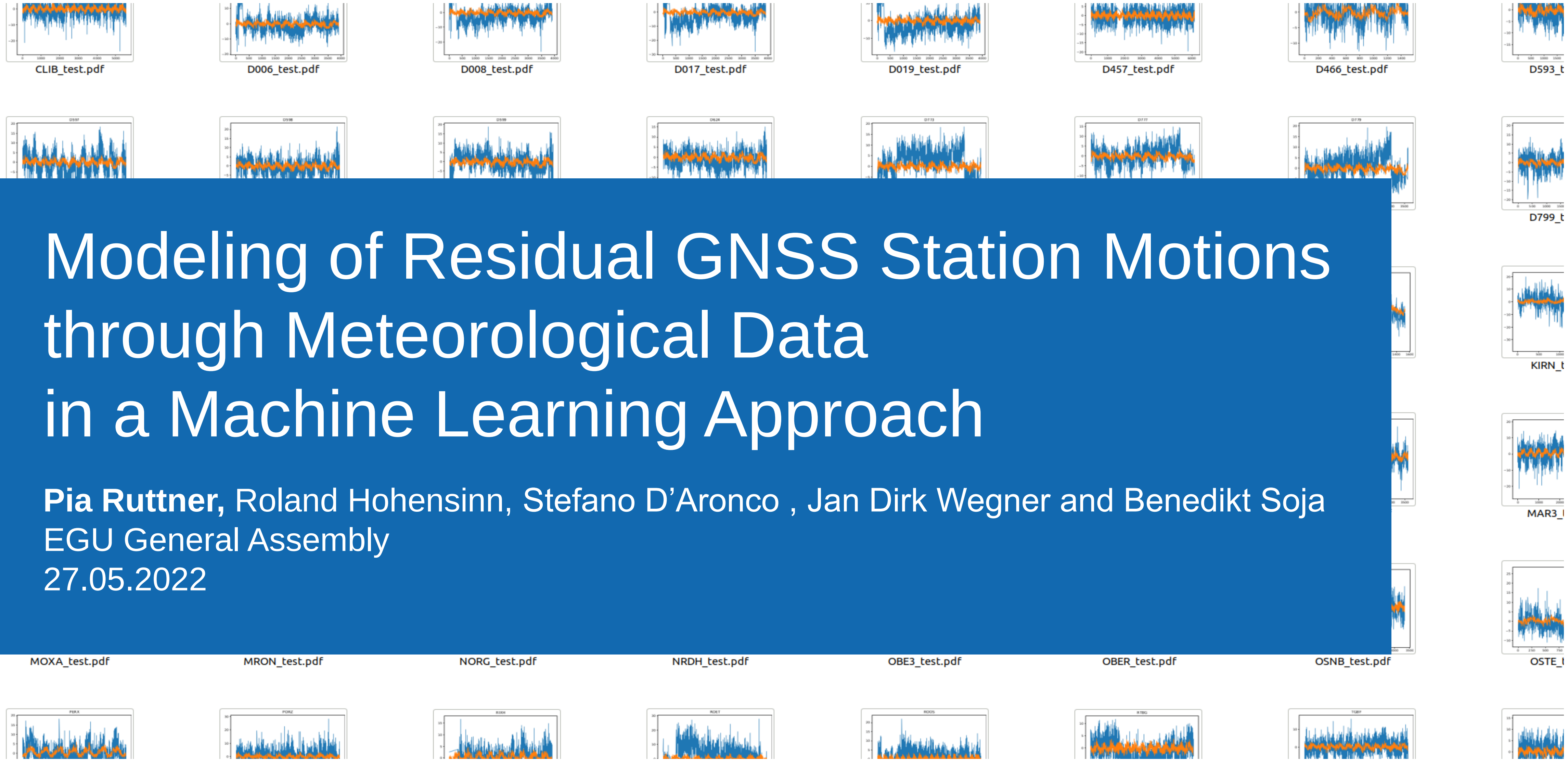

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Modeling of Residual GNSS Station Motions through Meteorological Data in a Machine Learning Approach

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Motivation & Objective

- Long-term GNSS observations
- Signals related to environmental influences

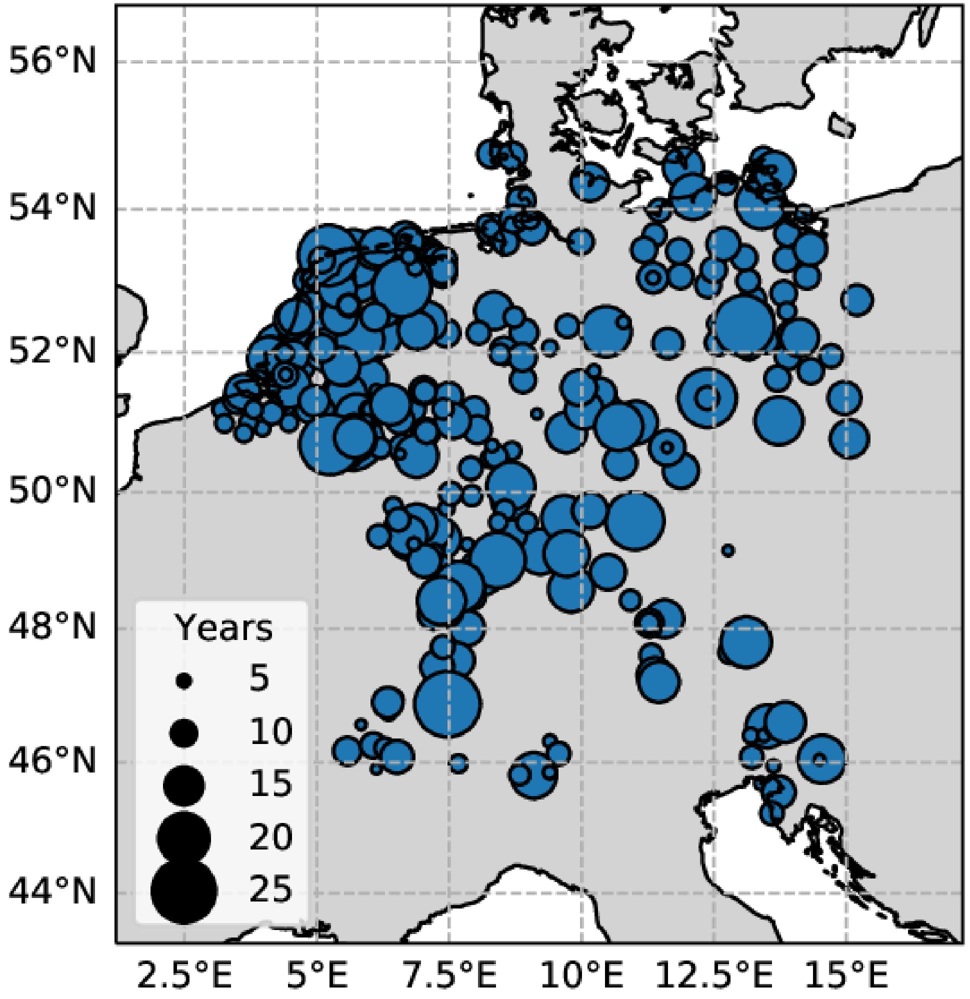
- Improve RMS of GNSS height residual time series by taking into account:
  - Environmental Loading Data (physical models)
  - Meteorological Data (Machine Learning approach)

GNSS Data - NEVADA

- Nevada Geodetic Laboratory

- Sampling: 24h
- Data Range: 01.01.1994 - 31.10.2020

- Preprocessing:
  - Remove Jumps, Outliers, linear Trend
  - min. 3.5 Years
  - max. 20% missing Data

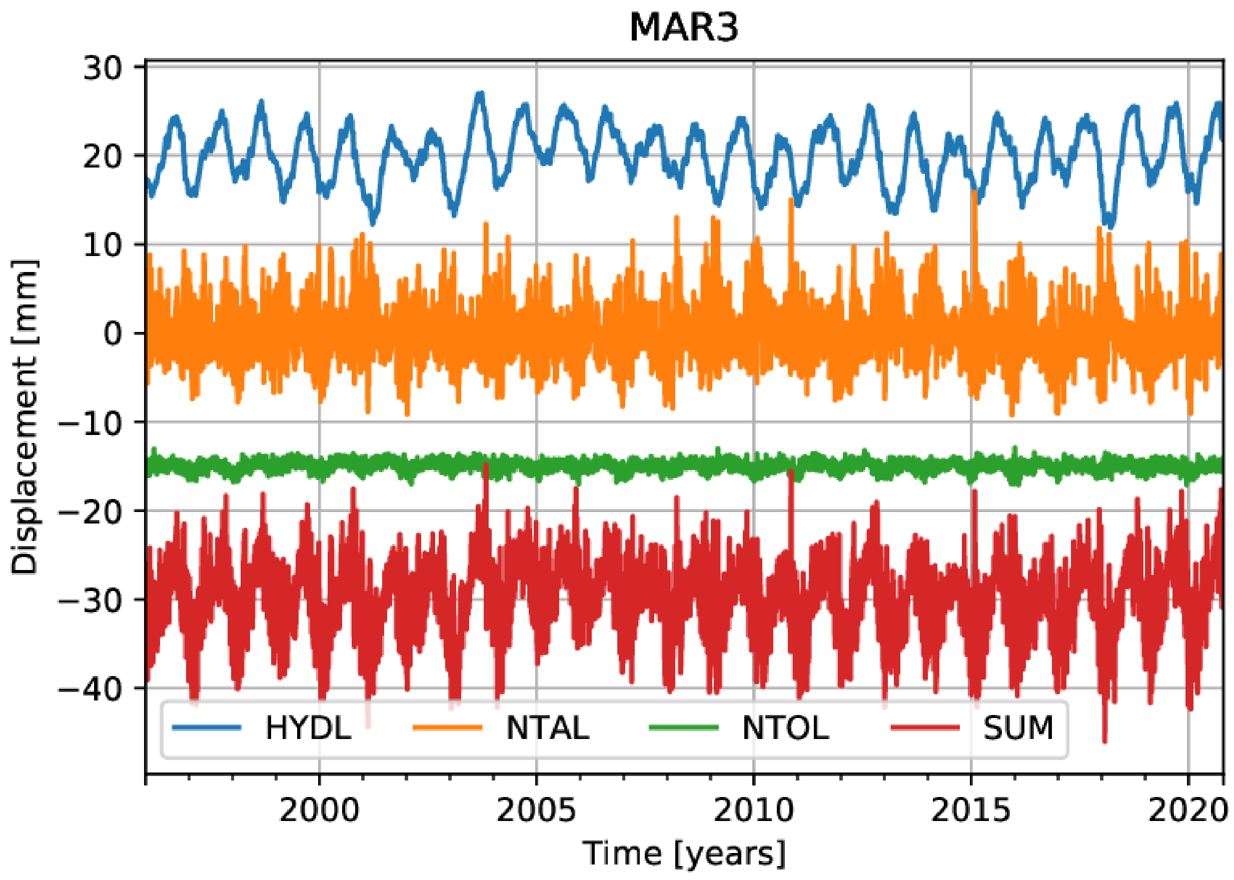


Environmental Loading Data - GFZ

- German Research Center for Geosciences

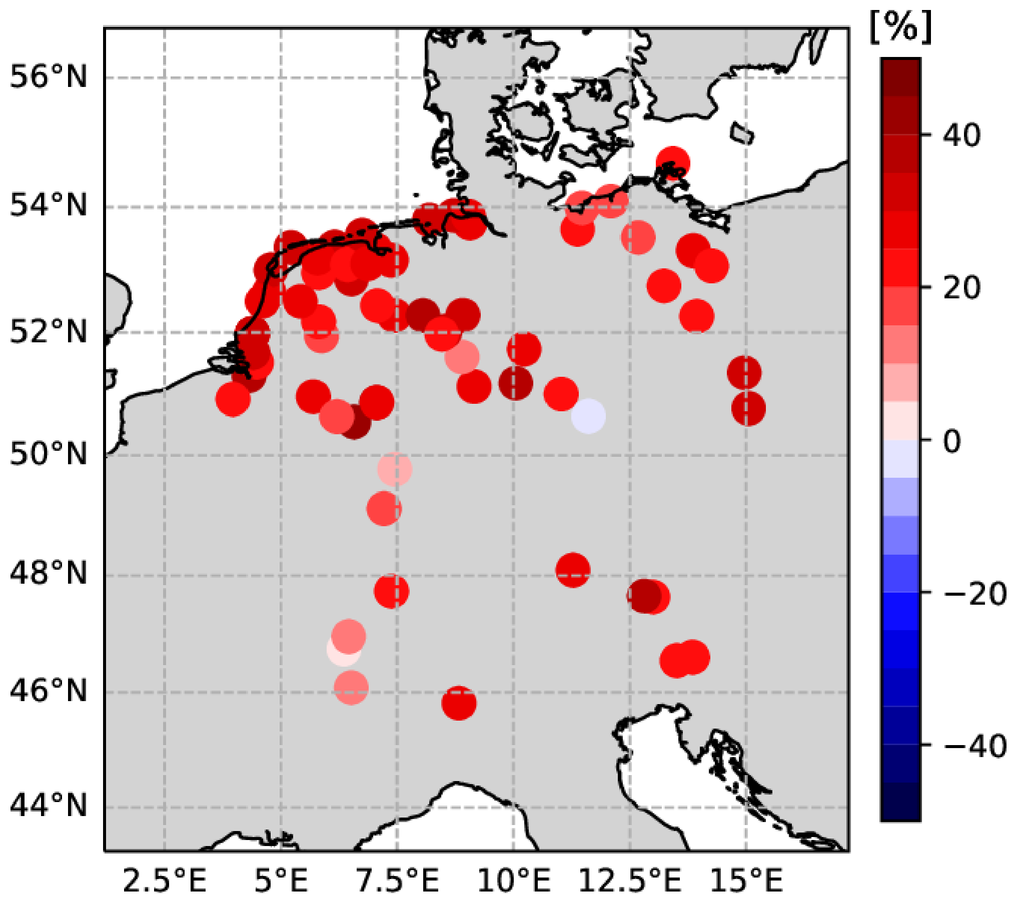
- Sampling: 24h / 3h
- 0.5° x 0.5° regular grid
- Data Range: 01.01.1996 – 19.10.2020

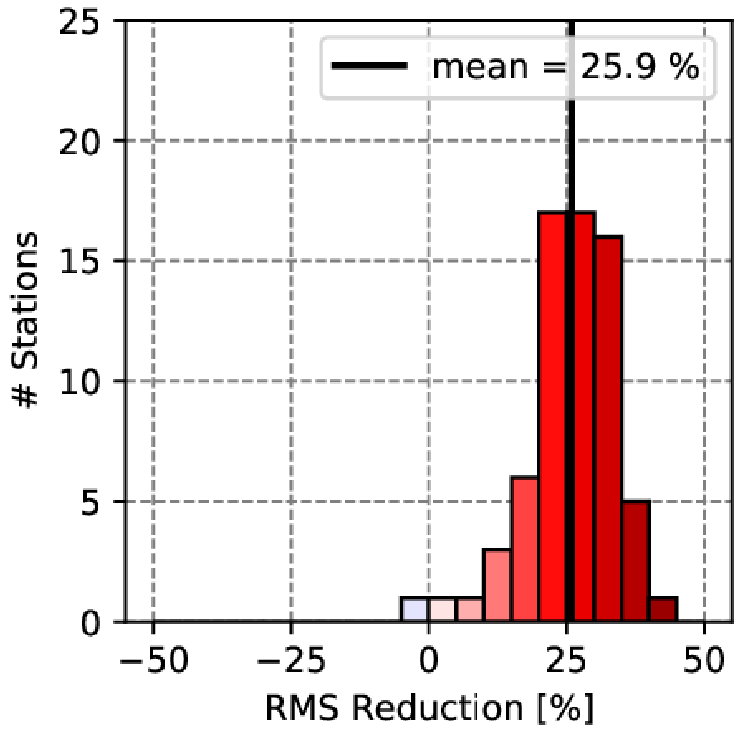
- Preprocessing:
  - Downsampling
  - Bilnear Interpolation



RMS Reduction Environmental Loadings

$$RMS\ Reduction = \left(1 - \frac{RMS(GNSS - Loading)}{RMS(GNSS)}\right)$$

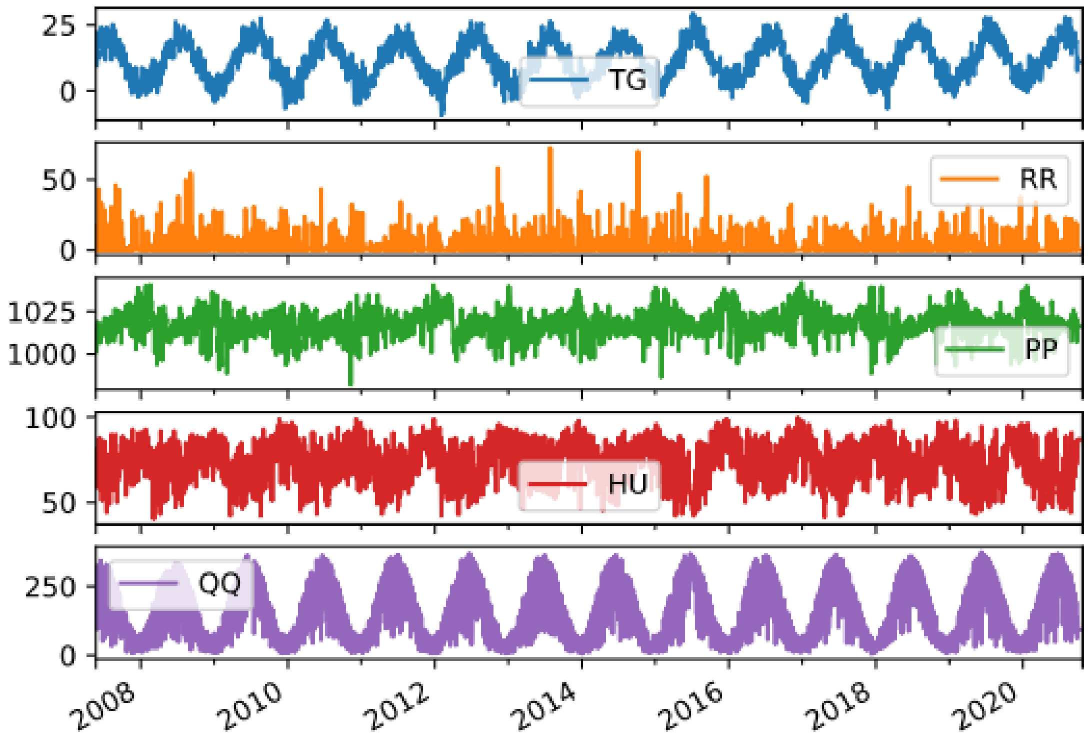




Meteorological Data - ECAD

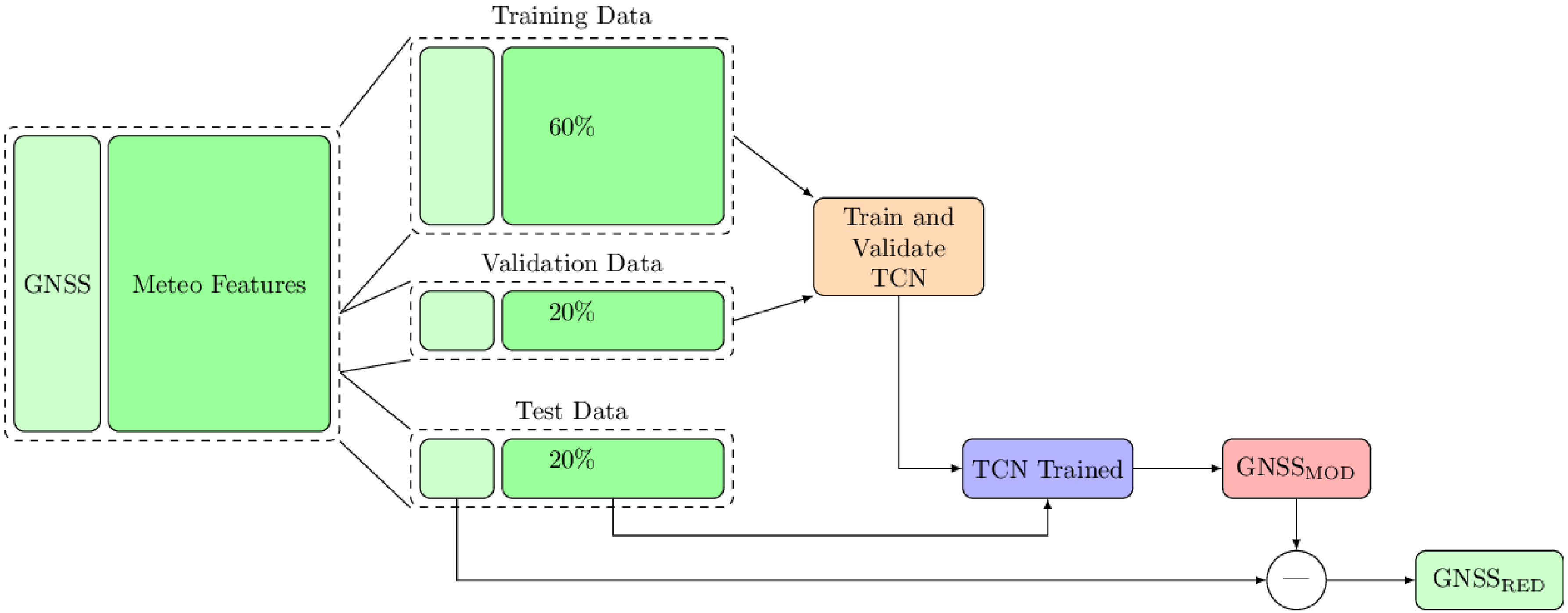
- European Climate Assessment and Dataset
  - Mean Temperature [°C] (TG)
  - Precipitation [mm] (RR)
  - Sea Level Pressure [hPa] (PP)
  - Humidity [%] (HU)
  - Radiation [W/m²] (QQ)
- Sampling: 24h
- Data Range: 01.01.1994 - 31.10.2020

MAR3



TCN training pipeline

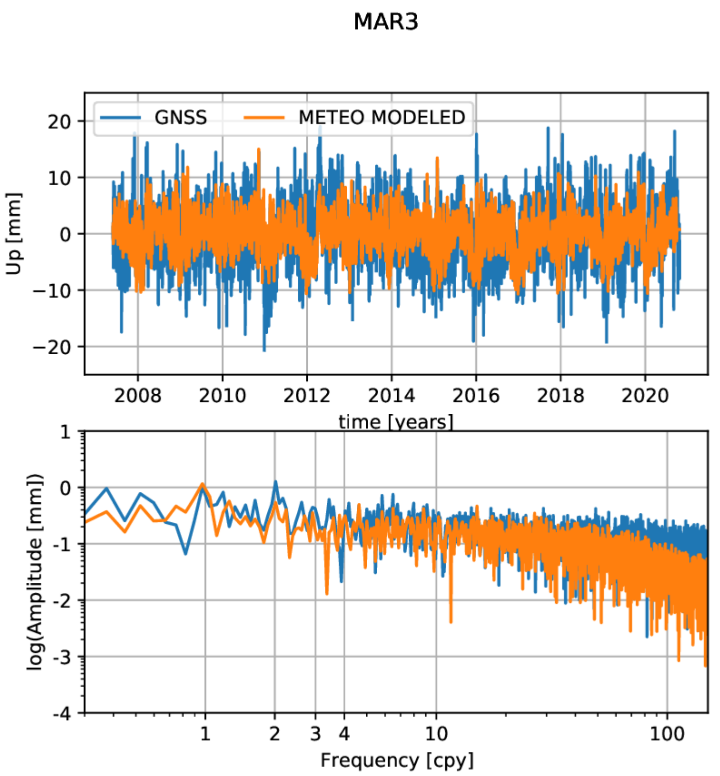
- Temporal Convolutional Neural Network
- Model GNSS height residual time series with raw meteorological data as input features

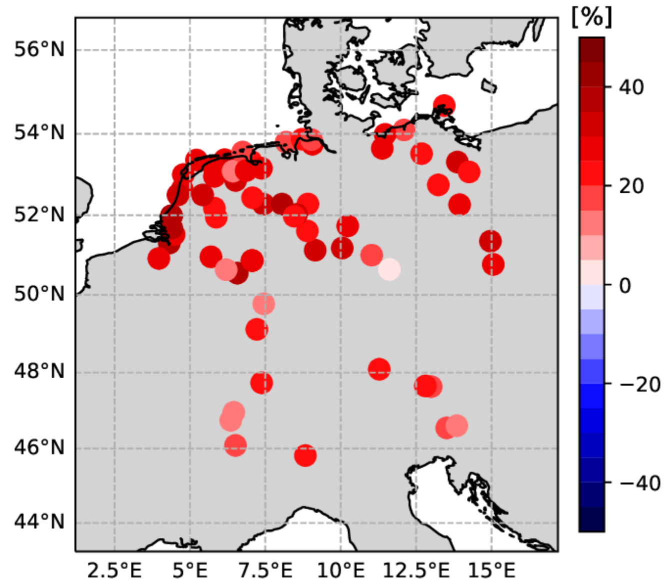


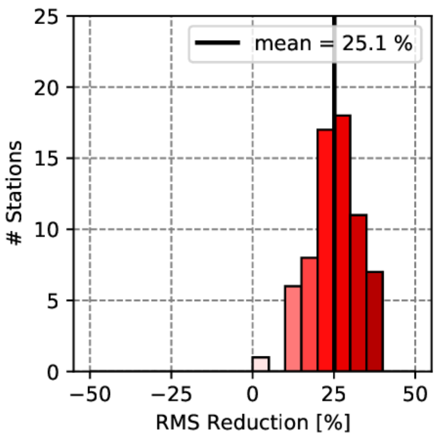
RMS Reduction TCN

- TCN trained on original GNSS height residual time series
- Result on similar level as reduction through environmental loading data

  → TCN is able to reconstruct physical models

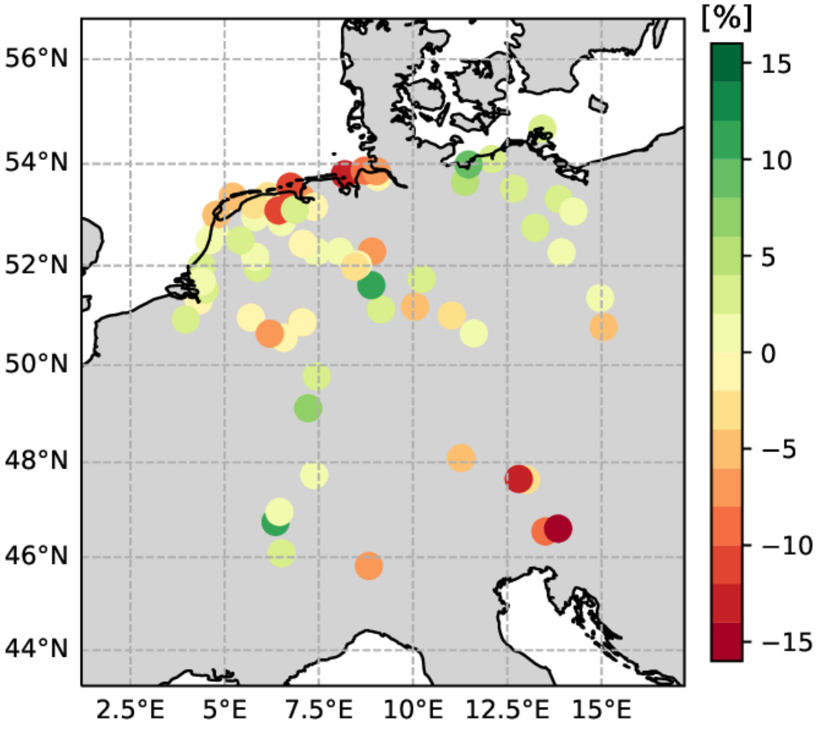


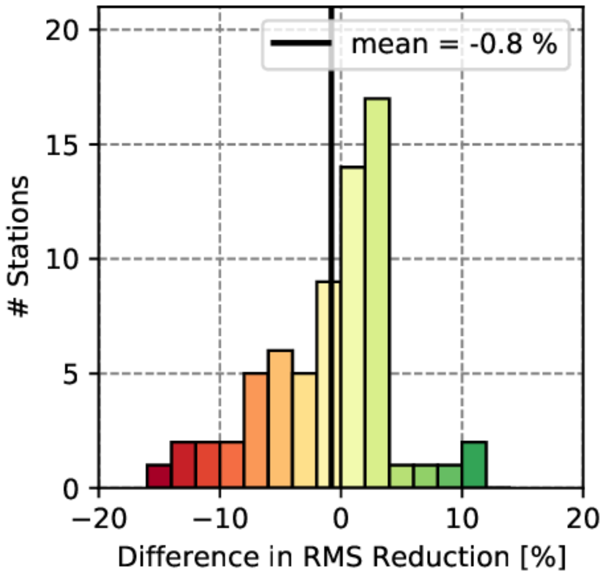




Difference in achieved RMS reductions

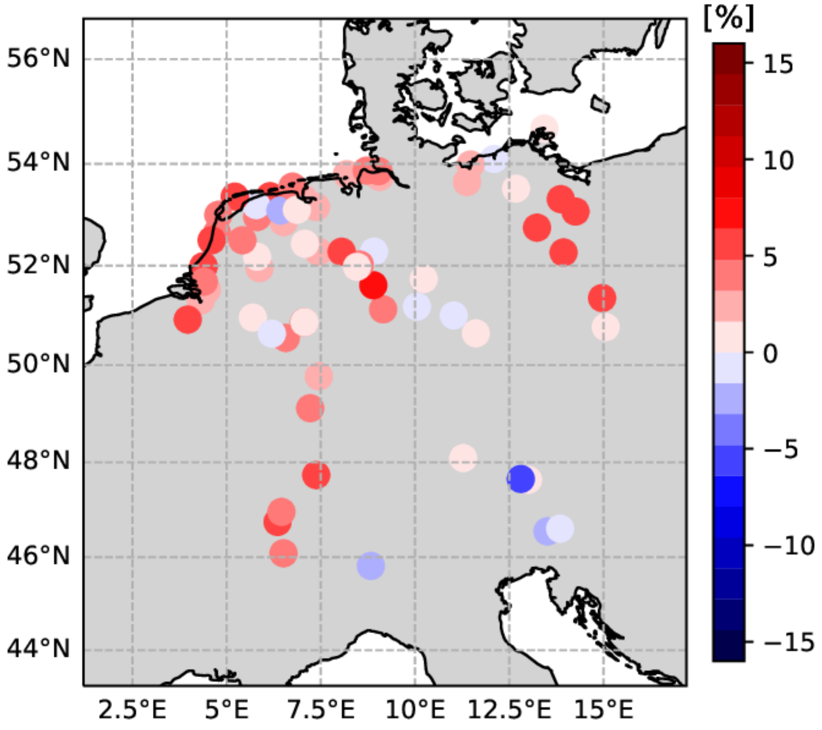
- RMS reduction rate using TCN modeled signal minus RMS reduction rate using environmental loadings
- Positive difference → TCN performed better
- Mean: slightly lower when using TCN modeled signal
- More stations with positive reduction rate when using TCN modeled signal

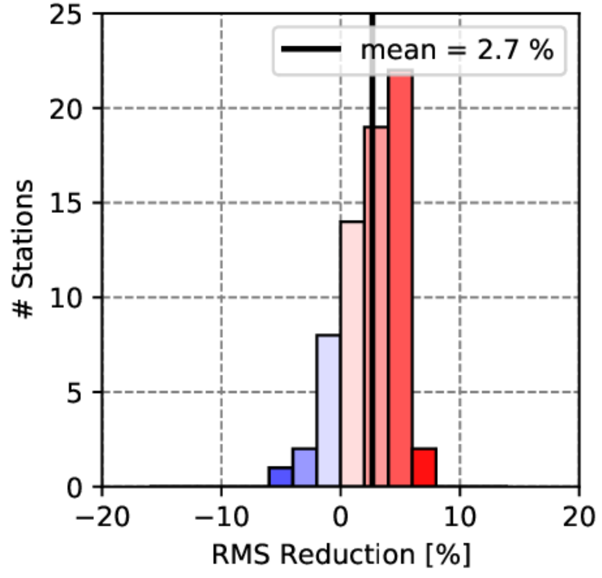




RMS Reductions TCN (reduced residuals)

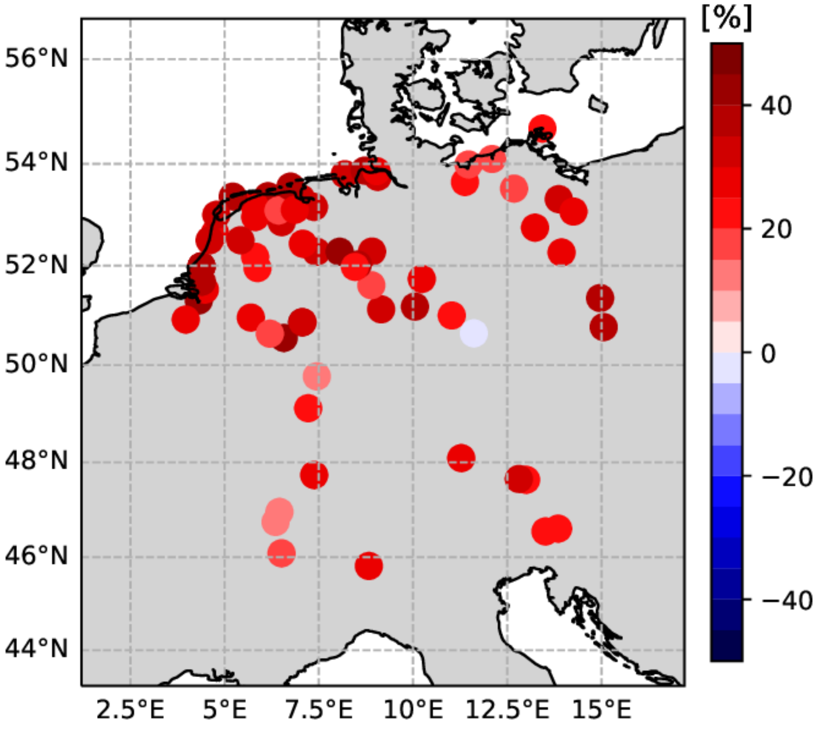
- TCN trained on reduced GNSS height residual time series (environmental loadings subtracted)
- Additional RMS reduction possible

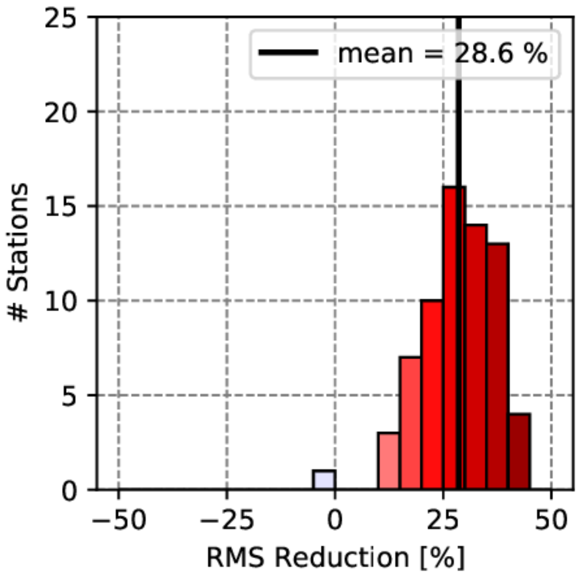




RMS Reductions Total

- Sum of RMS reductions
- Only one station slightly worse RMS after all reductions
- Overall mean reduction: 28.6%
- Max: 44 %





Take Home

- RMS reduction by environmental loadings and by TCN modeled signal using meteorological features on similar level

- Additional RMS reduction possible through TCN using meteorological data when using reduced GNSS time series (by environmental loadings)

- Potential of machine learning models for GNSS time series modeling

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