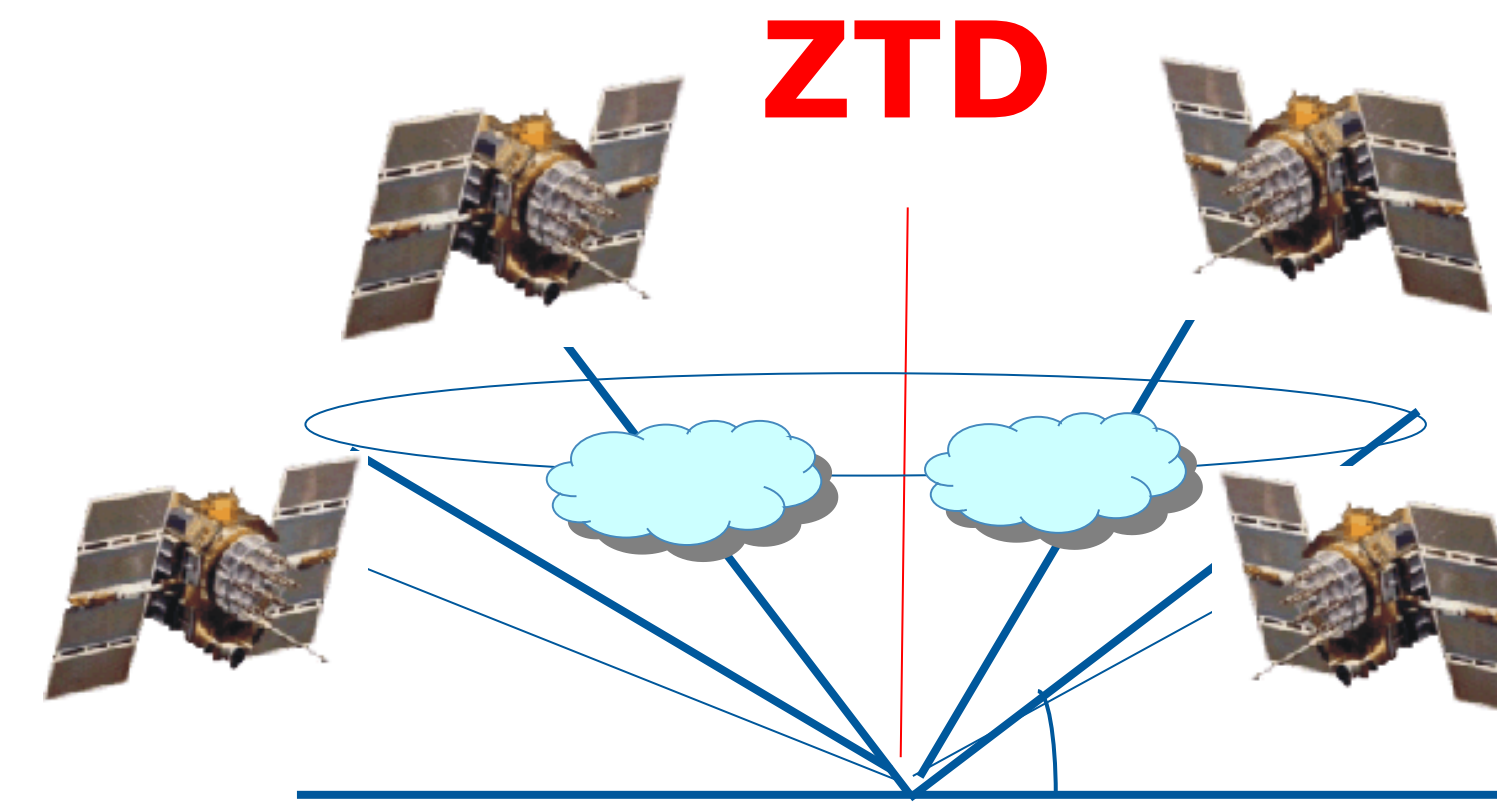


GNSS-derived Precipitable Water Vapor for Climate Research

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$$PWV = PWV(ZTD, T, p)$$



Why GNSS for atmospheric water vapor?

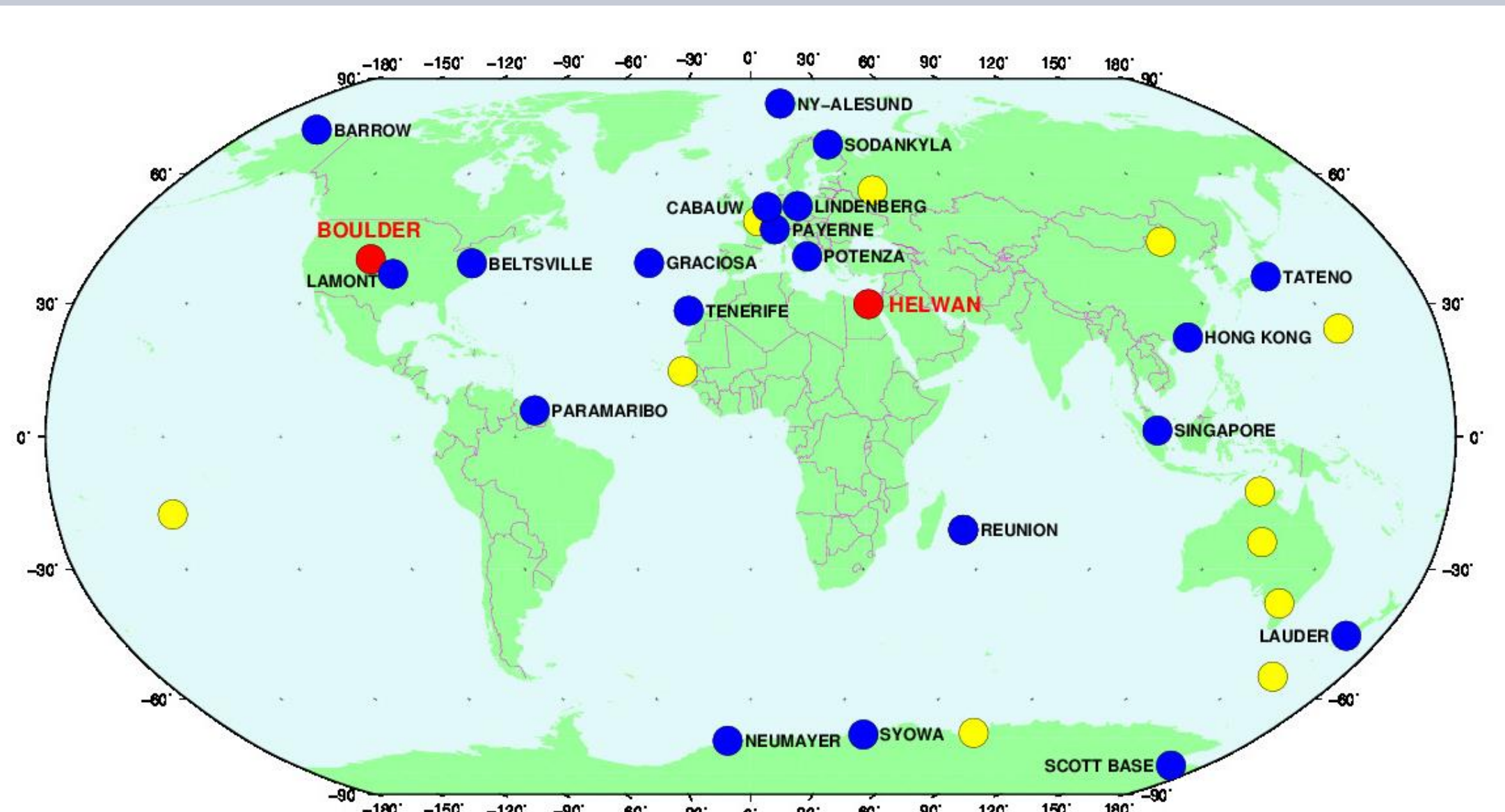
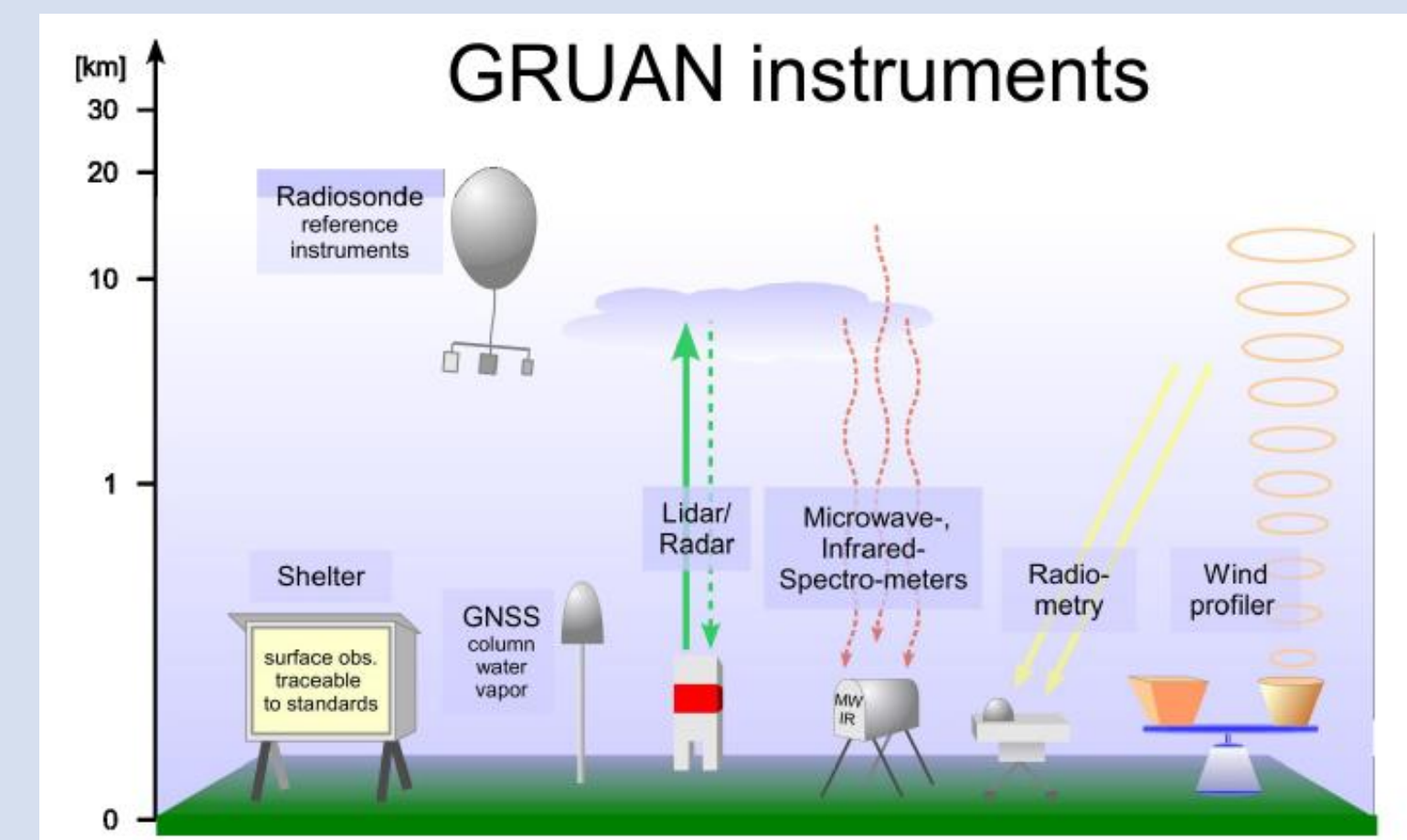
- High resolution in space and time, all-weather capability, low costs
- High accuracy (about 1mm) of derived precipitable water vapor (PWV), comparable with measurements by meteorological instruments like radiosondes (RS), water vapor radiometers (WVR) and others
- Long-term stability, continuous time series, water vapour trends with mm accuracy for climate research



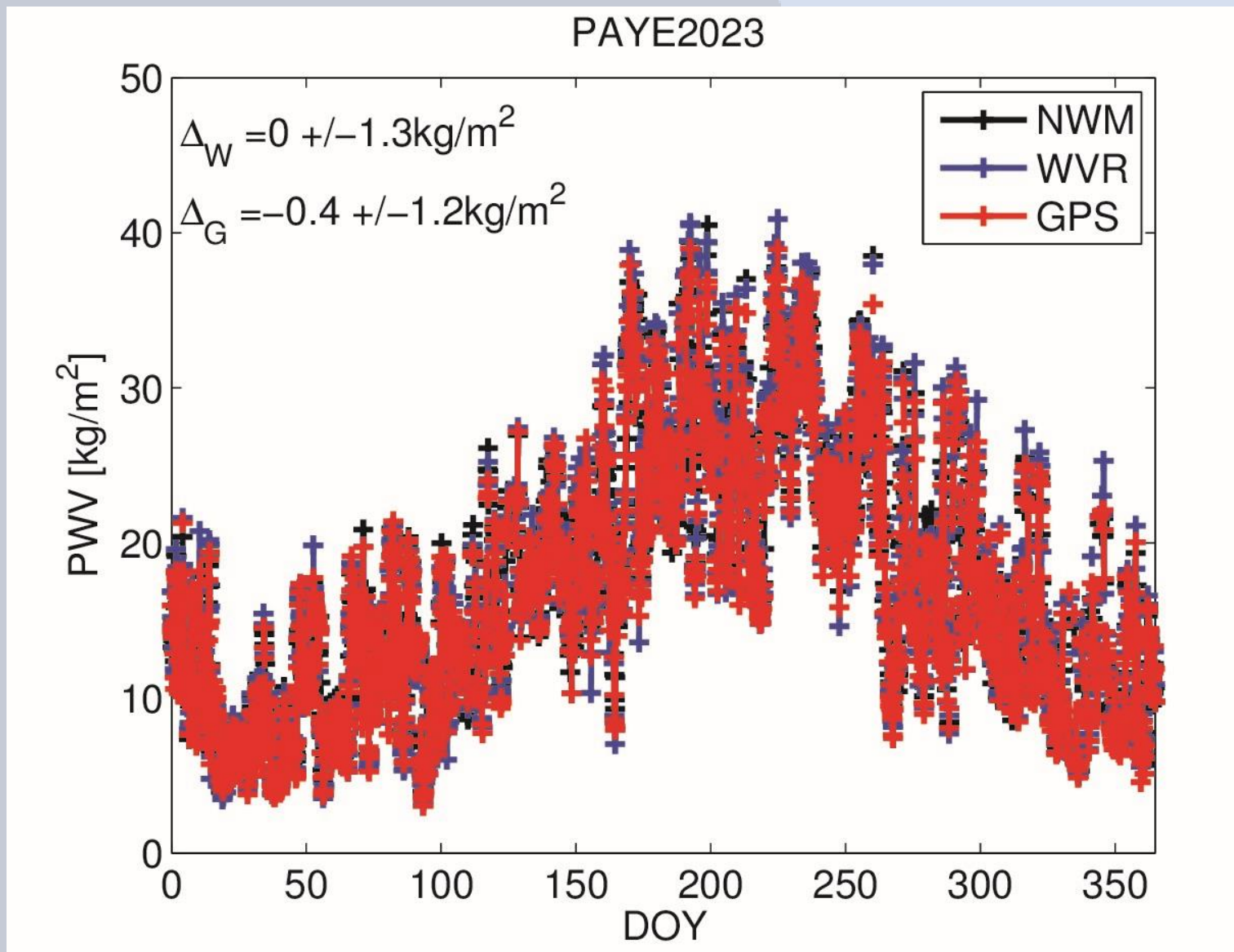
Global Climate Reference Network GRUAN www.gruan.org



- **GRUAN**: Global Climate Observing System (GCOS) Reference Upper-Air Network for ground-based **reference** observations of the atmosphere for **climate** in the frame of GCOS (WMO)
- **GRUAN measurements**: temperature, pressure, upper-air water vapor
- **GNSS is priority number one** technique for water vapor monitoring
- **Central Processing Centre** for GNSS-PWV established at GFZ
- **Certification** of GFZ GNSS-PWV products as GRUAN Data Product on-going



GRUAN GNSS Stations Network
20 GNSS stations in PWV processing (blue)
2 new stations planned (red)
In yellow GRUAN sites without GNSS



Validation of GNSS-PWV with Water Vapor Radiometer for GRUAN station Payerne, (Switzerland) for 2023

SITE ID	BIAS (mean -0.34/-0.52 kg/m ²)	STDDEV (kg/m ²)
Graciosa	+ 0.48 -0.94	+/- 1.83 1.50
Lindenberg	- 0.99 -1.17 LINDO	+/- 1.07 1.22
Lauder	- 0.54 -0.12	+/- 1.52 3.52
Ny Alesund	- 0.27 -0.43	+/- 0.57 0.64
Payerne	- 0.36 -0.57	+/- 1.18 1.01
Lamont	- 0.21 -0.67	+/- 1.72 1.19
Singapore	- 0.65 -1.39	+/- 1.34 1.56
Sodankylä	+ 0.27 +0.18 SODA	+/- 0.70 0.73
Barrow	- 0.81 -0.93	+/- 0.70 0.69

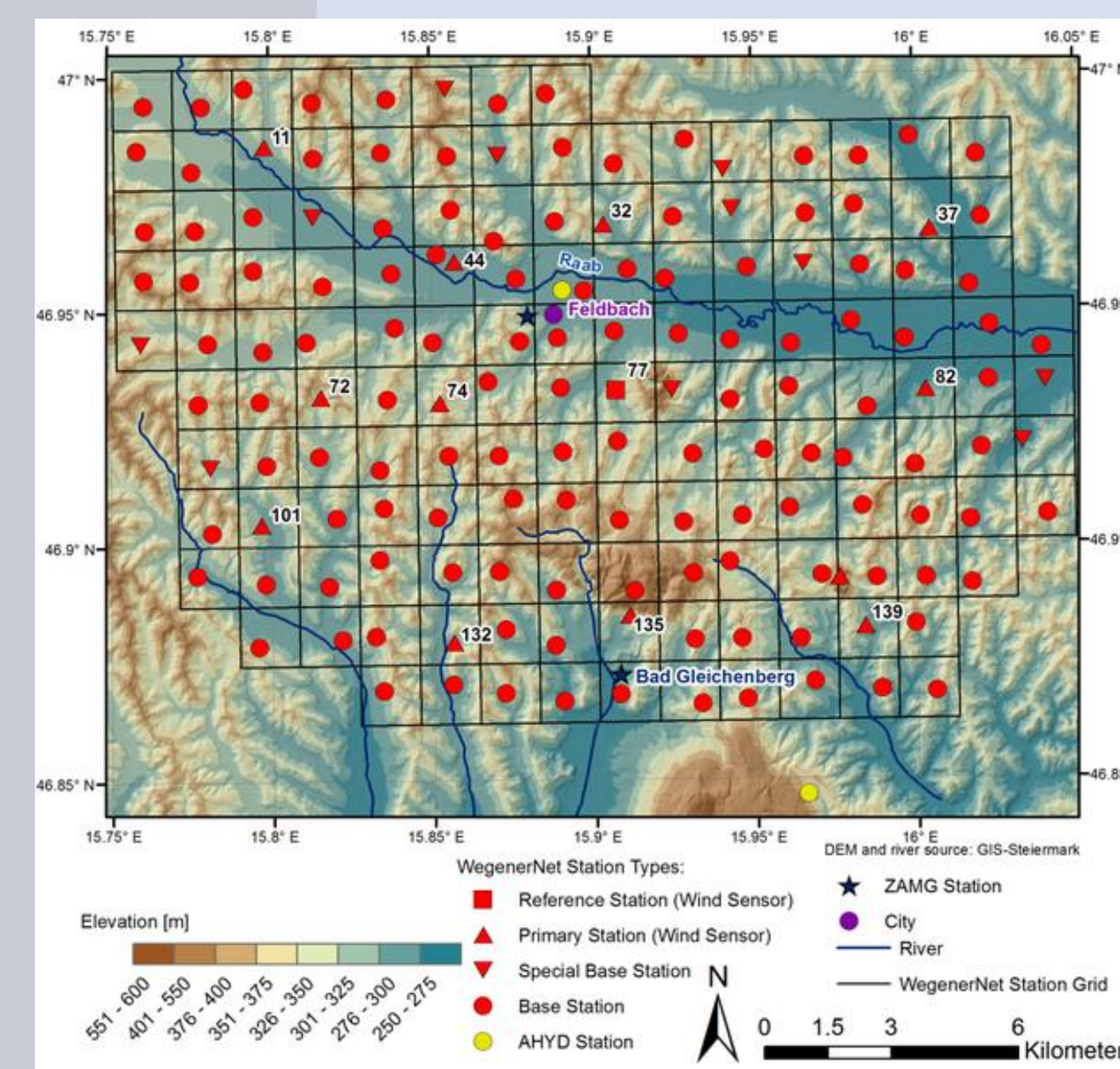
Validation of GNSS-PWV with Numerical Weather Model ERA5 and Radiosondes RS41 for GRUAN stations Table shows bias and stddev of GNSS-PWV minus ERA5 (blue) and RS41 (red) for 2021



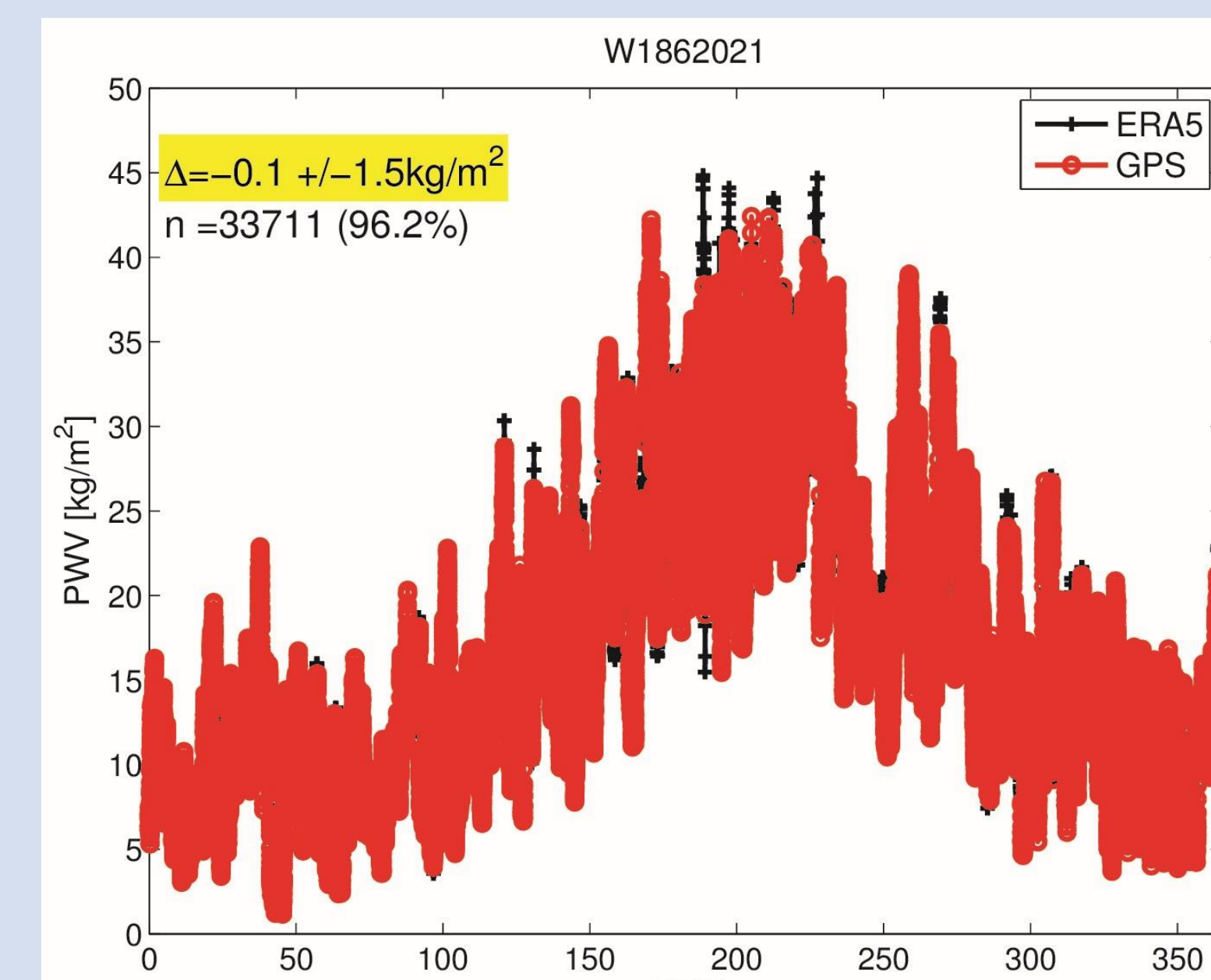
Regional Climate Station Network WegenerNet https://wegcenter.uni-graz.at



- Climate Station Network of Wegener Center of University Graz, Austria
- Comprised of over 150 meteorological stations, region Feldbach in South-Eastern Styria
- The measurements of temperature, humidity, precipitation and further parameters have been taken in 5-min intervals in the entire grid since Jan 1, 2007
- For the first time such a dense dataset covers more than one and a half decades
- 6 GNSS receivers installed on selected WegenerNet sites in 2020
- Automated GNSS-PWV processing at GFZ



WegenerNet Stations Network



Validation of GNSS-PWV with Numerical Weather Model ERA5 for WegenerNet site w186 (Feldbach, Austria) for 2021

References:

Dick, G., Zus, F., Wickert, J., Männel, B., Ramatschi, M. (2024): GNSS Precipitable Water Vapour for Climate Monitoring - Abstracts, EGU General Assembly 2024 (Vienna, Austria and Online 2024).
https://doi.org/10.5194/egusphere-egu24-11213