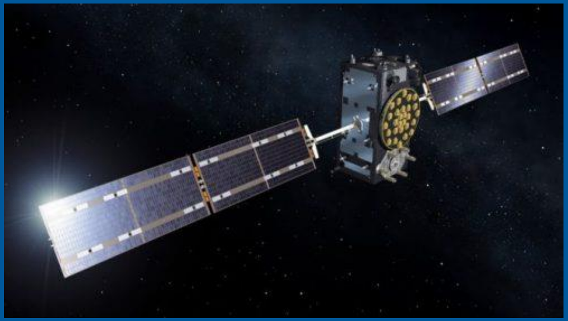


GNSS Processing Center at GFZ: Current Status of GNSS-PW GDP

Galina Dick

Florian Zus, Markus Bradke, Markus Ramatschi, Eric am Mihr, Benjamin Männel, Jens Wickert

GFZ Helmholtz Centre for Geosciences, Potsdam, Germany

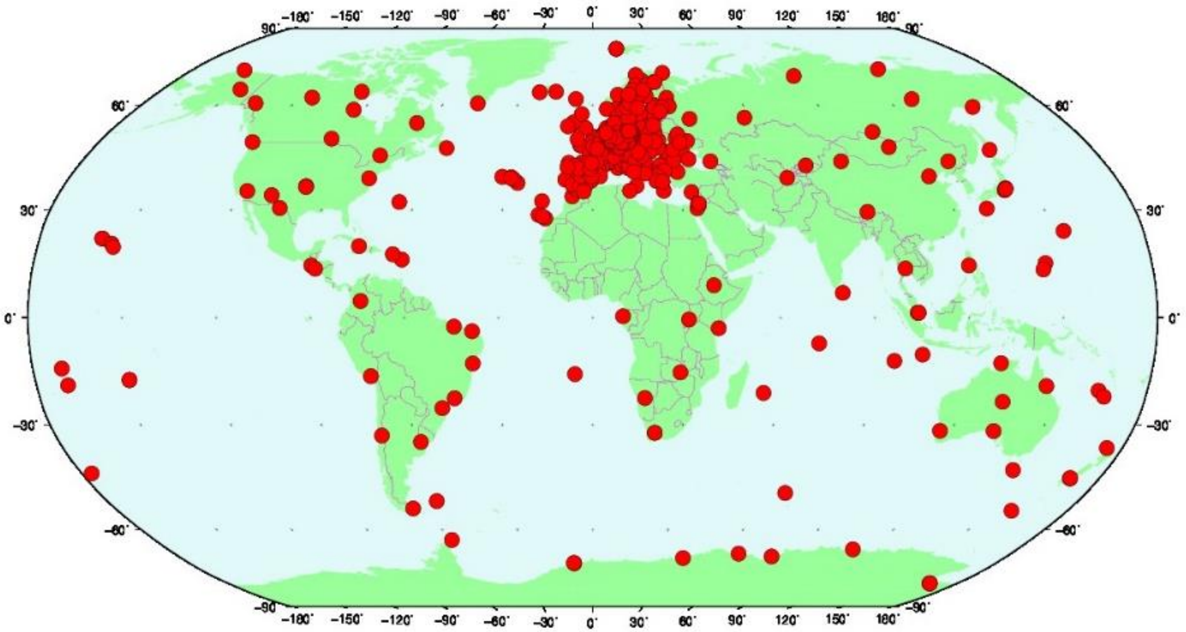
GRUAN ICM16
November 17-21, 2025, Puerto de la Cruz, Tenerife, Spain

GFZ Helmholtz Centre for Geosciences

HELMHOLTZ

GNSS Data Processing at GFZ

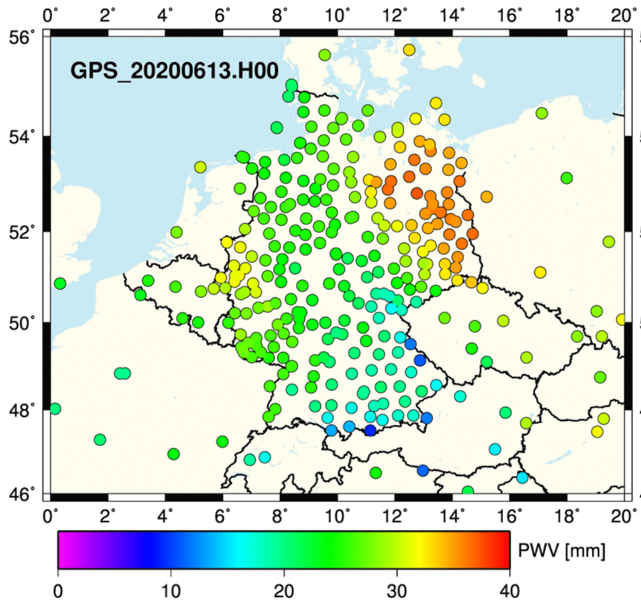
- Automatic processing of **hourly GNSS** data since 2000 **(24/7)**
- **GFZ EPOS.P8** in house software
- ~600 stations in processing (German SAPOS + EUREF + IGS + GRUAN)
- **All types of tropospheric products:**
  - ZTD/PWV/gradients with 15 min. time resolution
  - STD with 2.5 min. time resolution
- Time delay **< 15 minutes** after the end of each hour (**near real-time**)



GNSS-PW: Applications

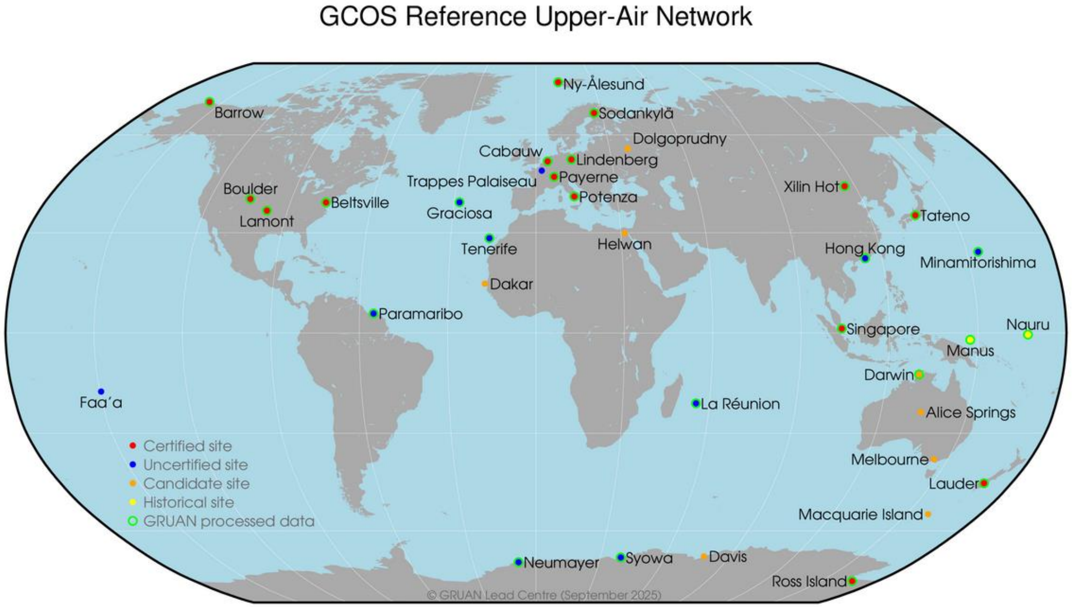
Near Real-Time

Weather Forecast:
GFZ GNSS products are used by European Weather Services for operational weather forecast (E-GVAP)



Post-Processing/REPRO

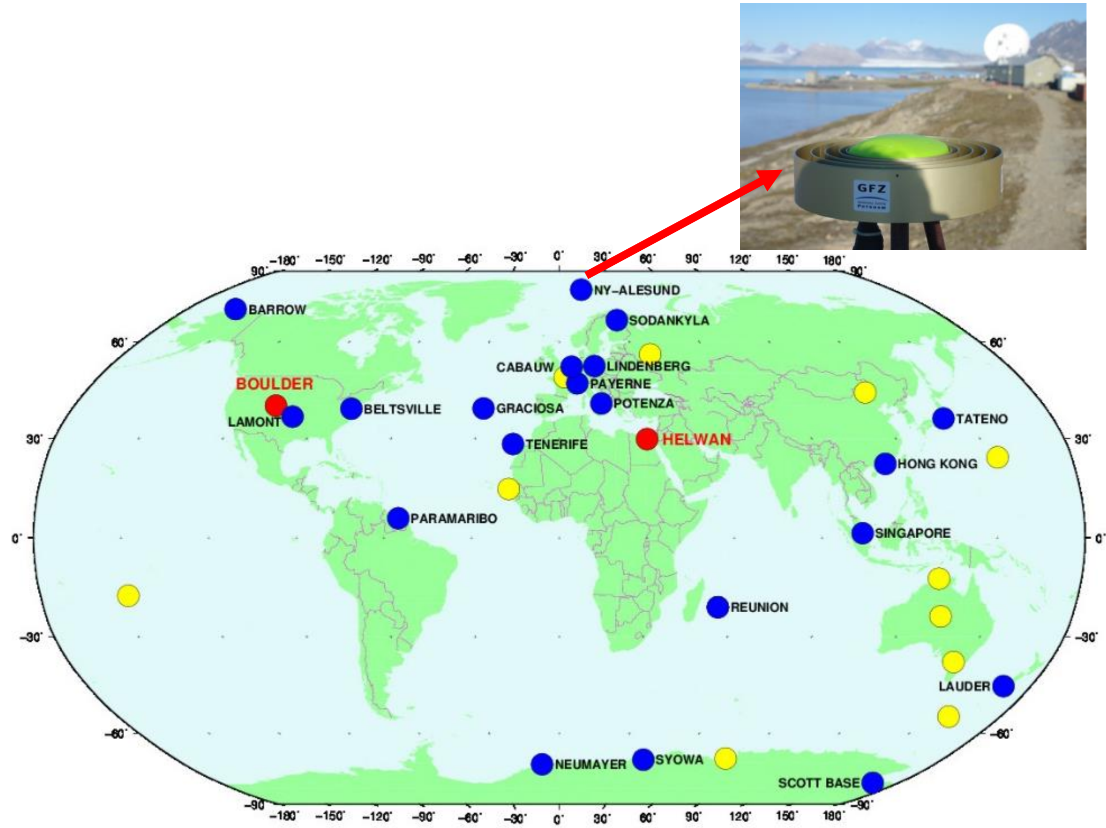
Climate Research:
GRUAN
WegenerNet



GFZ Contribution to GRUAN: GNSS-PW

- GNSS network (currently 20 GNSS sites)
- Operational Data Centre

Processing Centre:
- operational PW estimation
- consistent re-processing
- quality control and uncertainty estimation
- product validation

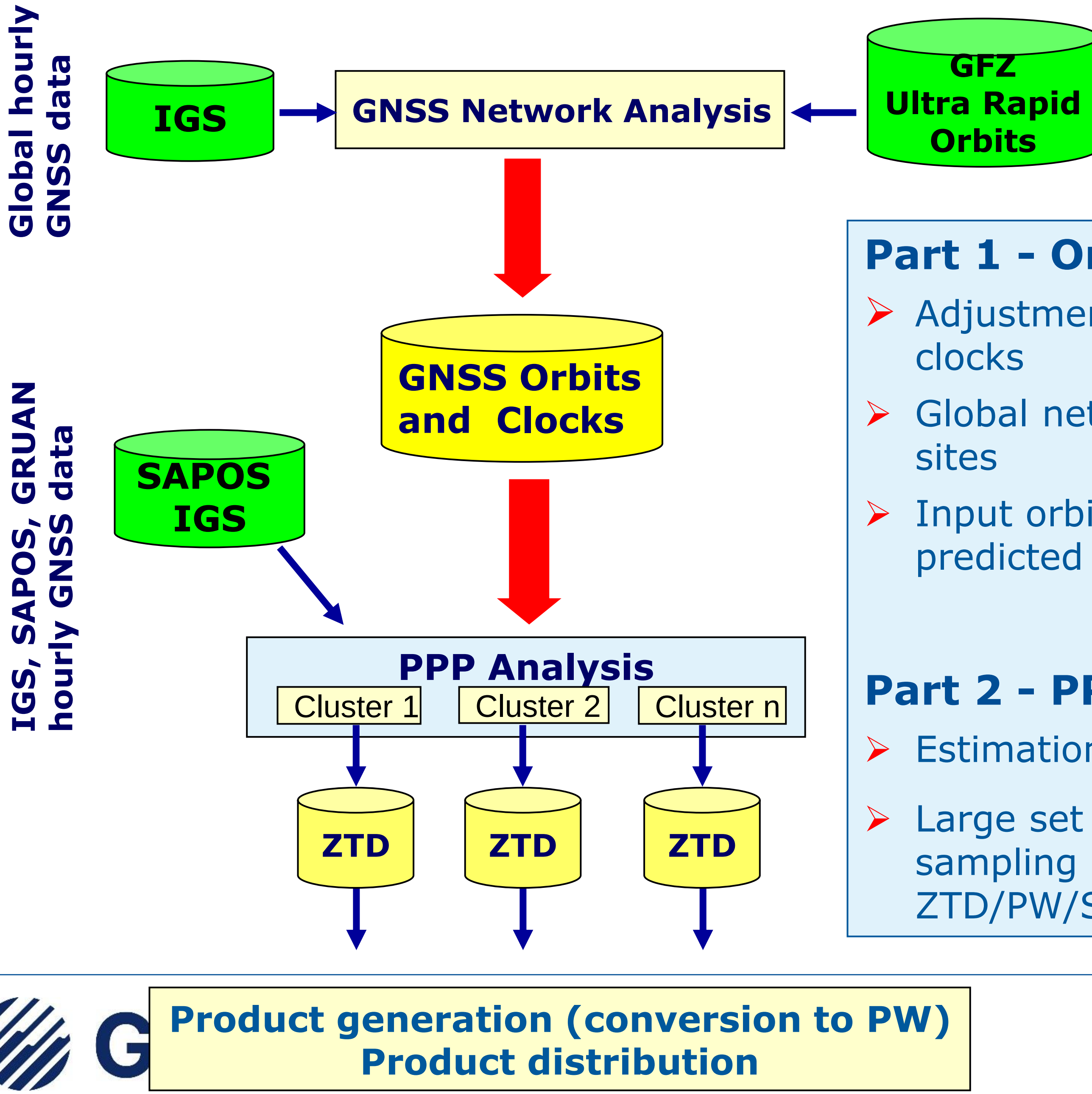


GCOS GLOBAL CLIMATE OBSERVING SYSTEM

GRUAN

WMO

GNSS Processing with GFZ EPOS.P8 Software



Part 1 - Orbit Improvement:

- Adjustment of precise orbits & clocks
- Global network: IGS + German sites
- Input orbits: GFZ 3h Ultra Rapid predicted

Part 2 - PPP Analysis:

- Estimation of trop. parameters
- Large set of parameters with high sampling rate: ZTD/PW/STD/Gradients

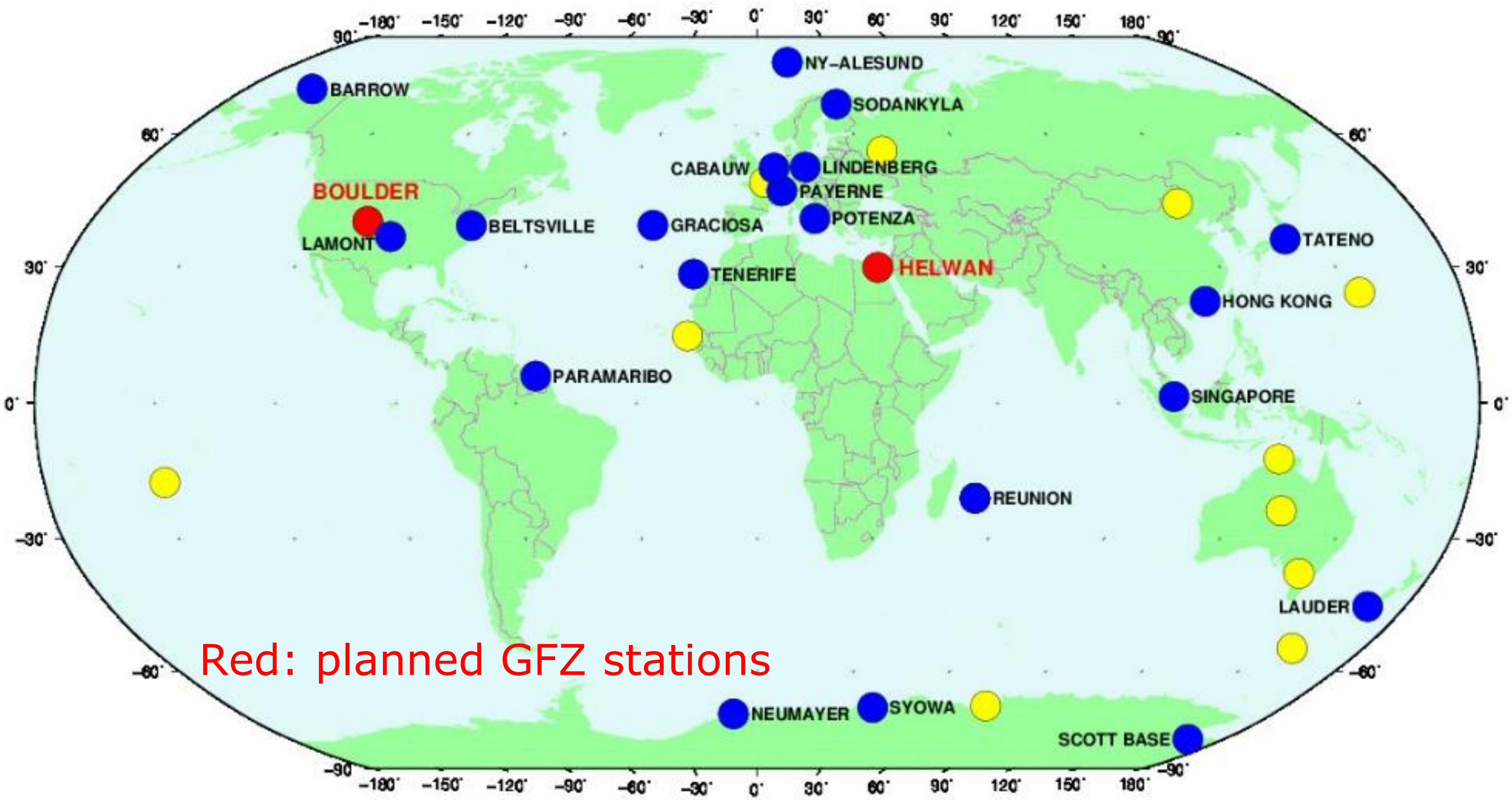
GNSS-PW Products for GRUAN

- **Near real-time (NRT):**
  - 24h sliding window
  - time delay about **1 hour**
  - **gaps** are possible
- **Post-processing** in NRT mode: **GNSS-PW GPD**
  - 24h sliding window
  - time delay several days
  - **NO** gaps
- **REPRO:**
  - daily processing with 24h data window (NOT sliding window!)
  - long time delay

GNSS-PW GDP Formats at GFZ

- **SINEX-TRO (IGS):**
  - daily file per site
- **COST 716 (COST Action 716):**
  - hourly (NRT mode) or daily (repro) file, all sites in one file
  - developed by European Weather Services for operational assimilation
- **ASCII (GFZ):**
  - one file per year and site, easy to read
- **NetCDF GFZ/DWD (M. Bender):**
  - finished

GRUAN GNSS Network



Blue: in GNSS-PW processing
2024: 17 sites
2025: 20 sites (**NEW**: Paramaribo, Hong Kong, Potenza)

Status GNSS-PW Processing

- **20 GNSS sites** in GNSS-PW processing chain:
  - Lindenberg (LDB2, LIN0)
  - Ny-Ålesund (NYA2, NYAL, NYA1)
  - Sodankylä (SODF, SODA)
  - Lauder (LDRZ)
  - Barrow (UTQI)
  - Graciosa (ENAO)
  - Lamont (SGPO)
  - Beltsville (HUBC)
  - Singapore (SMM1, SMS1) no data
  - Payerne (PAYE)
  - Cabauw (CBW1)
  - Ross Island (SCTB)
  - Tateno/Tsukuba (TATN, TSK2)
  - Syowa (SYOW)
  - Tenerife (TFEG)
  - Potenza (TITO) - **NEW**
  - Hong Kong (HKSC) - **NEW**
  - Paramaribo (PAOS -> PAOM) - **NEW**
  - Reunion will be included soon
  - Neumayer (NMSH) no PW-GDP, problems with data processing

Status Selected GNSS Sites in 2025

Potenza (TITO):

technical issues have been solved, PW-GDP available

Graciosa (ENAO):

replacement of GNSS hardware by GFZ in May 2025

Lindenberg (LIN0):

replacement of GNSS hardware by GFZ in July 2025

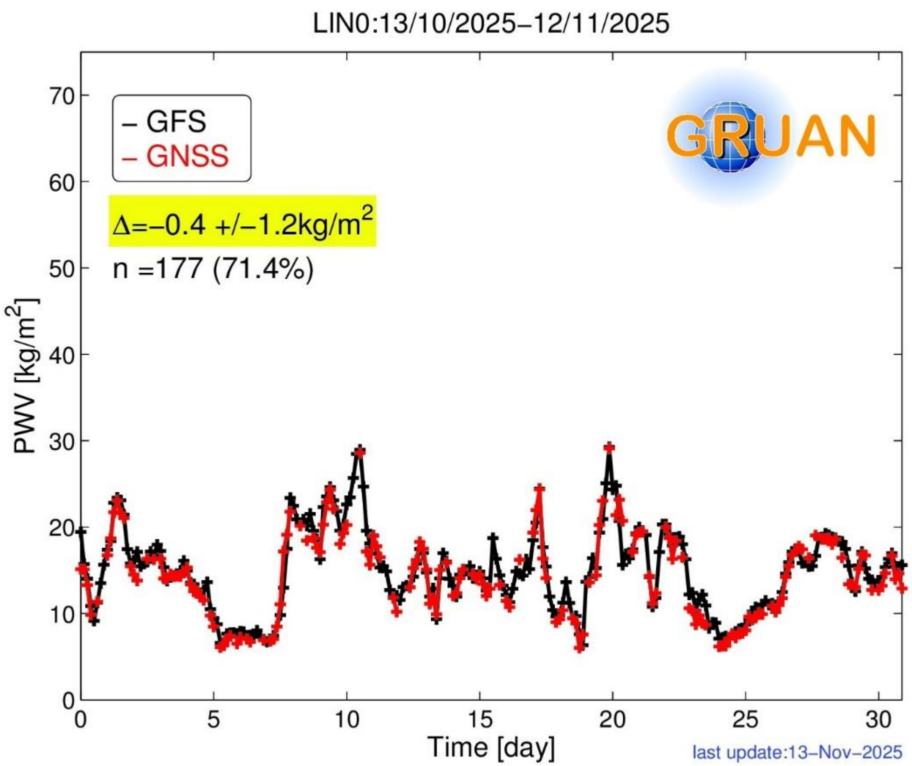
Paramaribo (PAOS –> PAOM):

new location of GNSS receiver (about 30m distance) new name for GNSS site PAOM since October 2025

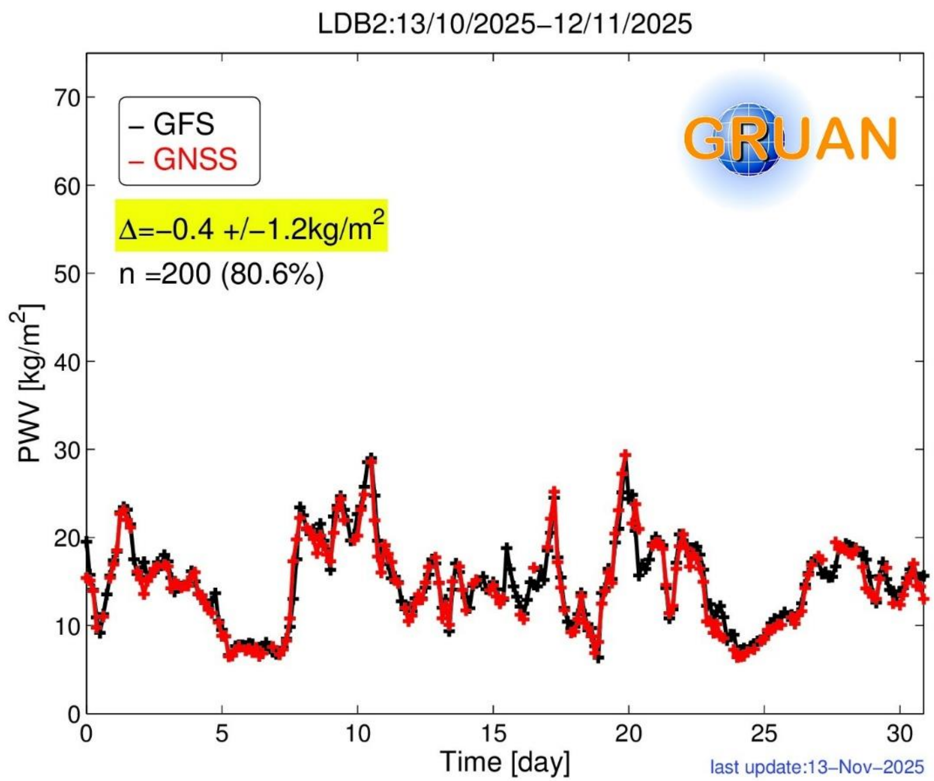
Singapore (SMS1):

no data flow to GFZ since March 2025 due to hardware problems

GNSS-PW for Lindenberg (LIN0 and LDB2)



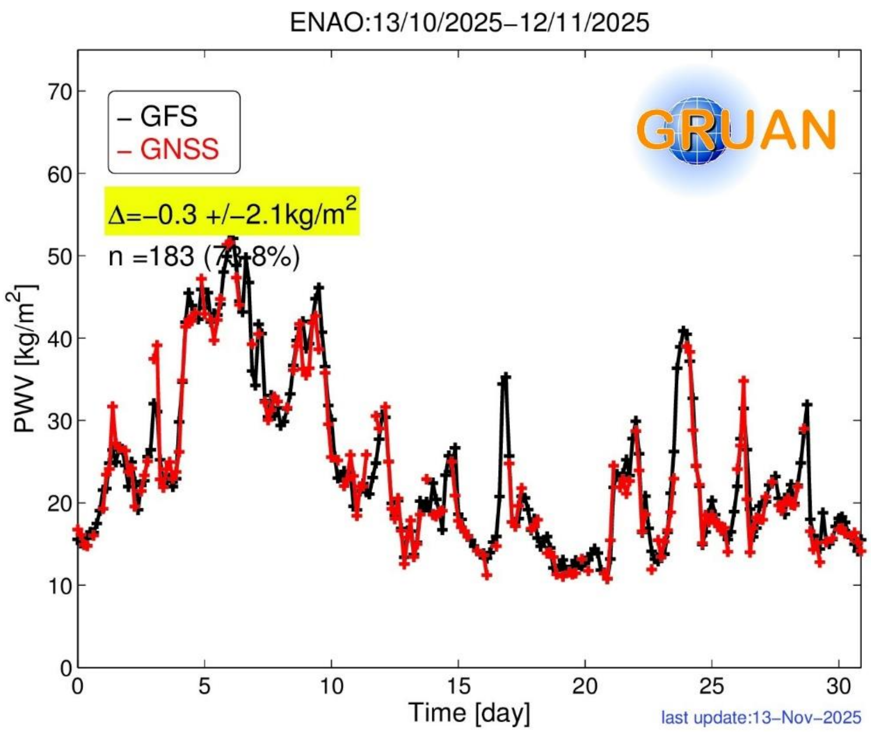
LIN0

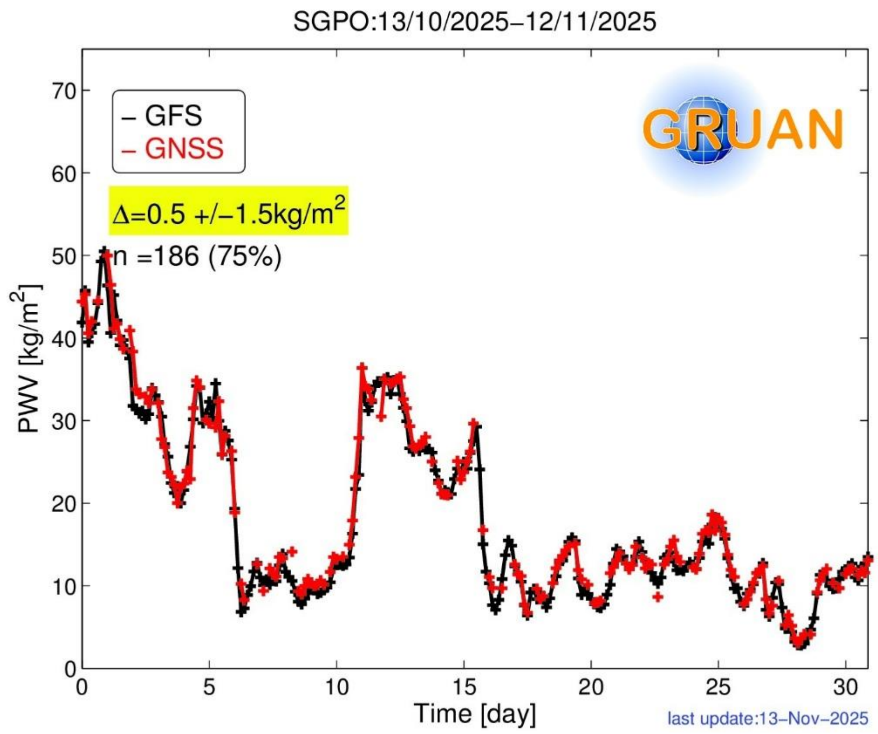


LDB2

Operational comparison with GFS for two collocated GNSS sites in Lindenberg, Nov 2025

GNSS-PW for Graciosa (ENAO) and Lamont (SPGO)



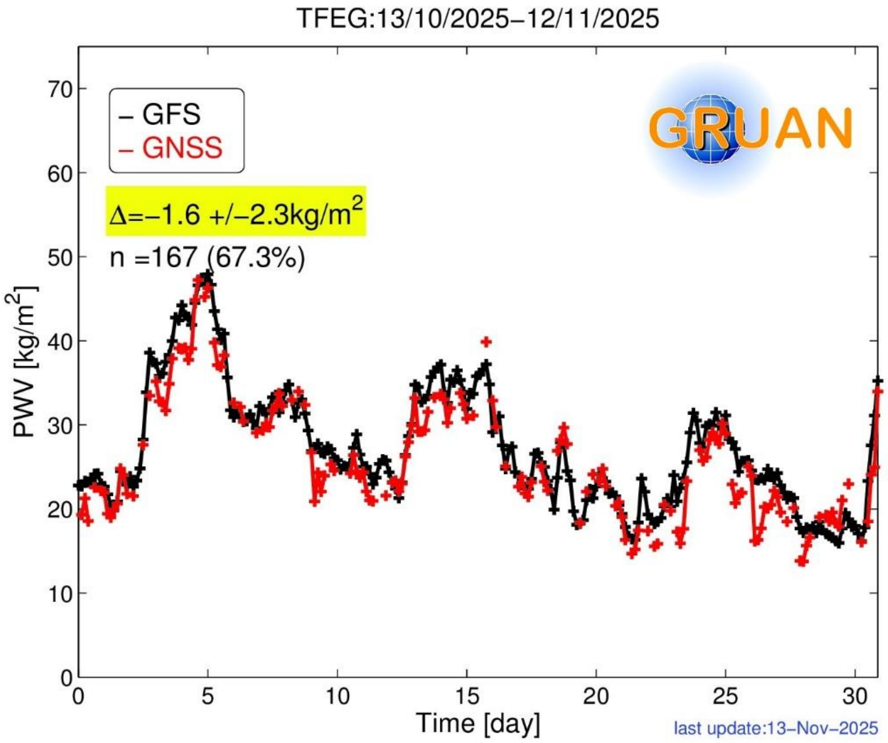


ENAO

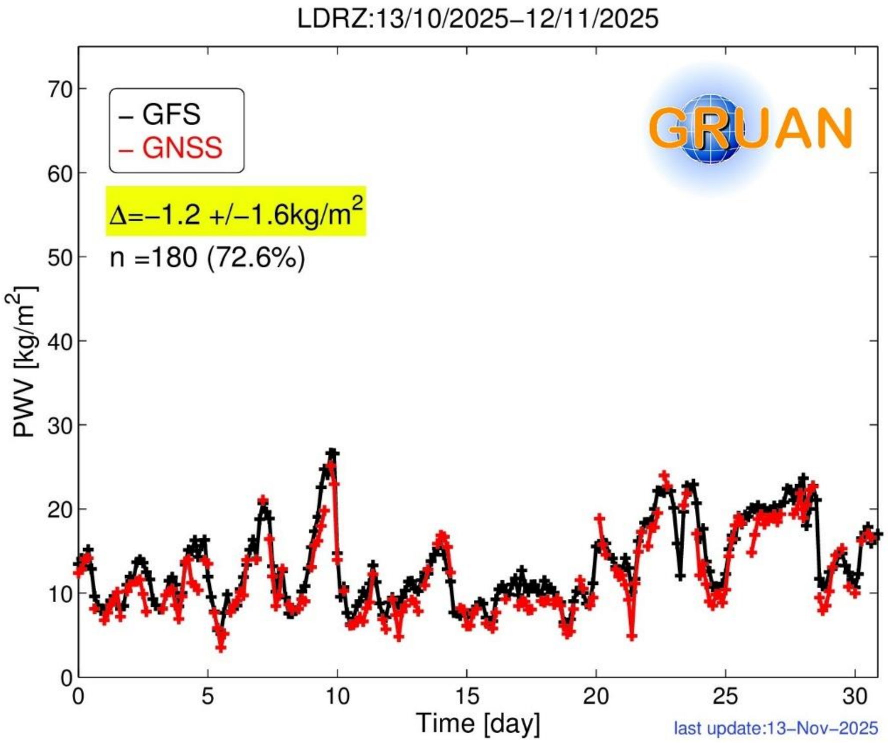
SPGO

Operational comparison with GFS for ENAO and SPGO, Nov 2025

GNSS-PW for Tenerife (TFEG) and Lauder (LDRZ)



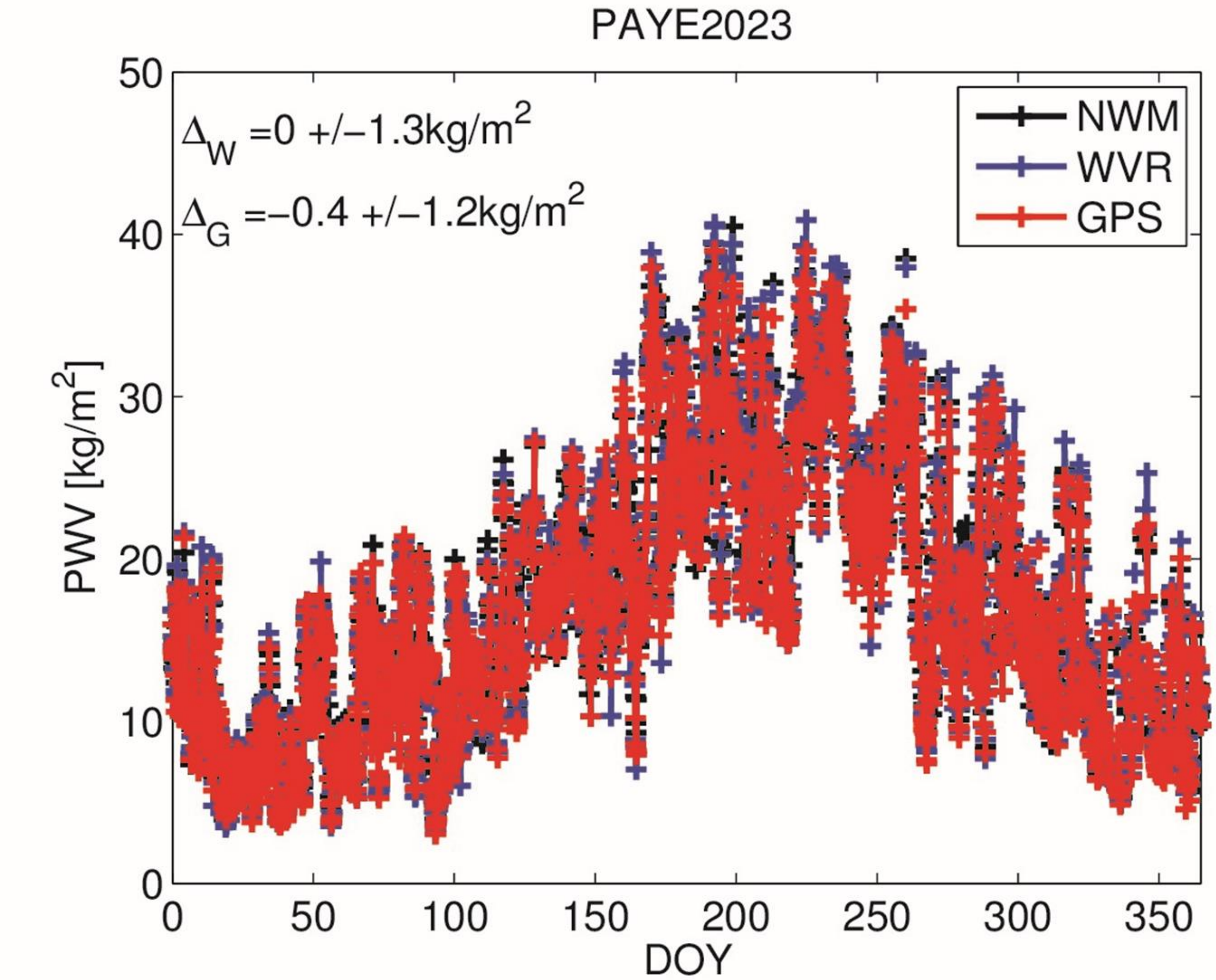
TFEG



LDRZ

Operational comparison with GFS for TFEG and LDRZ, Nov 2025

GNSS-PW vs WVR and NWM for Payerne



Comparisons of of GNSS-PW (red) with Water Vapor Radiometer (blue) and NWM ERA-5 (black) for GRUAN station Payerne (Switzerland) for 2023

GNSS-PWV minus ERA5 and RS41.v1 for 2023

SITE ID	BIAS (mean -0.18/-0.69 kg/m2)	STDDEV (kg/m2)
Graciosa	+ 0.48 (-1.00)	+/- 1.60 (1.15)
Lindenberg	- 1.10 (-1.28)	+/- 1.00 (1.26)
Lauder	- 0.40 (-0.21)	+/- 1.71 (3.62)
Ny-Alesund	- 0.20 (-0.46)	+/- 0.56 (0.64)
Payerne	- 0.40 (-0.39)	+/- 1.10 (1.01)
Lamont	- 0.19 (-0.51)	+/- 1.69 (1.25)
Singapore	+1.20 (-1.20)	+/- 2.55 (0.93)
Sodankyla	- 0.16 (-0.21)	+/- 0.74 (0.74)
Barrow	- 0.86 (-0.99)	+/- 0.70 (0.72)

Red: GRUAN radiosonde product RS41.v1

Summary and Outlook

- Operational providing of GNSS-PW in different formats, including NetCDF
- Operational comparisons with NWM
- Further validations with RS, WVR, VLBI and NWM
- Including of new GNSS sites to PW GDP
- Re-processing with PW uncertainty estimation for the whole time period 2011-2025 (ongoing)

NEW GFZ ADDRESS: @gfz.de

DOI for GRUAN GNSS-PW Data Product:

https://doi.org/10.5880/GFZ.1.1.2024.003

GFZ Helmholtz Centre for Geosciences

GNSS-PW Products on GFZ FTP

Available in SINEX-TRO and COST 716 Formats

NRT:

ftp://ftp.gfz.de/GNSS/products/nrttrop/
sinex_trop_GRUAN_EPOS8/w****
product_GRUAN_COST_EPOS8/y****/m**

REPRO:

ftp://ftp.gfz.de/GNSS/products/nrttrop/REPRO/
sinex_trop_EPOS8/w****
product_COST_EPOS8/y****/m**

NetCDF will be available after ICM16

Many thanks for your attention!