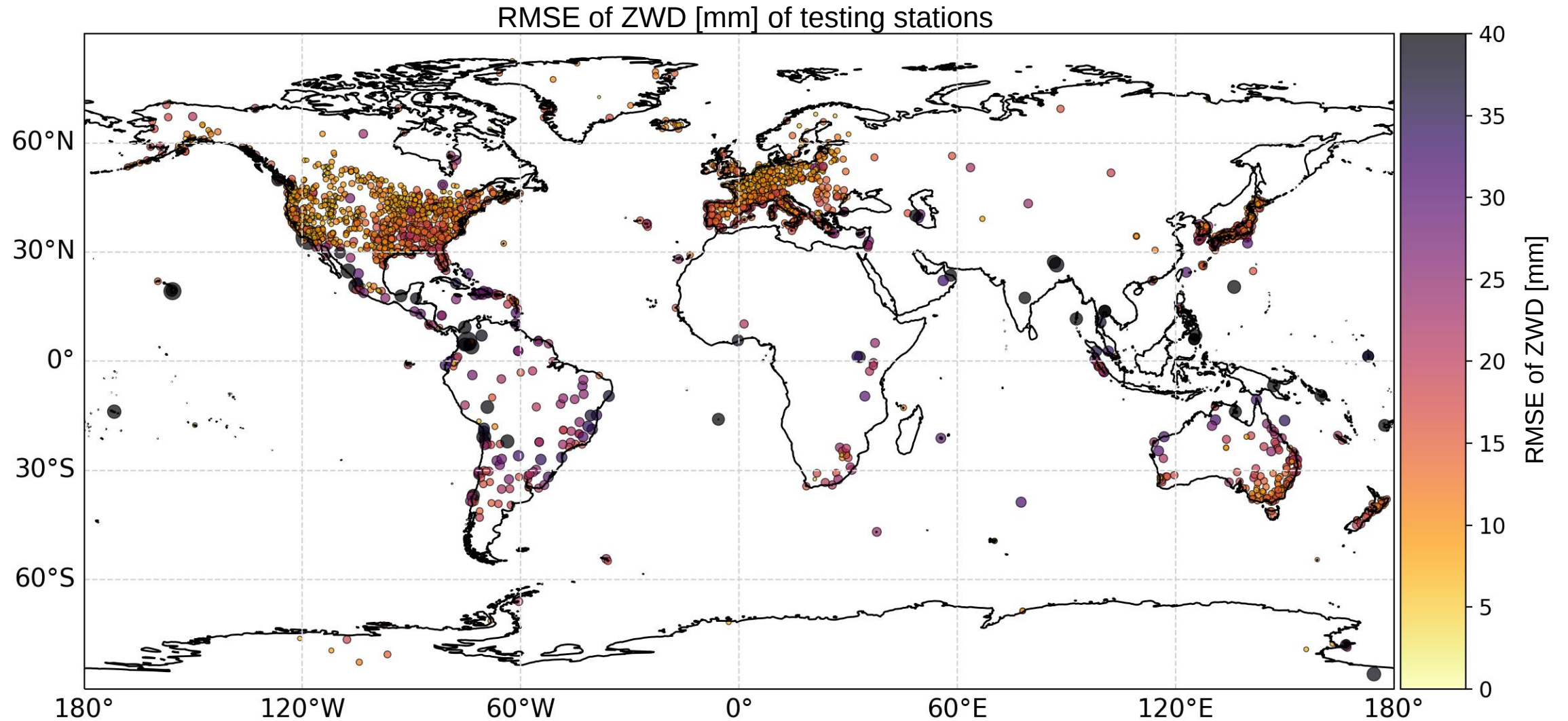
Global model for year 2019

Distribution of training and test stations for all available stations (2019)

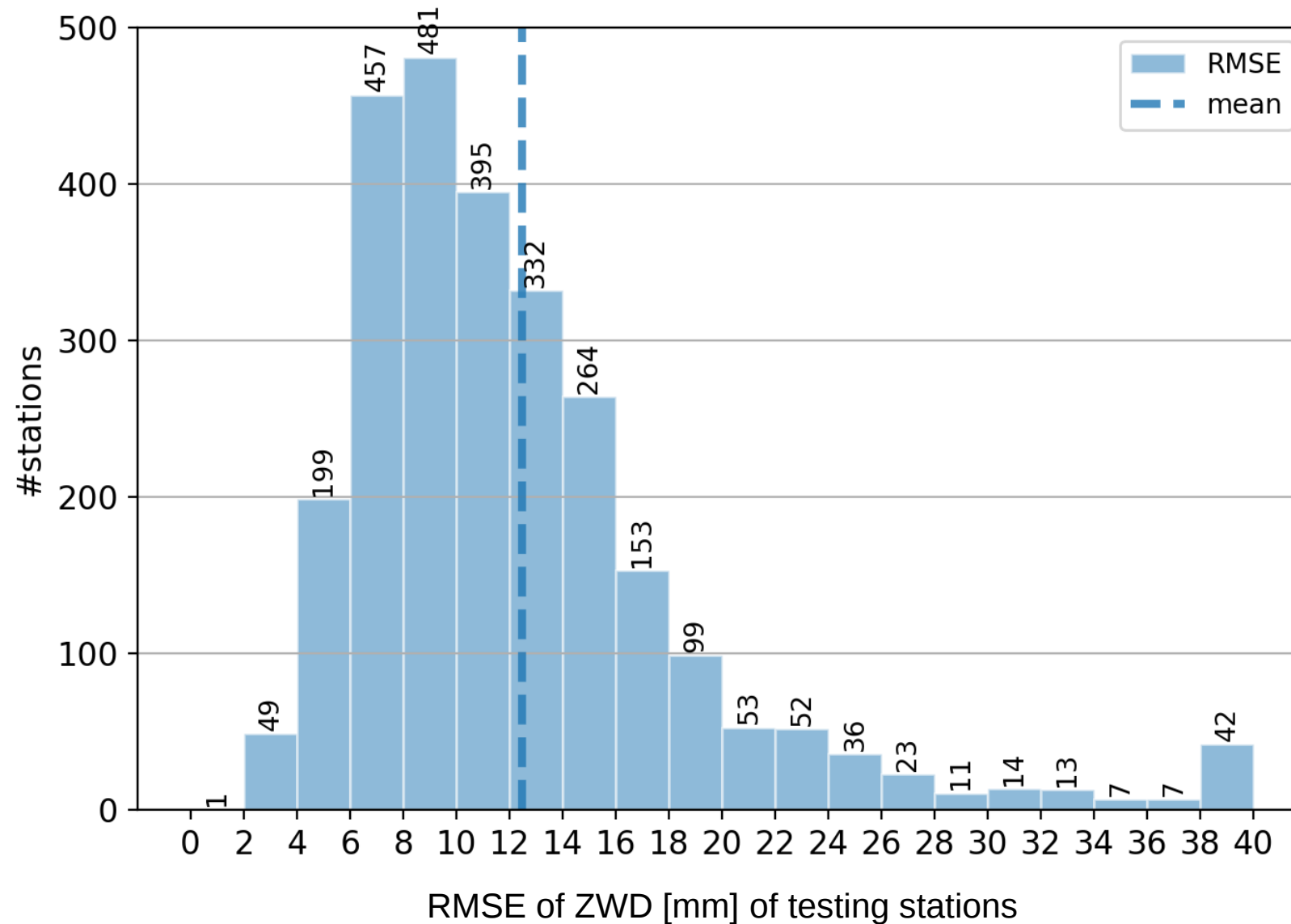


ML algorithm: **XGBoost**, Random Forest

Performance of individual test stations



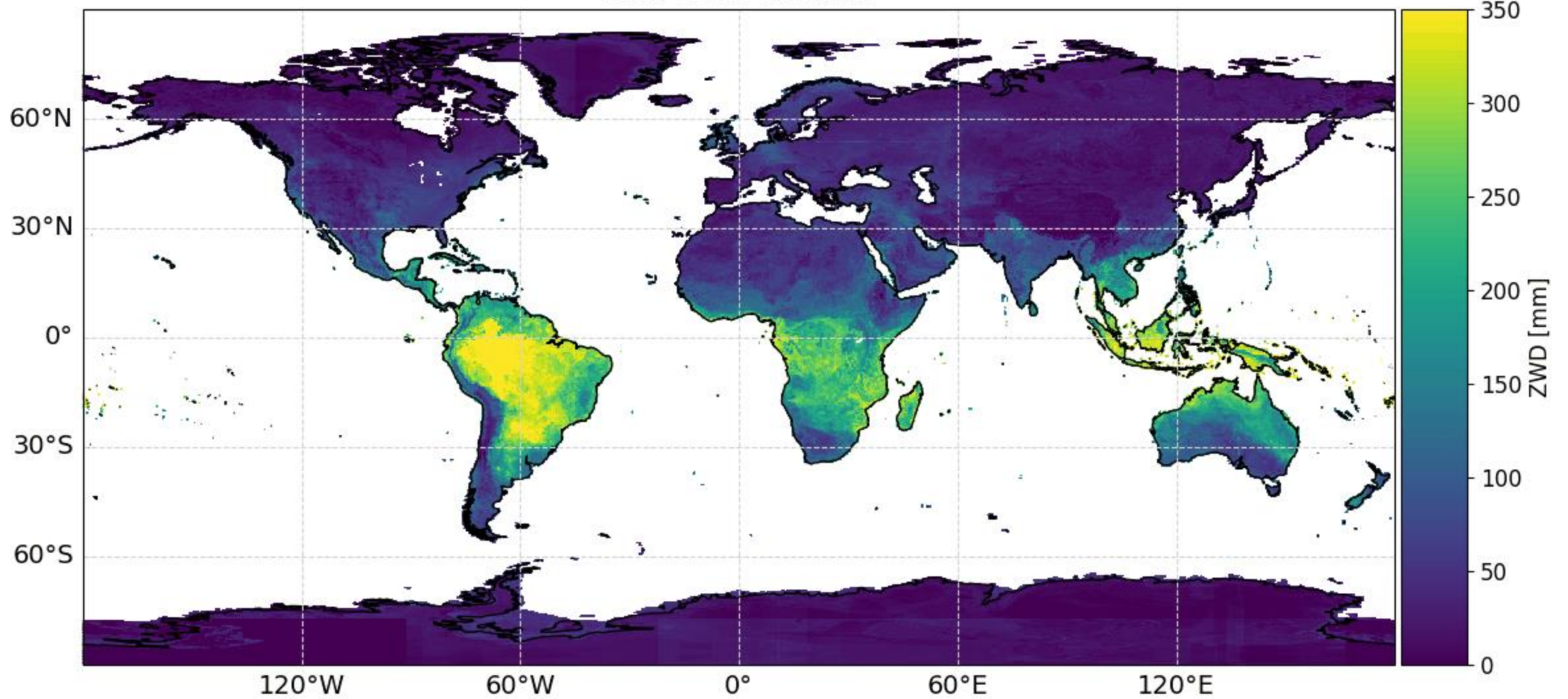
Performance of individual test stations



mean = 12.4 mm

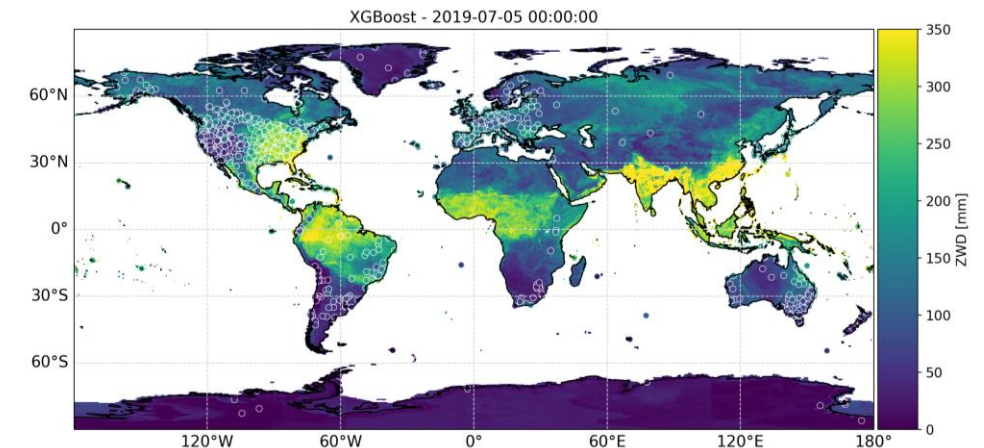
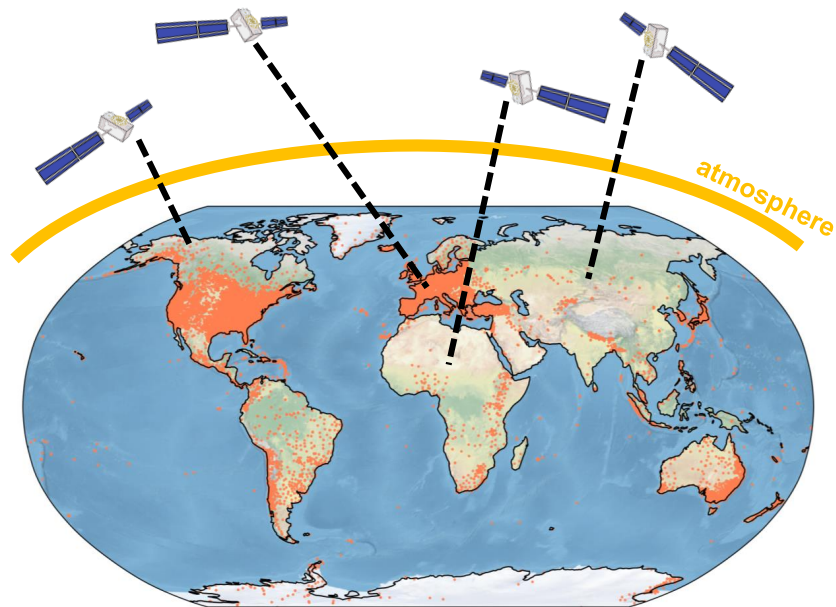
ZWD predictions for 2019

2019-01-06 00:00:00



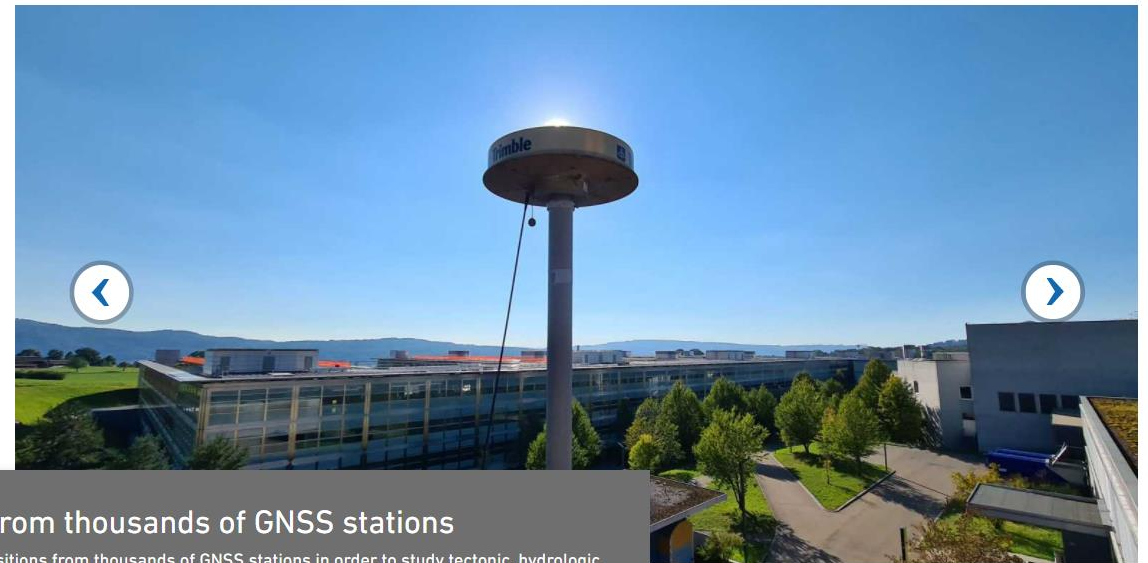
Summary

- Global ML-based ZWD model based on meteorological data
- Can make predictions of ZWD for every point on Earth (assuming meteorological data is available)
- Achieves an average RMSE of **12.4 mm**
- ML algorithms: **XGBoost** and Random Forest



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Learning from thousands of GNSS stations

We analyse the positions from thousands of GNSS stations in order to study tectonic, hydrologic and other geophysical effects with machine learning.

