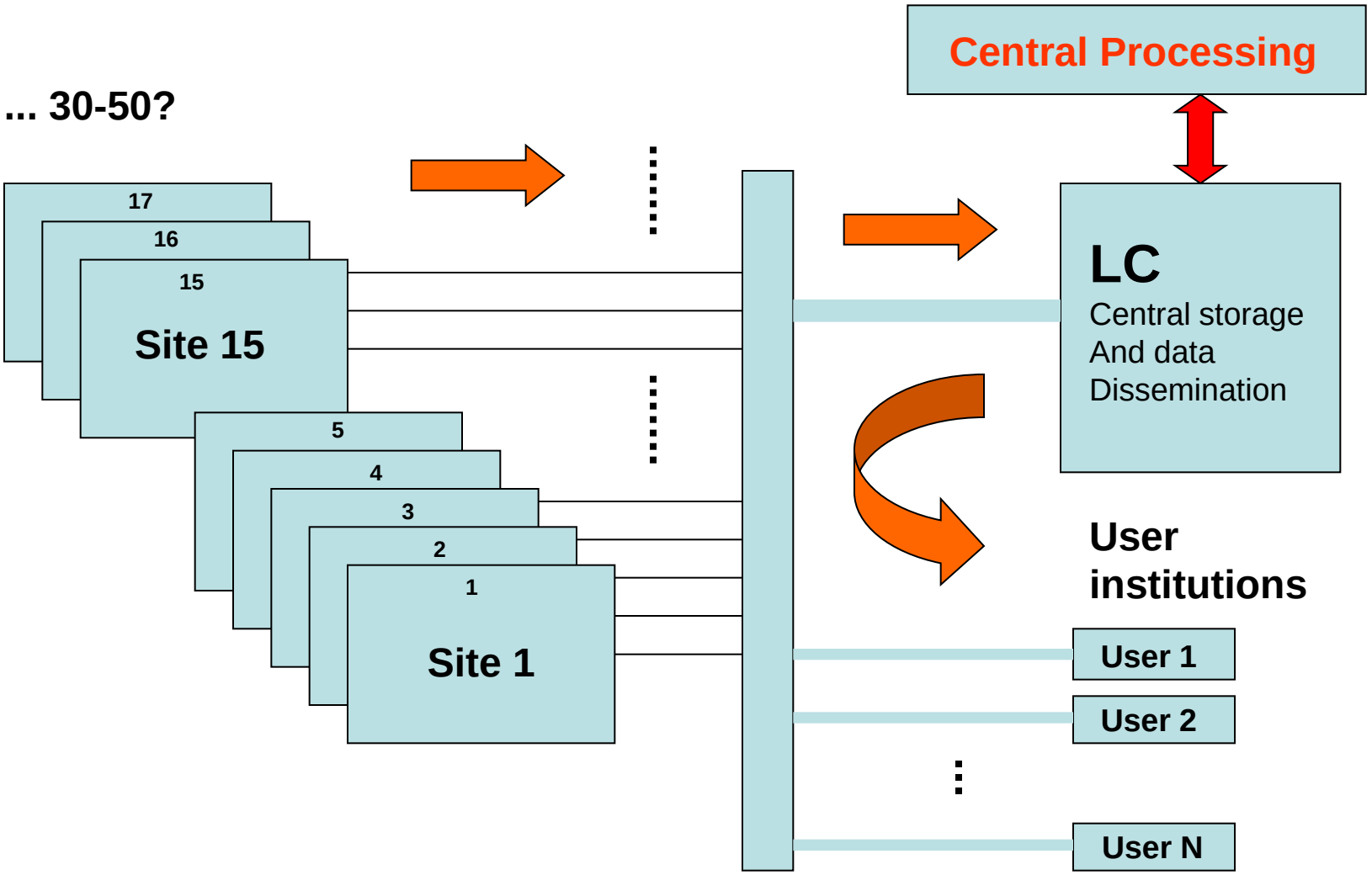
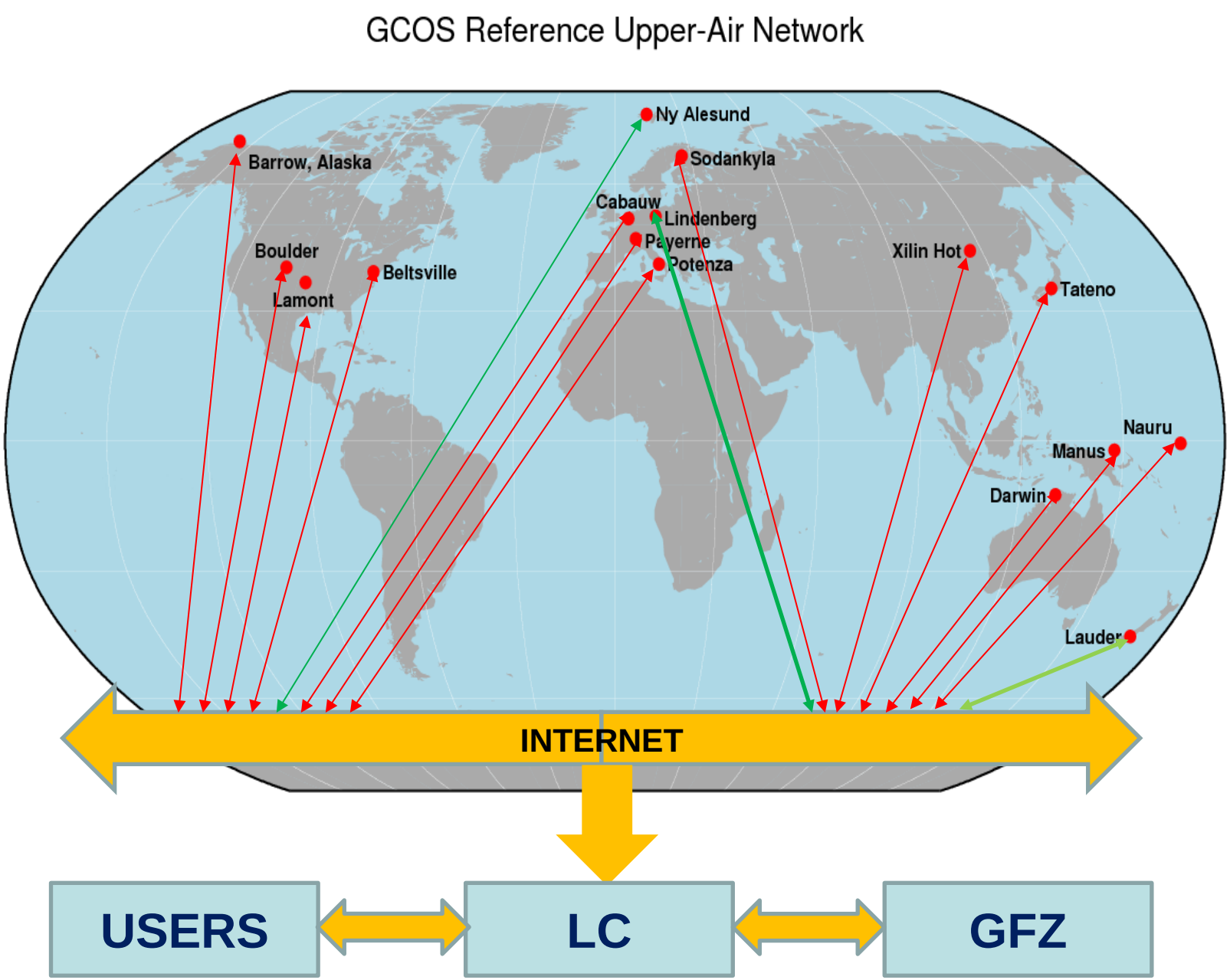
Global Navigation Satellite System-Precipitable Water (GNSS-PW) data stream

GCOS Reference Upper Air Network (GRUAN) 6th Implementation and Coordination Meeting (ICM)
Greenbelt, Maryland - USA

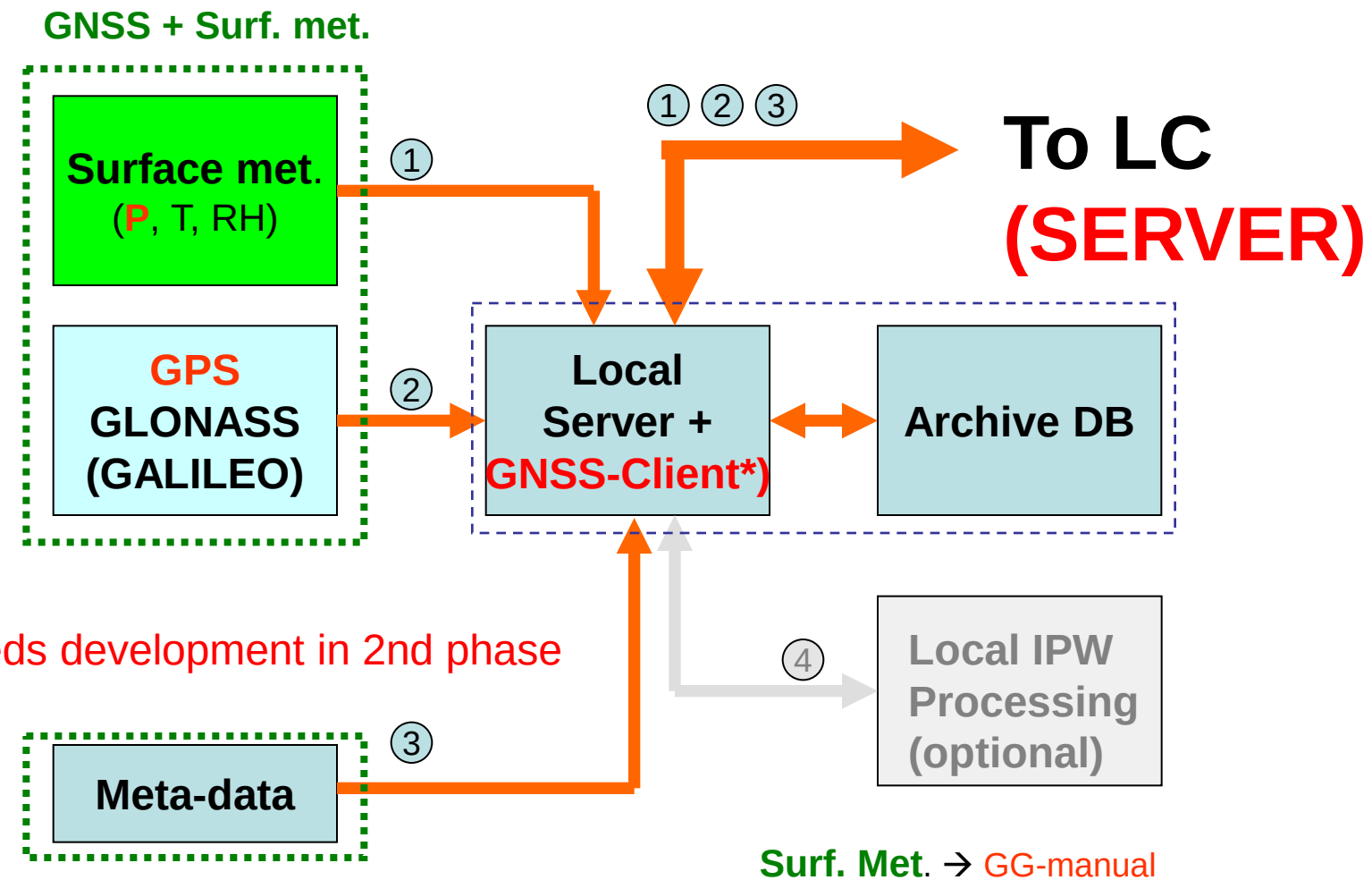
GRUAN – network of sites




GCOS Reference Upper-Air Network
Ny Alesund
Barrow, Alaska
Sodankyla
Cabauw
Lindenberg
Payerne
Potenza
Boulder
Beltsville
Lamont
Xilin Hot
Tateno
Nauru
Manus
Darwin
Lauder
INTERNET
USERS
LC
GFZ

Data stream at the site

CLIENT-SERVER application



*) Needs development in 2nd phase

Site Meta-data → site log- and history files (GG-manual)

Surf. Met. → GG-manual

GNSS-rules → GG-manual

The data

Data specification at ① ② ③ :

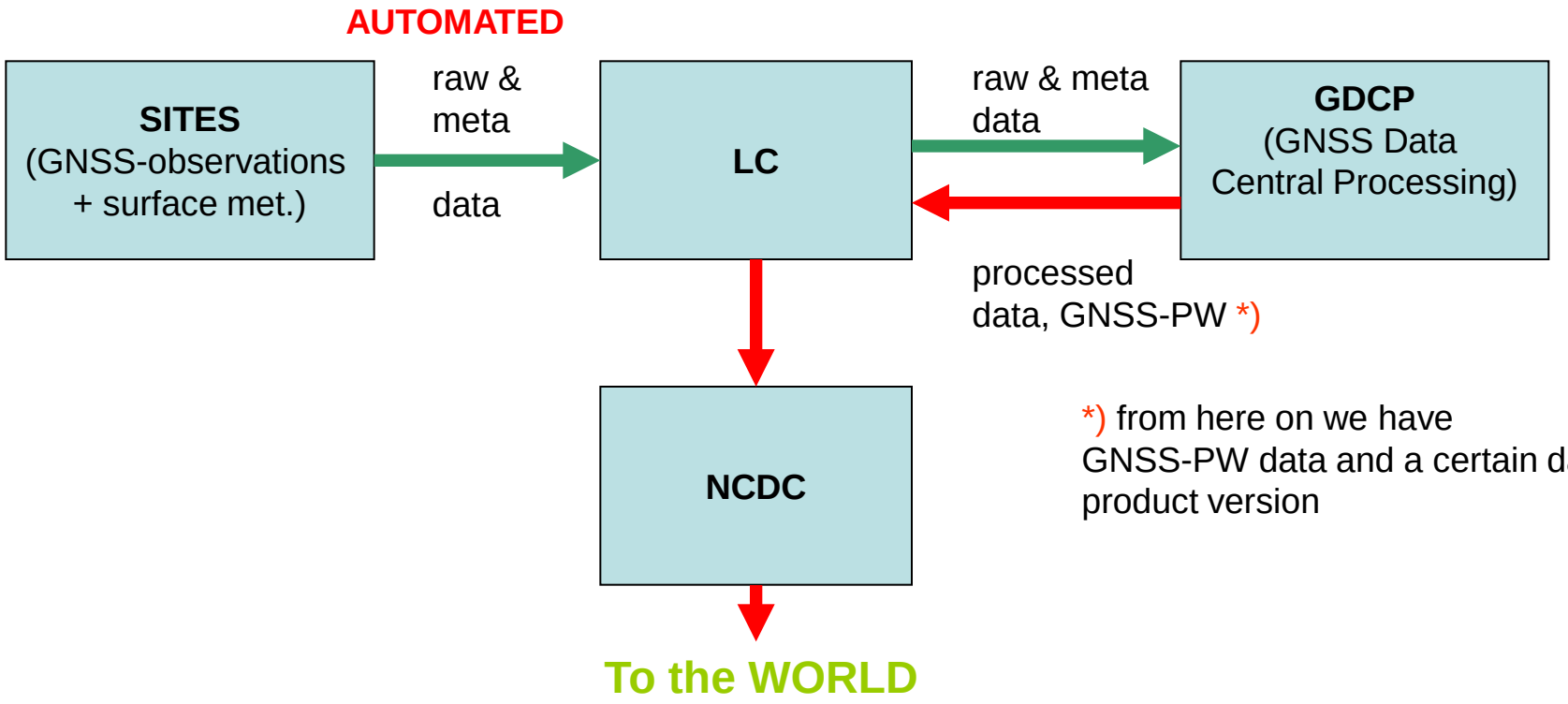
① Depends, where is the AWS (connected to the GNSS-receiver or the data comes from external collocated source), binary data stream or Meteo RINEX.
Conversion utilities are ususlly offered by GNSS-receiver manufacturers.
If the meteo-data comes from collocated AWS, the data is often at a different server – it must be downloaded and converted to meteo-RINEX. These converters are usually self-developed.
Maybe it needs some centralized suport?

② GNSS-observations: the initial data format is manufacturer-specific binary – compact, not human-readable.
Each manufacturer offers utilities for conversion to RINEX (**RINEX3**).
RINEX3 – (due to increasing number of navigation satellite systems)

Must be resolved what is more convienient for LC. The binaries are optimal, but from practical considerations it should be RINEX.

③ Site metadata (site log-files, site history): there is no clear consensus regarding formats yet.
All what gives light about conditions where/how the data is collected, what is noticed at the site.

FROM GNSS-PW PERSPECTIVE



*) from here on we have GNSS-PW data and a certain data product version

GRUAN GNSS-PW DATA PRODUCT
is distributed in E-GVAP (E-GVAP ASCII) format
(also known as „cost format“)

- well defined
- well documented
- easily convertable to BUFR and NetCDF.

Data flow (GNSS observations and meteodata) for central processing

Concept of central data processing and GNSS-PW uncertainty analysis:

1 Central Processing Centre - GFZ

According to the discussions between GFZ and LC

- the long term data archive will be maintained by LC,
- data conversion and processing will be done by GFZ.

How to get data to GFZ?

Initial solution: GNSS data and meteo via FTP

Using lftp software with a batch-file '**SyncGnssGruan.bat**' (by Michael Sommer).

For fine-tuning:
Edit the script and correct following lines:
* set lftp_cmd=< real full path to unpacked lftp.exe file, like D:\Tools\lftp\bin\lftp.exe >
* set local_path=< special full path to data directoy.
Please use '/' for '\' and ' /cygdrive/d/' for 'D:\' >
* set time_range=< e.g. now-1days or now-7days or ... >

```
@echo off
rem ============================================
rem === Upload GNSS files to GRUAN Lead Centre ===
rem ============================================
rem === Version: 1.0, 2014-02-03
rem === Author:  Michael Sommer
rem ============================================

rem *** Define ftp server of GRUAN Lead Centre ***
set ftp_server=ftp://ftp-incoming.dwd.de
set ftp_user=gruantmp
set ftp_pw=Euhoarv.
set ftp_path=in/processing/rannat/raw

rem *** Define local paths ***
set lftp_cmd=D:\Tools\lftp\bin\lftp.exe
set local_path=/cygdrive/d/TestFiles

rem *** Define additional properties ***
set time_range=now-1days

rem *** Use command LFTP ***
rem    (see website http://lftp.yar.ru/)
%lftp_cmd% %ftp_server% -u %ftp_user%,%ftp_pw% ^
-e "mirror --reverse --verbose --newer-than='%time_range%' %local_path% %ftp_path% && exit"

echo Upload finished.
rem FINISH batch script
```

RAW DATA FORMATS

Accepted data will be receiver proprietary
format (if the GFZ conversion tool accepts this format) in any sample-rate, or **RINEX version 3**
with 30 sec sample rate. (hourly or daily basis)

Both, LC and GFZ, installed FTP server to exchange GNSS raw and RINEX data,
metadata and products. Lindenberg and Ny Alesund are the first two sites for data flow. GFZ has developed their own Data Logging Tool for collecting/sending data from the sites for processing. It could be used at all sites (if decided so and agreed with GFZ).

The work is in progress (Lauder site has tried), but additional work needs to be done for supporting met-RINEX data flow and some hardware setups.

After the data can be regularly obtained from the first sites, the next step will be to specify the needs for related metadata and if/how to develop a similar tool for GNSS-data as it is done for radiosondes.

We must be aware about potential problems in data stream

... having ready-to-use strategies how to overcome them.

GRUAN – network as a network, operated by people and supported by standard hard- and software.

To handle everything as well as possible, technical documents have been Published (available or soon available on www.gruan.org documents):

- **GRUAN Ground-based GNSS Site Guidelines (TD6)**
- **Guidelines on operational use and data exchange protocols for GNSS water vapour**
- **Managing changes in GRUAN GNSS-PW product**

Raw data quality from the site is critical for data analysis. Automatic usage of TEQC tools (http://facility.unavco.org/software/teqc/teqc.html).
Surface met info from nearby meteostations can be often better quality guaranteed (regularly calibrated). Would be good to use some interpolated value for GNSS-site pressure sensor to avoid accidental large biases (these exist...)

IMPORTANCE OF METADATA – trees, buildings, snow/ice, severe weather...

Supporting continuity and quality

Every data collecting system has temporary gaps in data stream

a) **Planned**
b) **Unplanned**

HELP FROM DOCUMENTATION

Guidelines on operational use and data exchange protocols for GNSS water vapour

The document presents (best practices) draft guidelines on operational use and data exchange protocols for GNSS water vapour.

GNSS Data Table
"GRUAN GNSS Data and Product Table" & "Format Specification for COST-716 Processed GPS Data"
The table will be updated by GFZ whenever the E-GVAP document is updated (not very frequently).

The firs two documents and the GNSS Site Guidlines (TD6) give instructions and recommendations how to support the system with high quality raw data. The next (Managing changes in GRUAN GNSS-PW product) gives guidlines how to guarantee the quality for GNSS-PW data stream during long operation periods while changes come inevitable.

Managing changes in GRUAN GNSS-PW product

(covers both technical and data proccessing aspects)

These changes (termed as “7 items”) include:

1. GNSS instrumentation
2. operating procedures
3. GNSS data processing algorithms
4. instrument maintenance (e.g. firmware bug fix or upgrade) and operators
5. location of GNSS instruments
6. operating environments for GNSS instruments and other factors
7. auxiliary measurements and data (Ps and Tm) used to derive PW

Data gaps due to (planned) changes...

(Ref. Managing changes in GRUAN GNSS-PW product)

With management of changes the following principles are considered:

Embracing and preparing for change: disadvantages of making a change must be weighed against the advantages and benefits that are to be gained.

Change event notification: Whatever is the origin of the proposed change, the change event notification is sent to the GRUAN Lead Centre as an email

Justification of change: Assessment report must be submitted in which advantages and disadvantages of making the change.

Preparing for change: A quantitative assessment of the impacts. For instance the change of GNSS software may need an assessment period of at least 12-month in order to assess its performance under all the seasons. The impact on both the GNSS-PW product and its uncertainty needs to be assessed.

Validating impacts: ensure that the change is properly managed so that systematic biases and/or
drifts between the old and new GNSS-PW data are minimized.

Single changes: as many similarities as possible between the old and new systems should be maintained.
Multiple simultaneous changes (i.e. antenna and antenna location) should be avoided.

Network homogeneity: Maintaining network-wide homogeneity of GNSS-PW data is important. If change is implemented unilaterally (e.g. involving only one country or a single GNSS site), that change may introduce inconsistency with other stations in the network.

Supporting reprocessing: The raw GNSS data, as well as detailed metadata collected during change events,
need to be carefully collected so that reprocessing can be easily achieved.

Data versioning: Every reprocessing generating a new homogeneous time series of the full record of GNSS
measurements must be reflected in an increment in the data version (in GRUAN archives).

Monitoring changes

The importance of metadata

Validating managed changes using parallel observations

User-Friendliness

The majority of potential users will loose their motivation to use any data if the access and overview is complicated

Not only the data (GNSS-PW) should be easily accessible, but also information about the periods while the data is missing (access to metadata).

FINDING WAYS, HOW TO MAKE THE UNCERTAINTY ANALYSIS TRANSPARENT AND UNDERSTANDABLE FOR END-USERS.

... AND NOT FORGETTING THE NETWORK INFRASTRUCTURE (TOOLS FOR HELPING QUALITY CHECI AND SUPPORTING MONITORING OF THE DATA FLOW)

THANK YOU FOR YOUR ATTENTION!