

GRUAN GNSS Precipitable Water Task Team

Goal: To develop explicit guidance on hardware, software and data management practices to obtain GNSS PW measurements of consistent quality at all GRUAN sites.

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Kalev Rannat	Tallinn University of Technology, EE	co-chair
John Braun	UCAR, USA	
Galina Dick	GeoForschungsZentrum Potsdam, DE	GFZ
Gunnar Elgered	Chalmers University, SE	
Seth Gutman	NOAA, USA	retired???
Yoshinori Shoji	Meteorological Research Institute, JP	
Jens Wickert	GeoForschungsZentrum Potsdam, DE	GFZ
Jonathan Jones	Met Office, UK	
George Liu	Hong Kong Polytechnic University, HK	
Tong Ning	Lantmäteriet (Swedish Mapping, Cadastre and Land Registration Authority), Sweden	Developed uncertainty estimate algorithm

How does GNSS estimate precipitable water?

Total delay = ~~Ionosphere~~ + dry + wet

IONOSPHERE

The ionosphere delay is (inversely) proportional to the frequency of the radio-waves. Thus the delay can be calculated by measuring the difference in the travel times for the two frequencies

TROPOSPHERE

The troposphere slows both GPS frequencies equally. This means the tropospheric delay must be modeled as a free parameter in the GPS processing

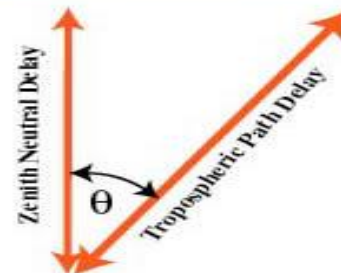
Precipitable Water (PW)

$$\text{ZTD} = \text{ZHD} + \text{ZWD}$$

$$\text{ZHD} = f(P_s)$$

$$\text{ZWD} = \text{ZTD} - \text{ZHD}$$

$$\text{PW} = f(T_m)$$

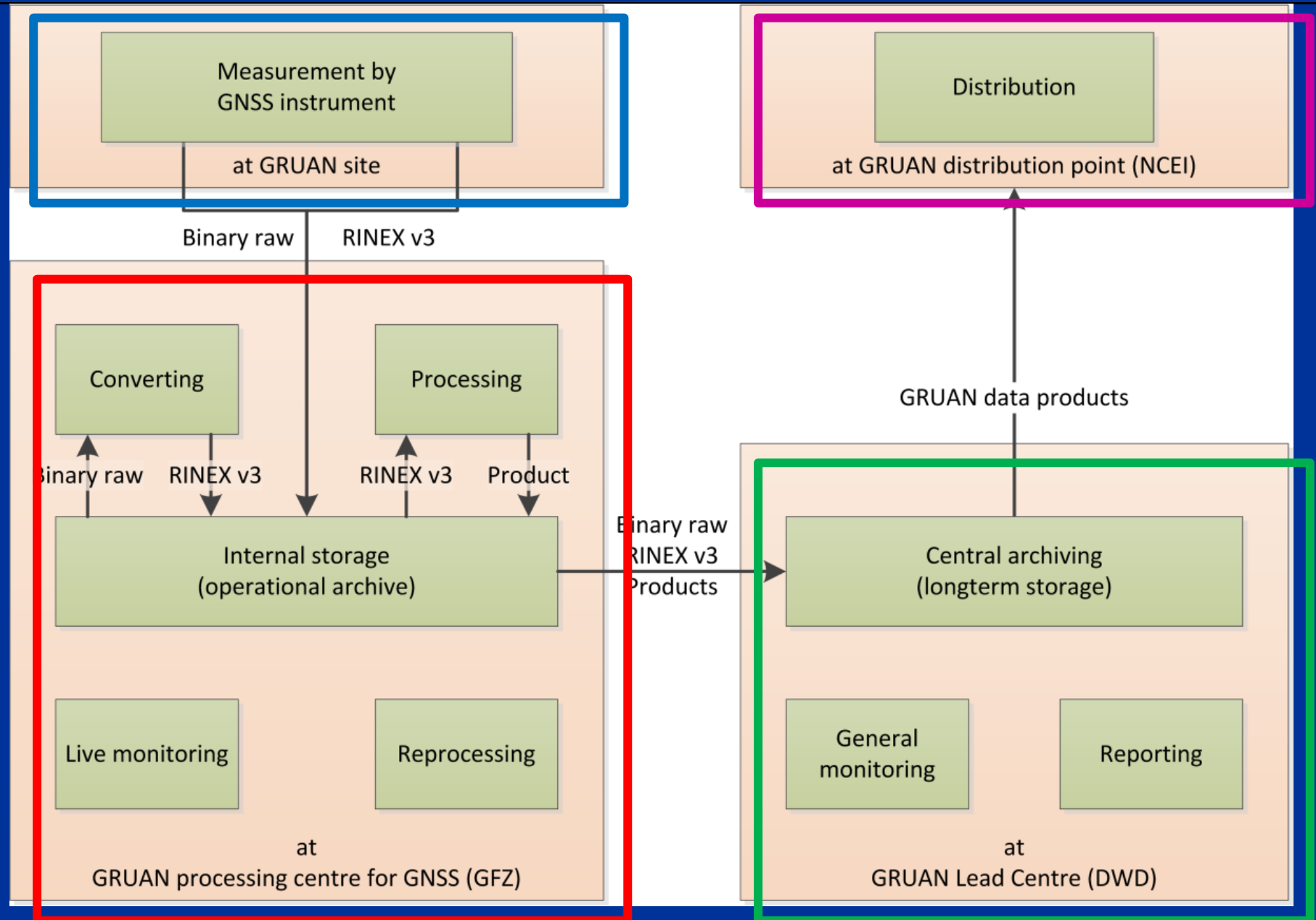


The tropospheric path delay is mapped to zenith by elevation (θ) dependent function(s)

Update from TT, GFZ and LC

1. **Technical document:** finalized in February, 2018 and sent to Peter and Ruud for review on Feb. 27, 2018.
2. **Data stream:** The sites in the operational processing are LDB0, LDRZ, NYA2, SODF, TMS3, UTQI. Some additional GRUAN sites will be added soon (Payern, Potenza, Cabauw).
3. **Data availability:** The experimental data (currently not certified) is available at ftp.ftp.gfz-potsdam.de for LDB0, LDB2, LDRZ, NYA2, SODF, TMS3.
4. **Comparisons with independent measurements** (e.g., Radiosonde): Fadwa Alshawaf (GFZ) did some comparisons with RS for GRUAN sites Lindenberg and NyAlesund.
5. **PW uncertainty estimate:** Ning et al. (2016) will be implemented, and the data will be reprocessed.
6. **GNSS “data monitoring tool”** (item #29 in GNSS-TT Report 2017): GFZ is currently developing the new ODC (Operational Data Center, Markus Bradke et al.) for handling of the raw GNSS data. Data monitoring of GRUAN sites will be included.

GNSS PW Data Flow



Key scientific requirements of a GRUAN data product are:

1. That the **raw data and measurement metadata** are retained in a secure archive such that they can be reprocessed at any time in the future to generate a revised final data product.
2. That all aspects of the measurement processing are **open and transparent**.
3. That the measurements are **traceable to SI units** or accepted community standards.
4. That the **uncertainty** in every processing step is identified, assessed and robustly quantified (commensurate with the Guide to Uncertainties in Measurements, JCGM 2008) to provide a comprehensive estimate of the uncertainty on each measurement and, in the case of profile measurements, at each point in the measured profile.

Discussions

1. **Technical document (12/2018): Review, revision and publish.**
2. **Certification of GNSS measurement program and data product:**
 - Follow “Strictly required guidelines” listed in TD6
 - Implementation of uncertainty estimate
 - Should we provide uncertainty estimate for all components (ZTD, Ps, Tm, PW ...)?
 - Initial evaluation of the data & comparisons with others & including uncertainty estimate
3. **Assessment of issues, data usage and potential improvements**
4. **Interactions among TT, LC, GFZ and sites?**
5. **Interactions with sites on assistance for new instruments and data processing; How to make sure to follow TD6?**
6. **Update the site inventory and add new sites**
(https://docs.google.com/spreadsheets/d/1M9vOFK8df3b_tIKJGznsyiJVo-htFZyIU8za_b55NPg/edit?usp=sharing update or add your site!!!). *Do all sites have GNSS receivers installed?*)
7. **GNSS-Side meeting at 5:15-6:15 pm TODAY**

Scientific applications of GRUAN GNSS-PW production: Interest & resources

