Advances in the development of new GRUAN data products:

GNSS PW

Galina Dick

Fadwa Alshawaf, Markus Bradke, Markus Ramatschi, Jens Wickert

GFZ German Research Centre for Geosciences

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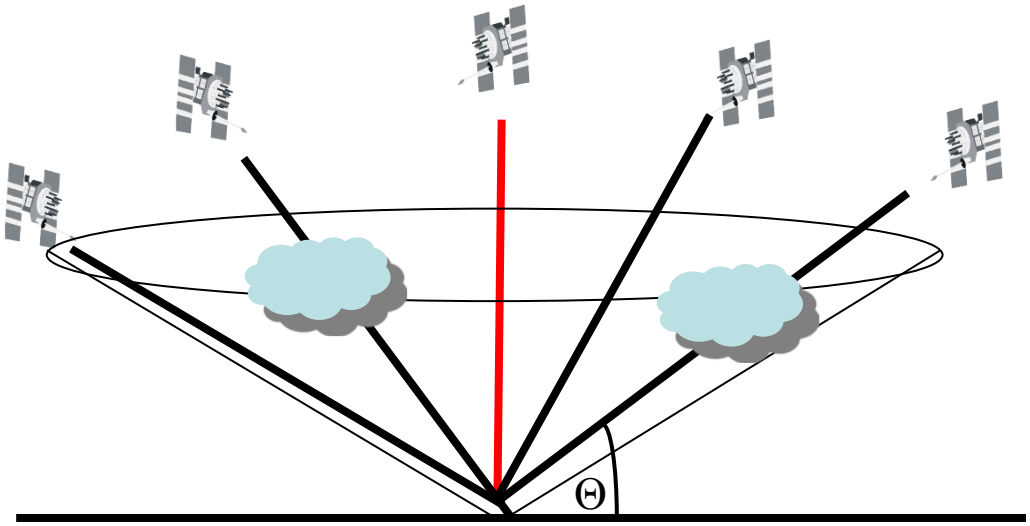
Precipitable Water Vapor with ground-based GNSS



Isotropic water vapor distribution & known mapping function (~1/sin Θ)

Additional: pressure and temperature at the station for conversion of ZTD to PW

Result of GNSS data analysis: Zenith Total Delay (ZTD) with mm-accuracy

dry, hydrostatic wet

$$ZTD = ZHD + ZWD$$

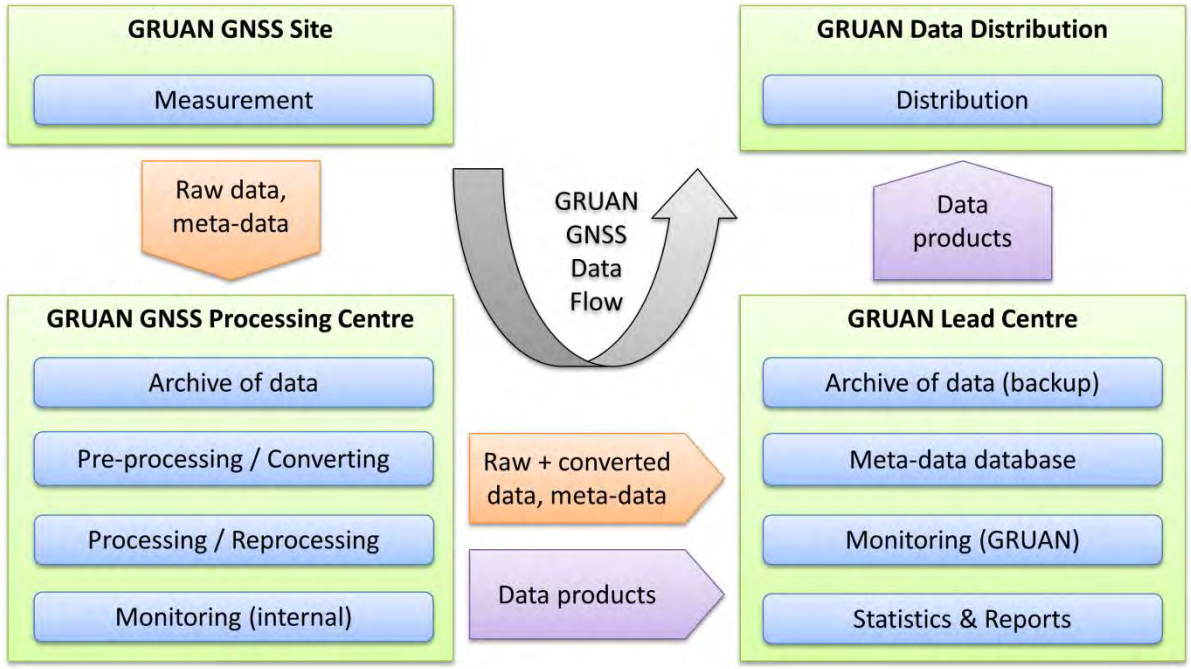
ZHD = f (pressure) [±1 mm accuracy]

$$PW = \Pi (T_m) \bullet ZWD$$

Converted Precipitable Water Vapor (PW)

Observations → GRUAN GNSS Data Product

GNSS obs. & site meteo.



GNSS PW & uncertainty

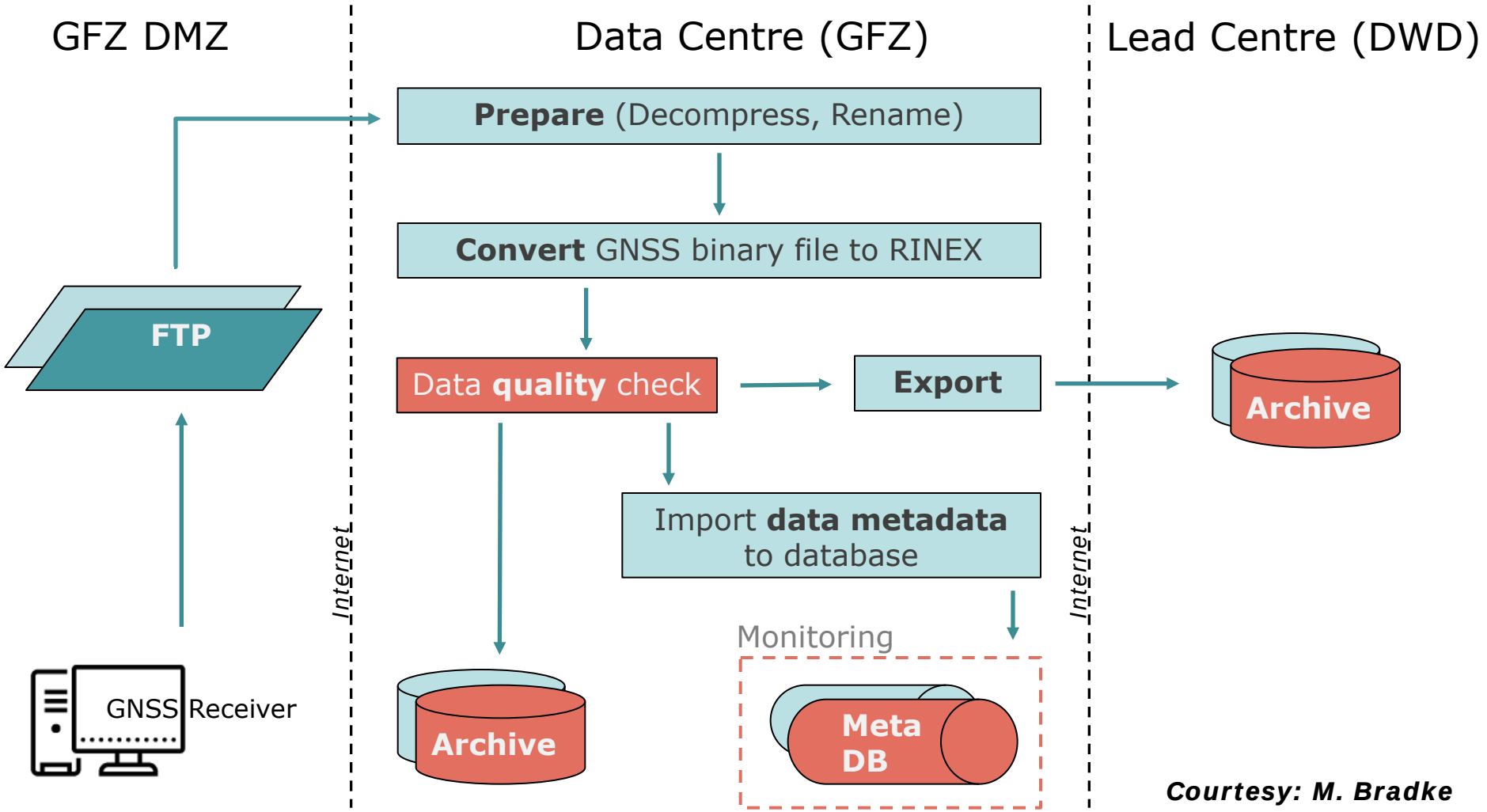
GNSS PW & uncertainty

Courtesy: M. Sommer, K. Rannat

Operational Data Centre at GFZ

- Development of a new raw Data Centre over the last year
- Ability to process all GNSS related data
- Data passes quality check before GNSS data analysis
- Monitoring of station behavior
  - Instant feedback for station operators
  - Presentation in a WebGUI
- Short raw data processing latency (< 10 seconds)

Raw GNSS Data Flow

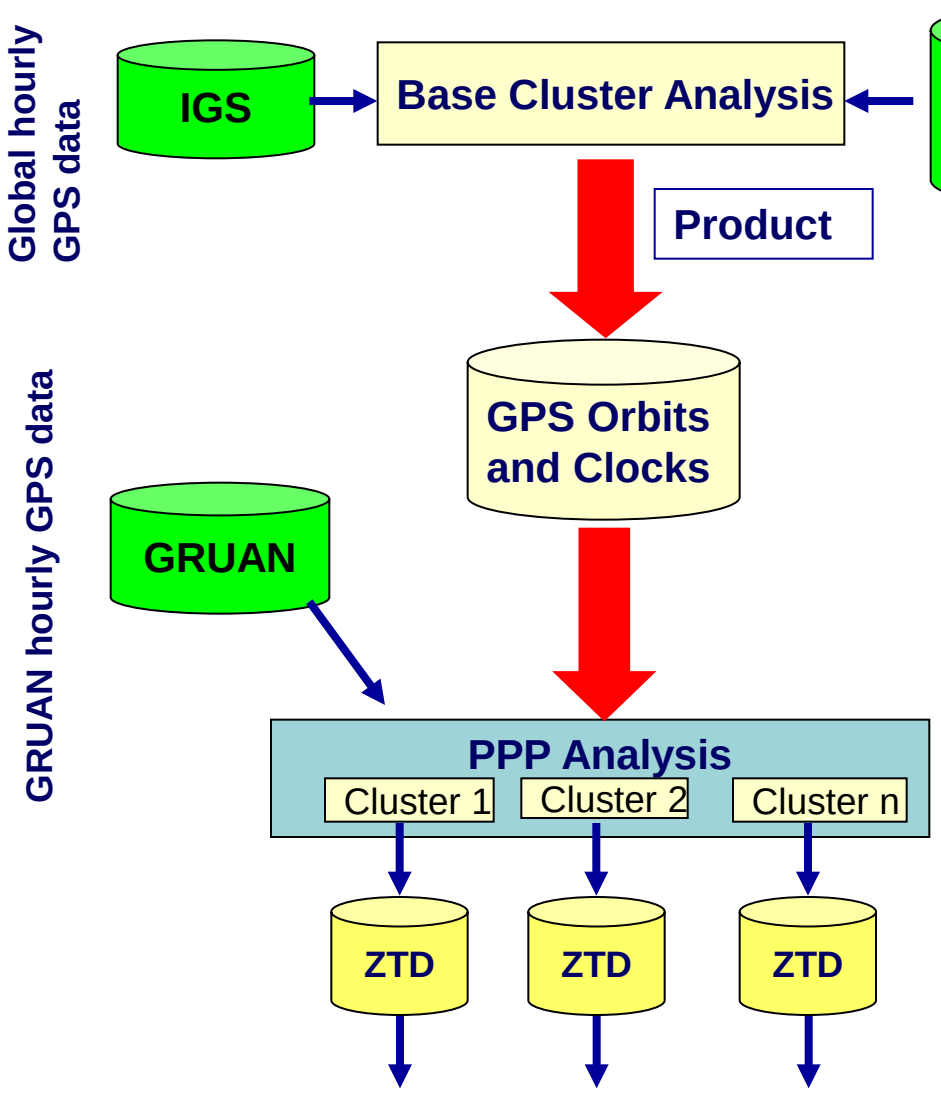


Courtesy: M. Bradke

Input from Station Operators

- Metadata (an IGS-conform site log)
  - ftp://igs.org/pub/station/general/blank.log
  - ftp://igs.org/pub/station/general/sitelog_instr.txt
- Example of data file for instant check (filename, quality)
  - Raw binary file (all types supported, e.g. Javad, Leica, Septentrio, Trimble)
  - RINEX v.3 (OBS, NAV, MET)
- A (constant) upload to our FTP server or your own FTP server
- Need **help** setting up a station? Please contact us.

GNSS Processing with GFZ EPOS Software (PPP strategy)



GFZ EPOS8 Software (PPP strategy):

Part 1 - Network orbit improvement:

- Adjustment of precise orbits & clocks
- Global network: ~100 IGS + German sites
- Input orbits: GFZ 3h Ultra Rapid (pred.)

Part 2 - PPP Analysis:

- Estimation of trop. parameters
- Large set of parameters possible: high sampling rate, ZTD/PW/STD/Gradi

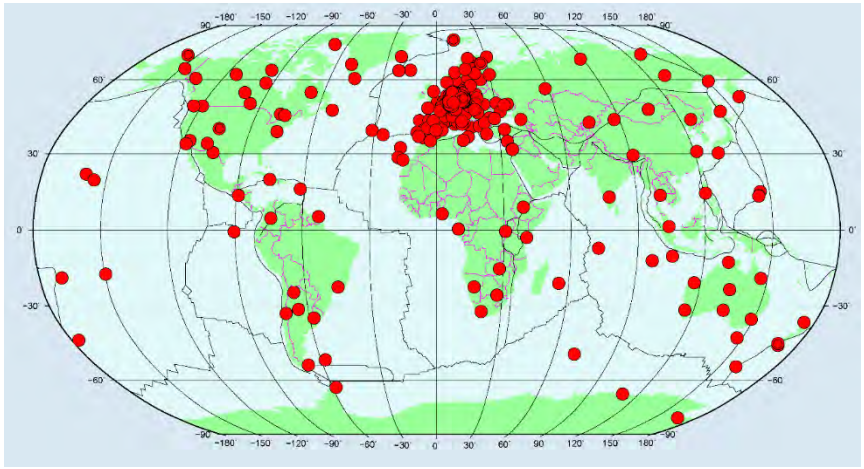
Processing time (LINUX PC):

<15 min for more than 500 stations

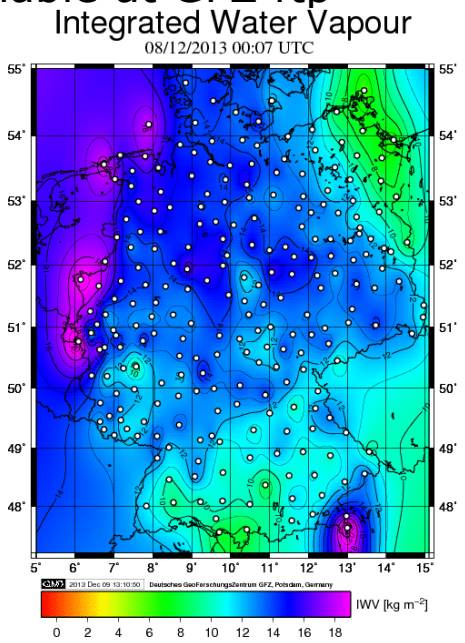
Product generation (conversion to PW)
Product distribution

Operational GNSS PW Monitoring at GFZ

- Automatically processing of hourly GNSS data with GFZ EPOS8 Software (PPP)
- ~600 stations in processing (German SAPOS + EUREF + IGS + GRUAN networks)
- Time delay < 30 minutes after the end of each hour (near real-time)
- ZTD/PW with 15 minutes time resolution
- ZTD/PW products both in COST and TRO-SINEX format, available at GFZ ftp
- Other products are also available: slants, gradients



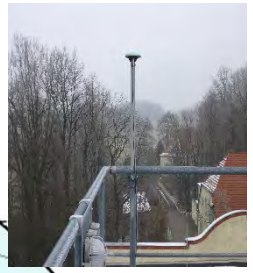
Zenith Total Delay
Precipitable Water
Slant Total Delay
Gradients



Orkan Xaver 8.12.2013

Operational use of GFZ ZTD data by several European meteo services for weather forecast (UK Met Office, MeteoFrance)

GRUAN GNSS Network



GFZ Helmholtz Centre Potsdam

GRUAN

HELMHOLTZ

GRUAN GNSS Station Lindenberg (Germany)

- GFZ station LDB0, installed 2007
- GNSS data and PW products available starting from 2007
- Reprocessing on-going -> DONE
- Automatically hourly GNSS raw data flow and NRT analysis
- Co-located GNSS station is LDB2 (operated by BKG)
- Validation with RS data and ERA-Interim model (talk by Fadwa Alshawaf tomorrow)

GRUAN GNSS Station Ny-Alesund (Norway)

- GFZ station NYA2, installed 2011, GNSS data and PW products available starting from 2011
- Reprocessing on-going -> DONE
- Automatically hourly GNSS raw data flow and NRT analysis

- Co-located GNSS stations are NYAL and NAY1
- Validation with RS data and ERA-Interim model
- Validation with other collocated instruments planned

GRUAN GNSS Station 'Table Mountain', close to Boulder (USA)

- GFZ station TMS3, installed 2014
- GNSS data and PW products available since end of 2014
- ZTD NRT products available starting from Jan 2017
- Reprocessing will be done -> DONE
- Automatically hourly GNSS raw data flow and NRT analysis

GRUAN GNSS Station Sodankyla (Finland)

- FMI/GFZ station SODF, installed Feb 2015, GFZ site software
- Co-located GNSS station SODA
- GNSS data available since 2015
- PW NRT products available
- Reprocessing will be done -> DONE
- Automatically hourly GNSS raw data flow and NRT analysis

Courtesy: Rigel Kivi (FMI)

GRUAN GNSS Station Lauder (New Zealand)

- GNSS station LDRZ, installed 2012
- GNSS data available since 2012
- ICM-9: PW products available only in reprocessing mode -> NEW: PW products available also in NRT
- Reprocessing on-going -> DONE
- ICM-9: NO automatically hourly GNSS raw data flow and NRT analysis -> NEW: processing chain is automated

New GNSS Station at NSA-C1 site of Barrow

- GNSS station is named UTQI
- installed by GFZ in July 2017
- GNSS data and PW products are available starting from July 2017
- automatically hourly GNSS raw data flow and NRT analysis, PW products are available operationally

Summary GNSS PW Processing

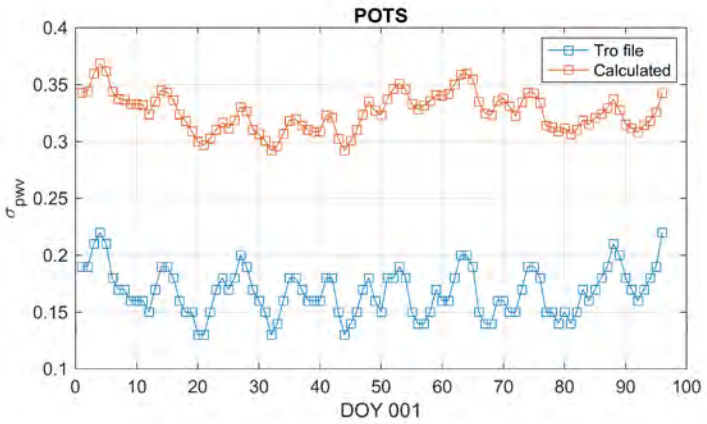
- Automatically hourly GNSS raw data flow and NRT PW analysis established at GFZ

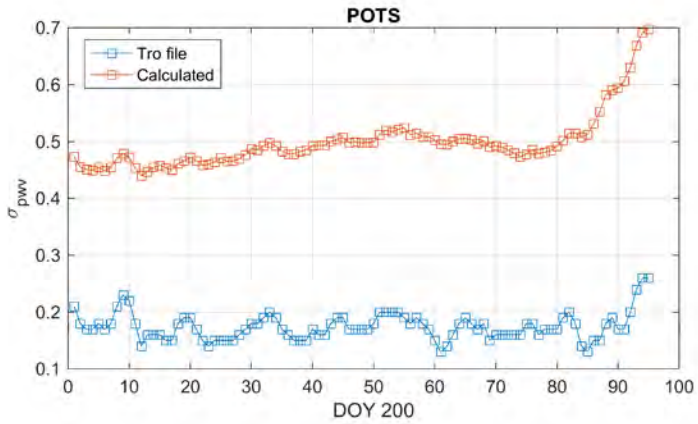
- GNSS stations in automated PW processing chain:

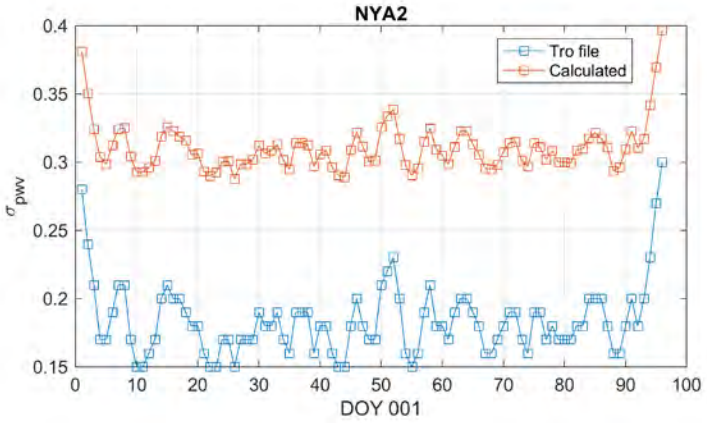
  Lindenberg (LDB0, LDB2)
  Ny-Alesund (NYA2, NYAL, NYA1)
  Boulder 'Table Mountain' (TMS3)
  Sodankyla (SODF, SODA)
  Lauder (LDRZ)
  Barrow (UTQI)

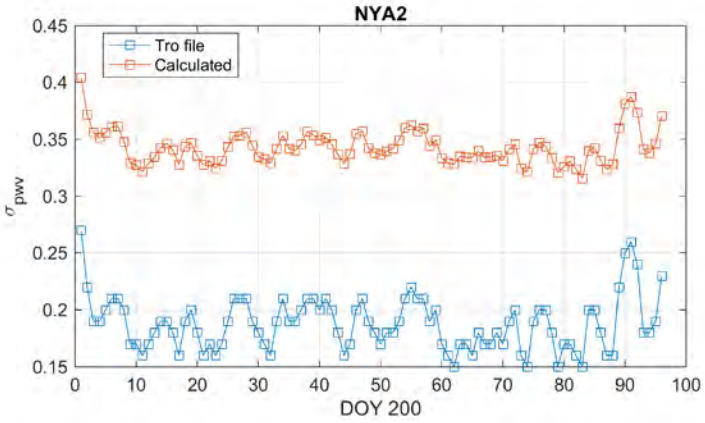
- Reprocessing done for 2011-2017
- Data flow to LC Lindenberg

GNSS PW Uncertainty Estimation





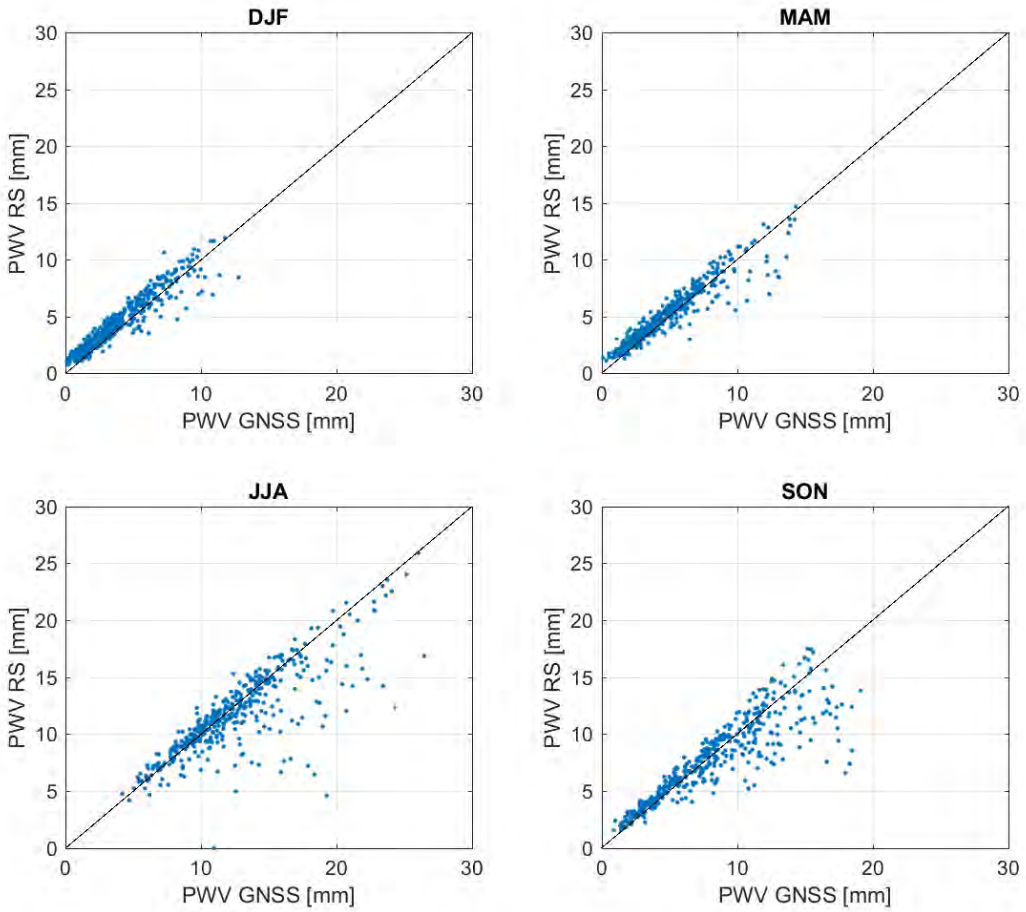




Courtesy: F. Alshawaf

PW GNSS uncertainties as estimated according Tong Ning algorithm (red) and according current estimation procedure (blue).
Examples for stations Potsdam and Ny-Alesund, DOYs 001 and 200, 2017

GNSS PW Validation with RS at Ny-Alesund



PW GNSS results from GNSS data for 2011-2016 compared seasonally with RS at Ny-Alesund GRUAN site (talk by F. Alshawaf tomorrow)

Future work

GNSS data processing and PW products:

- PW uncertainty estimation after T. Ning will be added to automated PW processing chain (currently in testing phase)
- Reprocessing with new PW uncertainty estimation will be done
- PW time series homogenisation and trend analysis will be continued
- Validation with RS and other collocated meteorological (WVR) and geodetic instruments (VLBI) will be performed

GRUAN sites:

- Payerne (Switzerland), Cabauw (Netherlands) and Potenza (Italy): GNSS data flow and processing at GFZ (in progress)
- Dolgoprudny (Russia): negotiations on GNSS data flow and processing via GFZ (in progress)
- Singapore (Singapore) and Tateno (Japan): GFZ contacted these sites
- Other GRUAN sites will be contacted by GFZ and PW TT

GFZ Products on FTP

ftp ftp.gfz-potsdam.de
user: anonymous

GRUAN NRT:
cd GNSS/products/nrttrop/sinex_trop_GRUAN_EPOS8/w****
cd GNSS/products/nrttrop/product_GRUAN_COST_EPOS8/y****/m**

REPRO:
cd GNSS/products/nrttrop/REPRO/sinex_trop_EPOS8/w****
cd GNSS/products/nrttrop/REPRO/product_COST_EPOS8/y****/m**

GFZ Contacts

Operational Data Centre:

Markus Bradke bradke@gfz-potsdam.de +49 331 288 1182

GNSS Network & Hardware:

Markus Ramatschi maram@gfz-potsdam.de +49 331 288 1746

GRUAN Analysis Centre:

Galina Dick dick@gfz-potsdam.de +49 331 288 1185

Many thanks for your attention!