GNSS-PW Progress

Session 5: Other GRUAN products

Markus Bradke

Helmholtz-Centre Potsdam - GFZ German Research Centre for Geosciences
Telegrafenberg, 14473 Potsdam, Germany
Department 1: Geodesy and Remote Sensing

Road Map

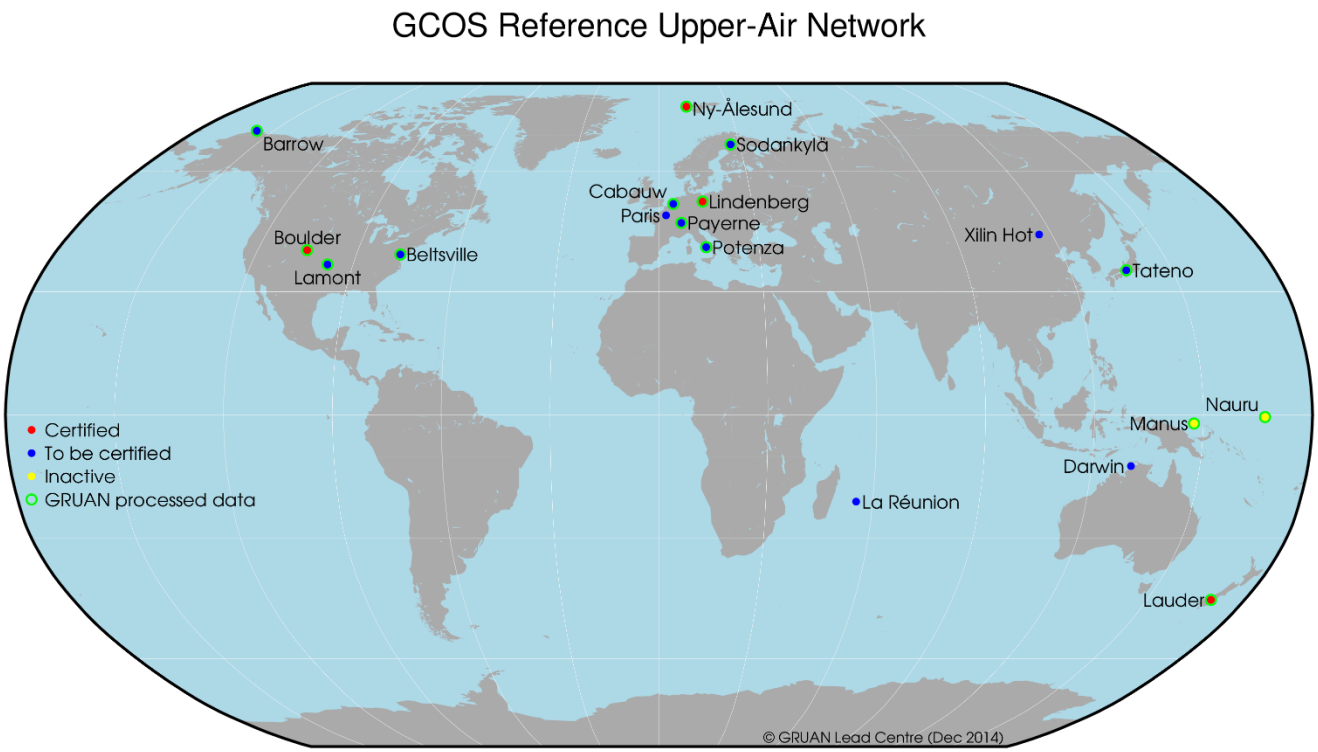
- ✓ GNSS Station Installation
  - ✓ Background
  - ✓ Principles & Requirements
- ✓ GFZ GNSS Data Centre
  - ✓ Processing of GNSS data
  - ✓ Archiving of GNSS data
- ✓ GFZ GNSS Metadata Handling
  - ✓ Objective and Sensitisation for GNSS metadata
  - ✓ (All-in-)One solution

GNSS Station Installation

Background

- Ground-based GNSS-PW as Priority 1 measurement in GRUAN
- Derivation of atmospheric parameters from GNSS observations requires analysis of GNSS data
  - Zenith Total Delay (ZTD)
  - Precipitable Water Vapour (PW)
- Usage of precise analysing methods prerequisites the obedience of certain standards and conventions to ensure quality of the GRUAN Network

GNSS Station Installation



- Small Networks need to be effective

- High requirements regarding location, monumentation, equipment and operation (IGS_MON, GRUAN_TD-6)

Fig.: GRUAN Network Map (December 2014)

GNSS Station Installation

Monumentation

- Monument must be grounded on a long-term stable and solid soil
- Avoid using locations with known geological instabilities (salt domes, mining districts, fluctuating groundwater)
- Clear horizon with minimal obstructions > 10 degrees elevation
- No significant changes of surroundings (buildings, trees, constructions, etc.) in (near) future
- Avoid regions with surface vibrations (high traffic, ocean waves, etc.)
- Antenna height over ground: > 45 cm
- To think about: Derivation of soil moisture possible (antenna height over ground ~ 2 m, untilled surroundings, clear „field“)

GNSS Station Installation

Monumentation

- Characteristics of satellite signal reception of antenna influenced by Near Field
- Keep distance to potentially reflecting objects (metal containers, water sources, etc.) to minimize multipath effects → ChokeRing
- Monument must be higher than snowfall levels
- Avoid nearby high voltage power lines
- Avoid radio frequency interferences

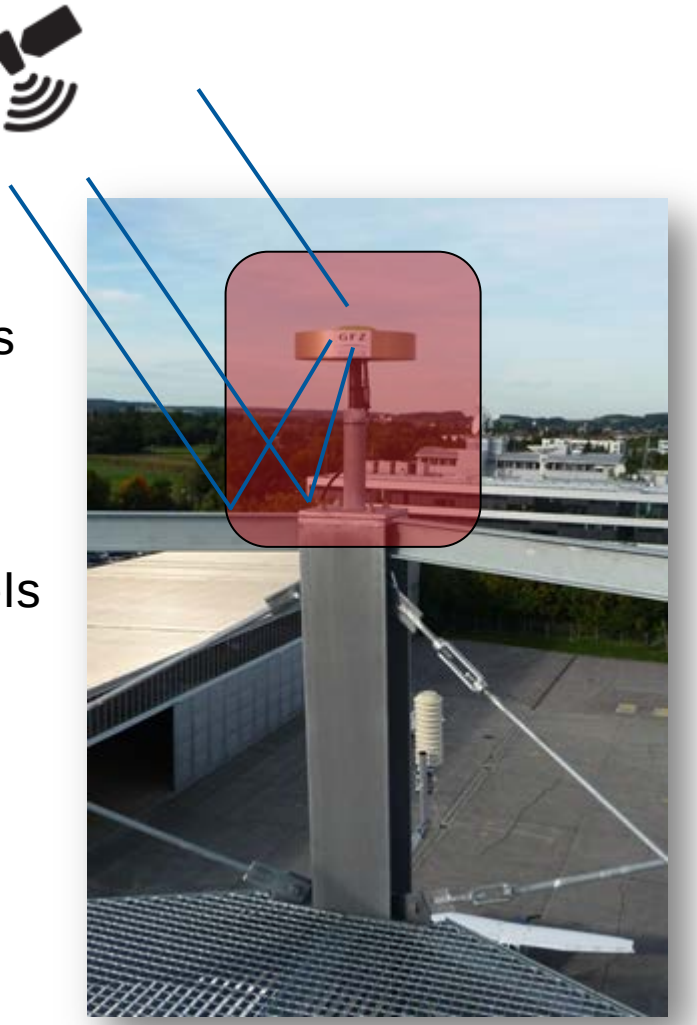


Fig.: Antenna Near Field effects

GNSS Station Installation

Monumentation examples

GNSS Station Installation

Antenna

- Antenna type should be approved by the IGS (IGS_RATAB)
- Individual calibration is desirable

- Orientation to True North (North mark / Antenna cable)

- Fixed attachment (motion < 0.1 mm) to Antenna Mounting Point

- Surveying of eccentricities (N E U) from station marker to Antenna Reference Point (ARP) with accuracy of 1 mm (Distance < 5 m)

→ needs to be reported in Site log and RINEX header

- Antenna Change? Parallel measurement if possible with old and new antenna configuration

GNSS Station Installation

Radome

- Avoid using additional radomes if circumstances don‘t make it necessary (e.g. wildlife, antenna security, weather)
- Avoid using non-spherical radomes
- Use of radome effects the estimated vertical component of a coordinate
- Cause errors of 2 mm to 40 mm depending on the cover type, the antenna type, and the elevation cutoff angle used for data processing (Braun et al. 1997)
- If you use a radome, calibration of antenna/radome pair is required

Fig.: USGS short antenna dome

GNSS Station Installation

Receiver

- Capability to track code and phase on L1/2

- Minimum sampling interval: 30 s (better use 1 Hz and sample after)
- Elevation mask: ≤ 3 deg

- The future will come:
  - Use RINEX v3 as exchange format (to record all satellite systems)
  - Use receivers that are capable to be updated to Multi-GNSS constellation (option files)

- From the perspective of a Data Centre:
  - Use receiver manufacturers that reveal their data formats (each vendor provides own data format)
  - Usage of one converter tool instead of multiple easier to implement

GNSS Station Installation

Meteorological Sensors

- The minimum set of observables: pressure and temperature
  - Pressure sensor accuracy: ≤ 0.5 hPa
  - Temperature sensor accuracy: ≤ 0.1 Kelvin

- Instrument drift and bias must be minimized through routine calibration

- Exchange format: RINEX (GFZ can provide Tool for Vaisala sensors)

- Measurement of height difference between Antenna and Pressure Sensor (Accuracy 1 m or better)

- Interval: ≤ 60 min (10 min preferred)

GNSS Station Installation

What else?

- Backup as much as you can (afford)
- Continuous electric power (UPS)
- Data access via internet, satellite link, etc.
- Monitoring of system / Remote switch
- VPN (Virtual Private Network) for secure data transfer / access
- Redundant PC for storage of data (additional storage on receiver is expensive)

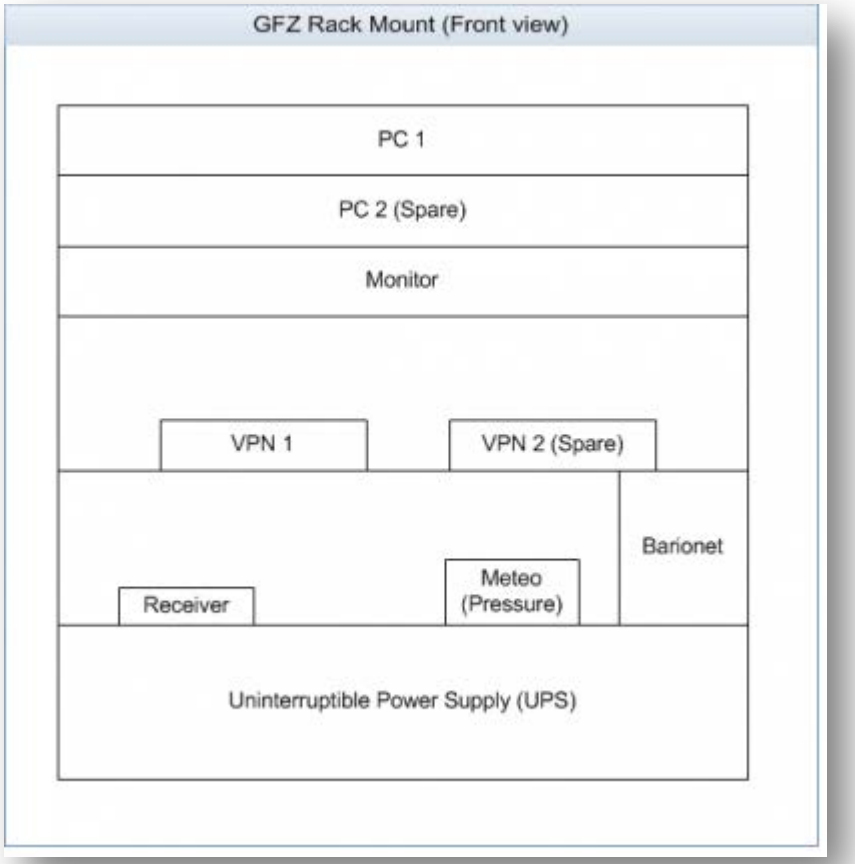
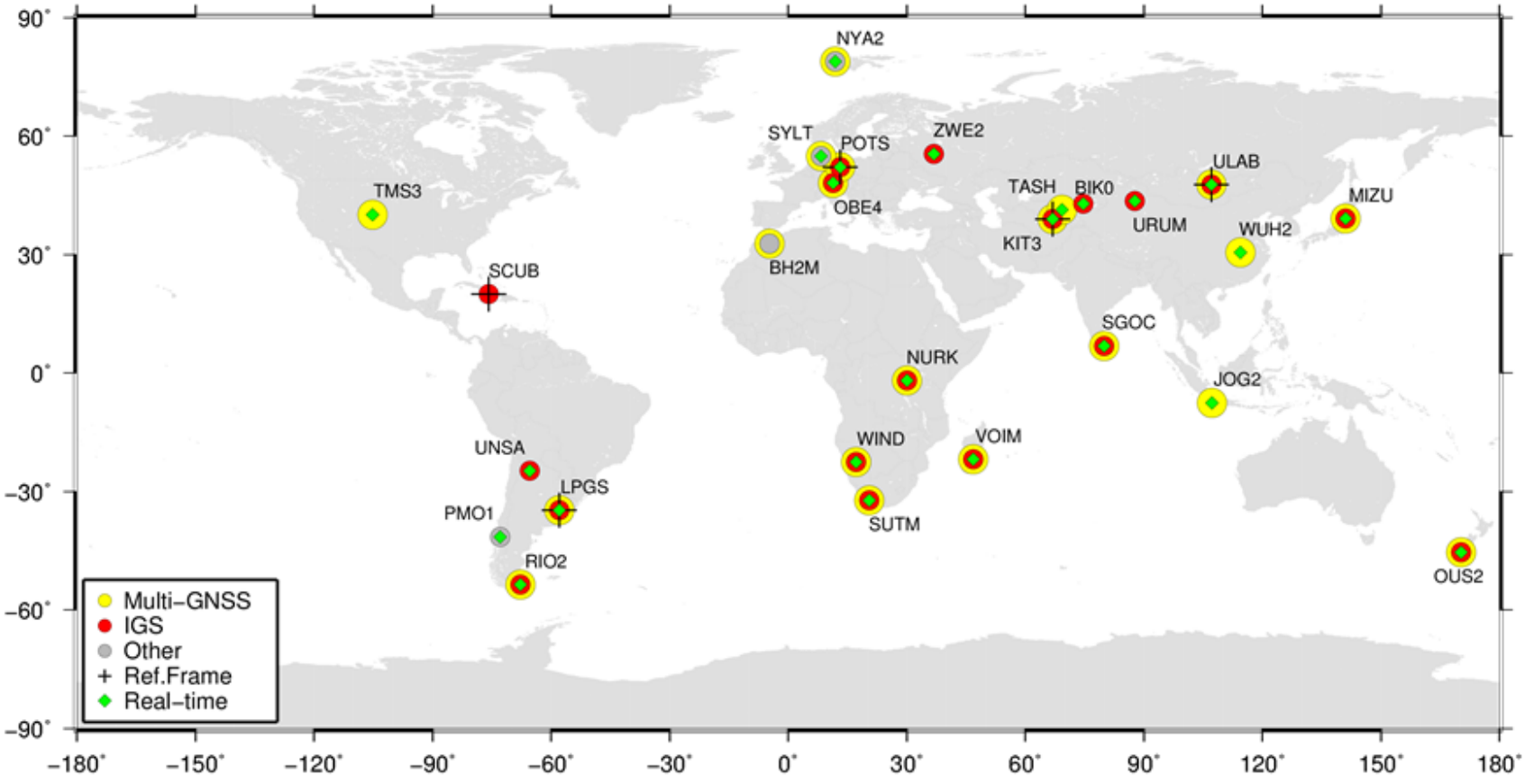


Fig.: The GFZ Global Station Setup

GFZ GNSS Data Centre

Global GNSS Network



GMT 2014 Oct 21 11:08:12

GFZ GNSS Data Centre

International contribution

- GFZ Operational Data Centre (ODC)
  - 21 stations @ **IGS** International GNSS Service, 6 core stations
  - 20 stations @ **MGEX** Multi-GNSS EXperiment
  - 15 stations @ **GRAS** GNSS Receiver for Atmospheric Sounding within MetOp
  - 02 stations @ **EPN** EUREF Permanent Network
  - 04 stations @ **ESA** European Space Agency: Galileo Experimental Sensor Stations
  - 02 stations @ **GRUAN** GCOS Reference Upper Air Network

GFZ GNSS Data Centre

Processing of GNSS data

- Recorded data are processed in a 5-step processing chain
  - Collect: Collection of incoming data
  - Prepare: Preparation of data (Decompression, Dehatanaka, Renaming of files)
  - Raw2RNX: Conversion of raw binary receiver files to RINEX v3
  - RNXCheck: Syntax check of RINEX files, metadata check vs. database
  - Export: Distribution of generated files to several destinations (e.g. GRUAN LC)

- Provision of data in different combinations:
  - High-rated data: 15M-1Hz
  - Spliced/sampled data: 01H-30S, 01D-30S

- Monitoring of data availability

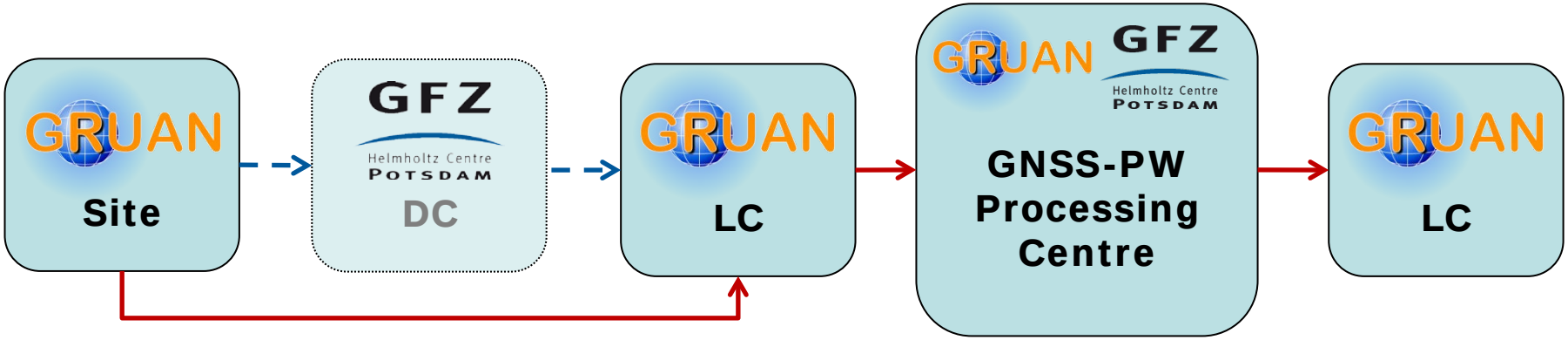
- Real-Time NTRIP streams to IGS and GFZ casters

GFZ GNSS Data Centre

Archiving of GNSS data

- RINEX v3
  - Observation data
  - Navigation data
  - Meteorological data (needs to be generated individually)

- Receiver RAW binaries
  - RINEX is just a format generated by a converter
  - Archiving of receiver binaries are necessary for re-generation of RINEX



GFZ GNSS Metadata Handling

Motivation

- GNSS metadata is an important topic / key for a good analysis
- Precise analysis of GNSS observation data based on a variety of station and satellite metadata
- Consistency, integrity and validity of metadata must be ensured
- Status Quo:
  - Storage in ASCII files
  - Inconsistencies in metadata
  - Connecting different metadata unmanageable
  - Too many different metadata sources → Usage of different metadata sets by AC‘s

GFZ GNSS Metadata Handling

Objective

- Development of semisys (**Se**nsor **M**eta **I**nformation **Sys**tem)
- Contains all metadata relevant for the analysis of GNSS data
- Storage: PostgreSQL Database
- Data Set: validated, consistent, up-to-date
- Access: HTTP/FTP interface
  - http://semisys.gfz-potsdam.de
  - ftp://ftp.gfz-potsdam.de/GNSS/metadata

GFZ GNSS Metadata Handling

semisys System Design

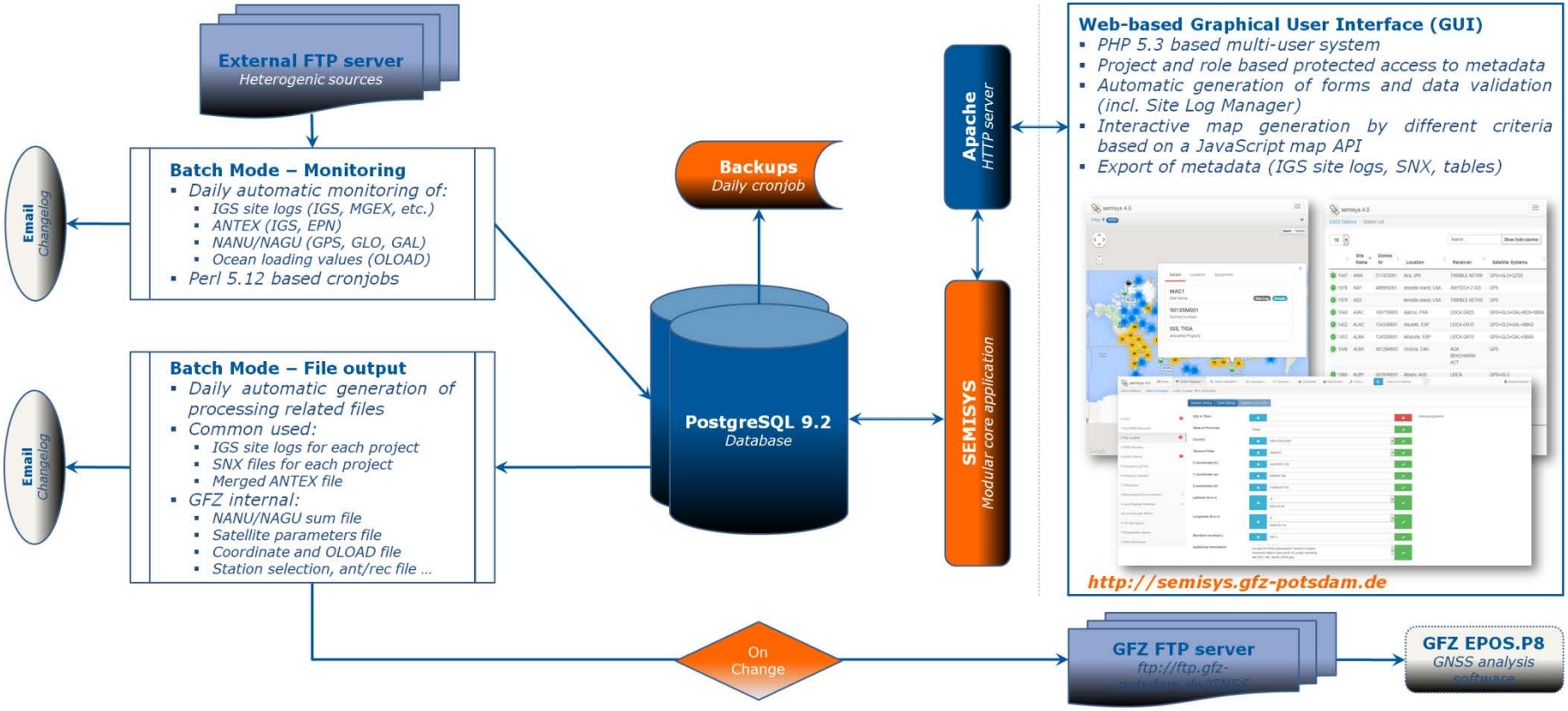


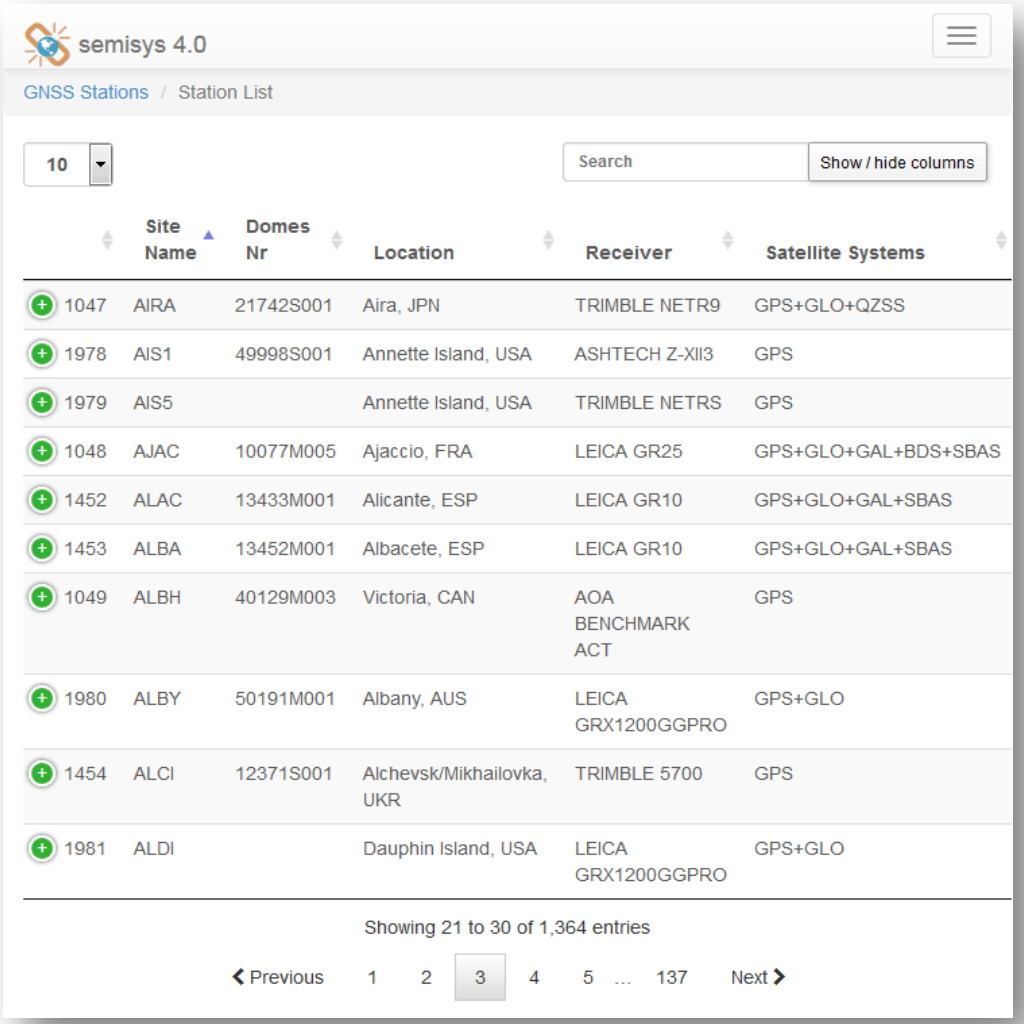
Fig.: Basic system design of semisys, data flow and client/server communication.

GFZ GNSS Metadata Handling

semisys Portfolio

GNSS Station List

- All available stations on one page
- Summary with most important facts (e.g. location, antenna, receiver)

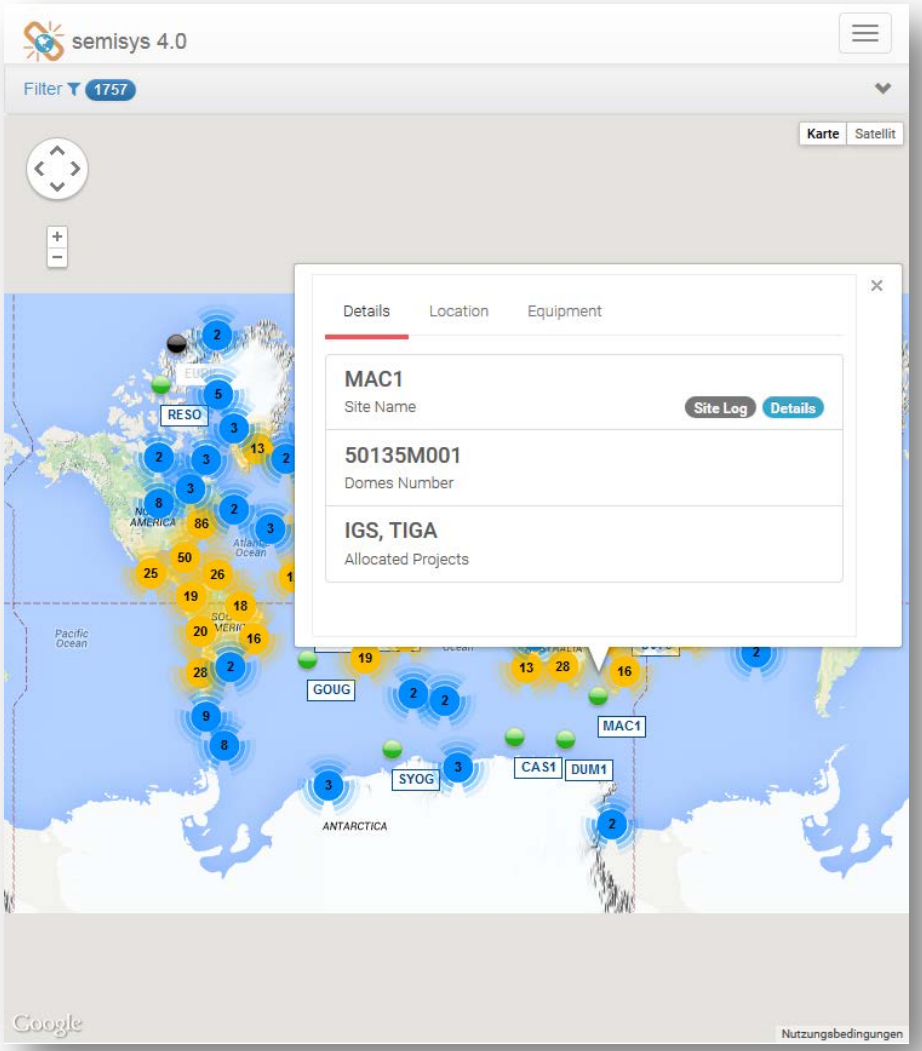


GFZ GNSS Metadata Handling

semisys Portfolio

GNSS Station Map

- All GNSS stations on one map
- Get details about a specific station

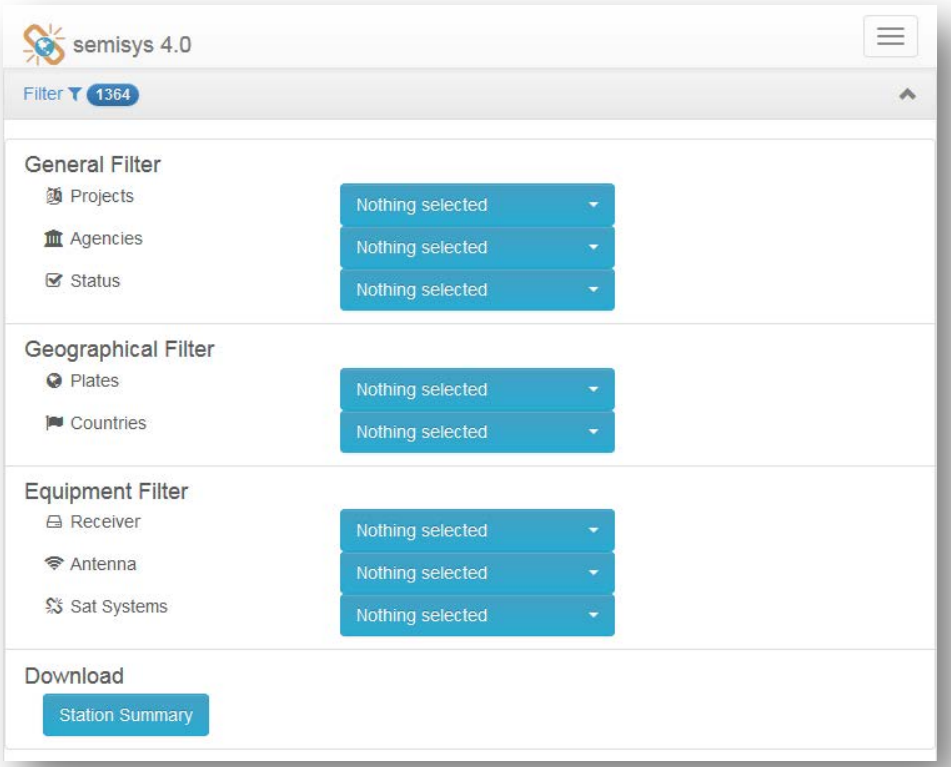


GFZ GNSS Metadata Handling

semisys Portfolio

GNSS Station Map

- All GNSS stations on one map
- Get details about a specific station
- Filter stations by different criteria

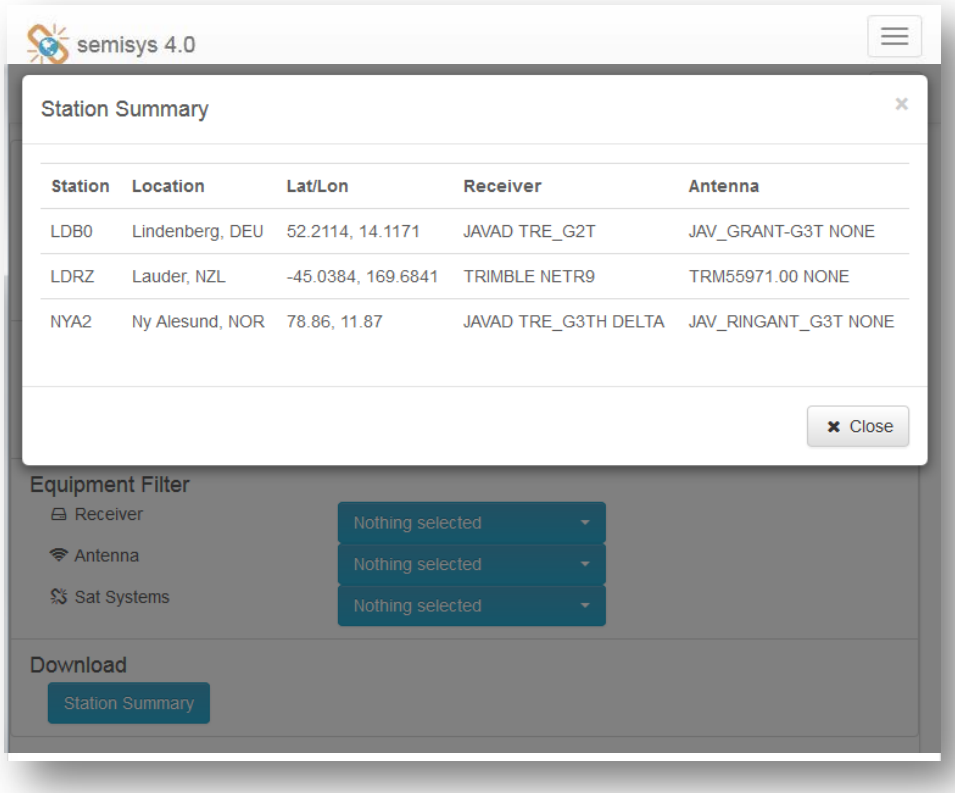


GFZ GNSS Metadata Handling

semisys Portfolio

GNSS Station Map

- All GNSS stations on one map
- Get details about a specific station
- Filter stations by different criteria
- Generate a station summary output



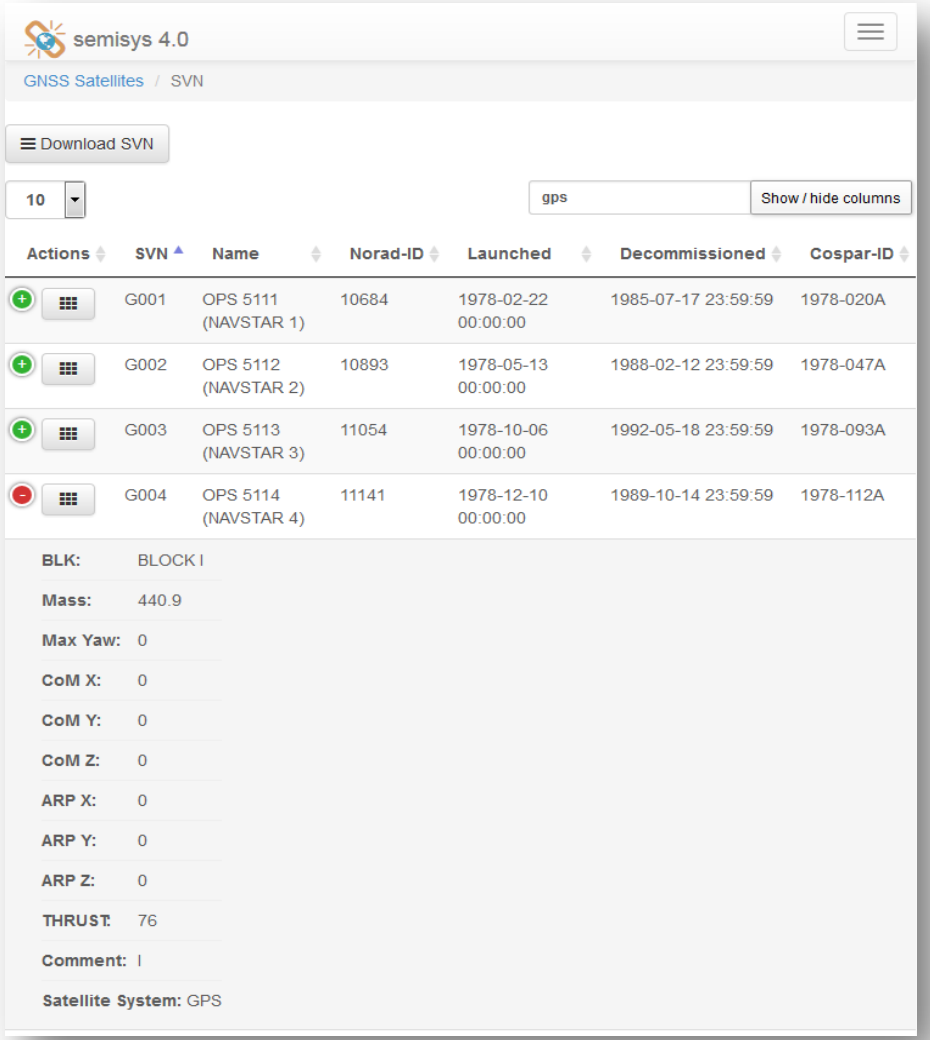
GFZ GNSS Metadata Handling

semisys Portfolio

GNSS Satellites

- Details about all available GNS:
  - GPS
  - GLO
  - GAL
  - BDS
  - SBAS
  - QZSS
- Allocation to PRN‘s (ID of satellite)

- NANU/NAGU for:
  - GPS
  - GLO
  - GAL



NANU: Notice Advisories for NAVSTAR Users (GPS)
NAGU: Notice Advisories for GLONASS/Galileo Users

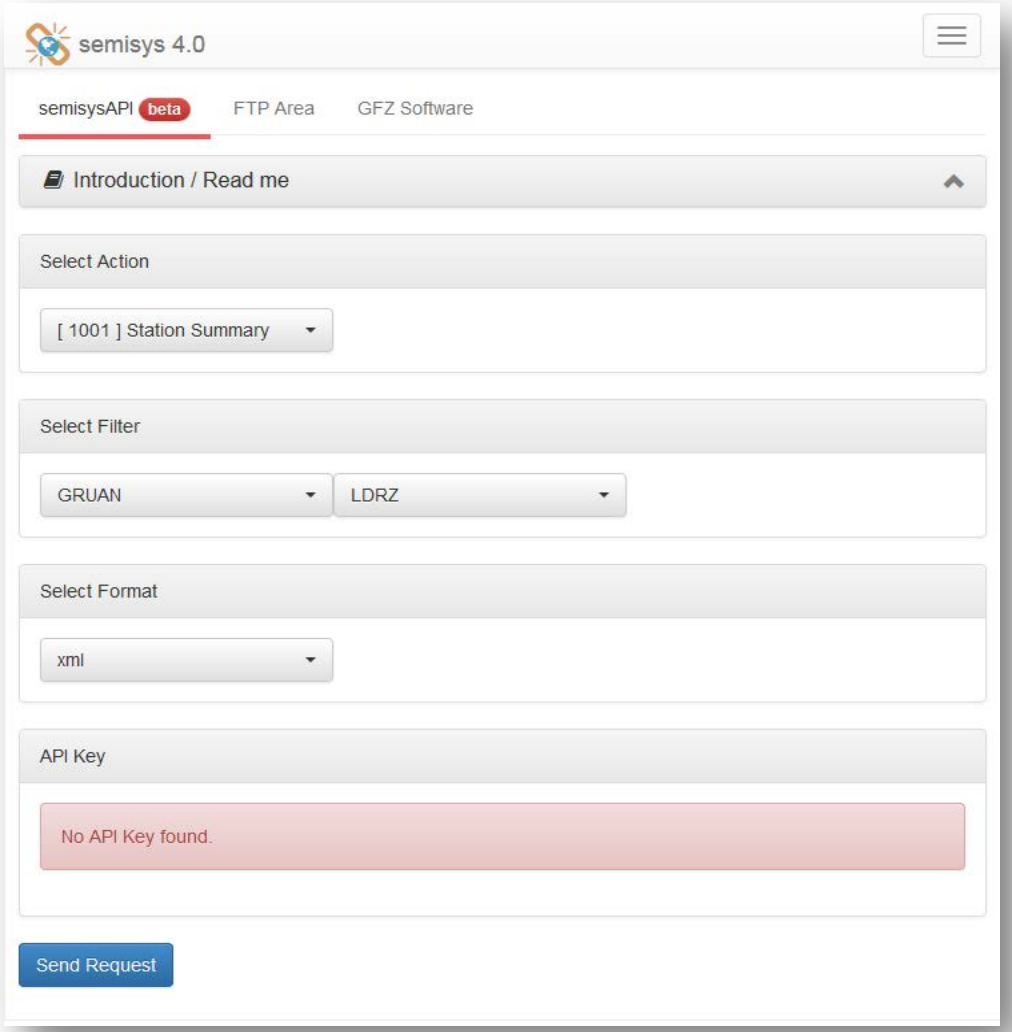
GFZ GNSS Metadata Handling

semisys Portfolio

semisysAPI

- Get access to the metadata via a web-based service

- Advantages:
  - Aggregation of metadata into an existing web infrastructure
  - Usage in a shell environment
  - Format independence (XML, JSON)



XML: eXtensible Markup Language
JSON: JavaScript Object Notification

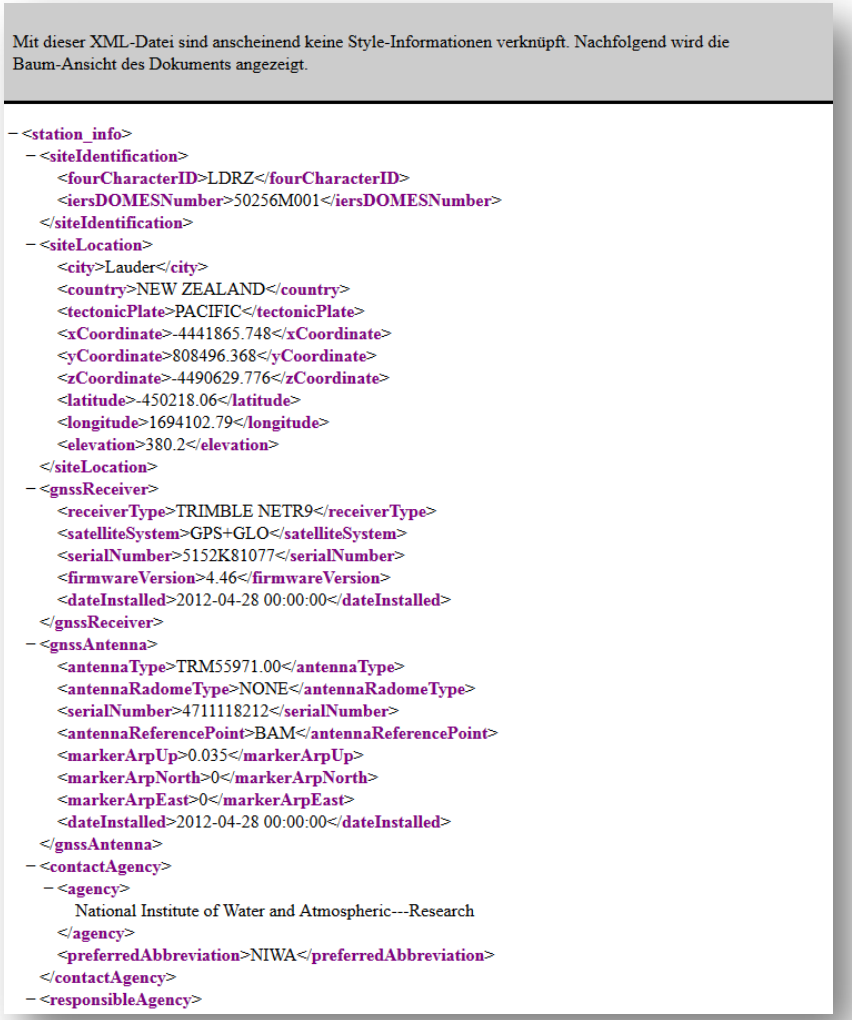
GFZ GNSS Metadata Handling

semisys Portfolio

semisysAPI

- Output dependent on selected action:
  - Station Summary XML, JSON
  - Site log ASCII
  - SINEX ASCII
  - SVN XML, JSON
  - PRN-SVN XML, JSON
  - NANU/NAGU XML, JSON

- Easy to extend

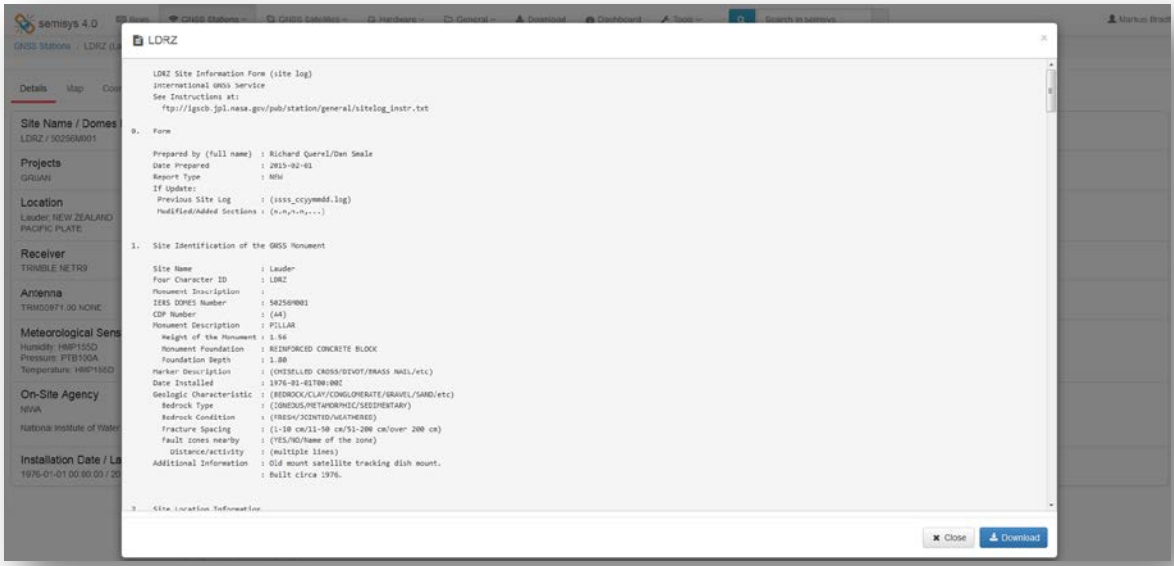


GFZ GNSS Metadata Handling

semisys Portfolio

GNSS Station Details

- Get general information about a specific station
- Site log (Revision Control)
- Processed initial coordinates and velocities
- Map view
- Site images

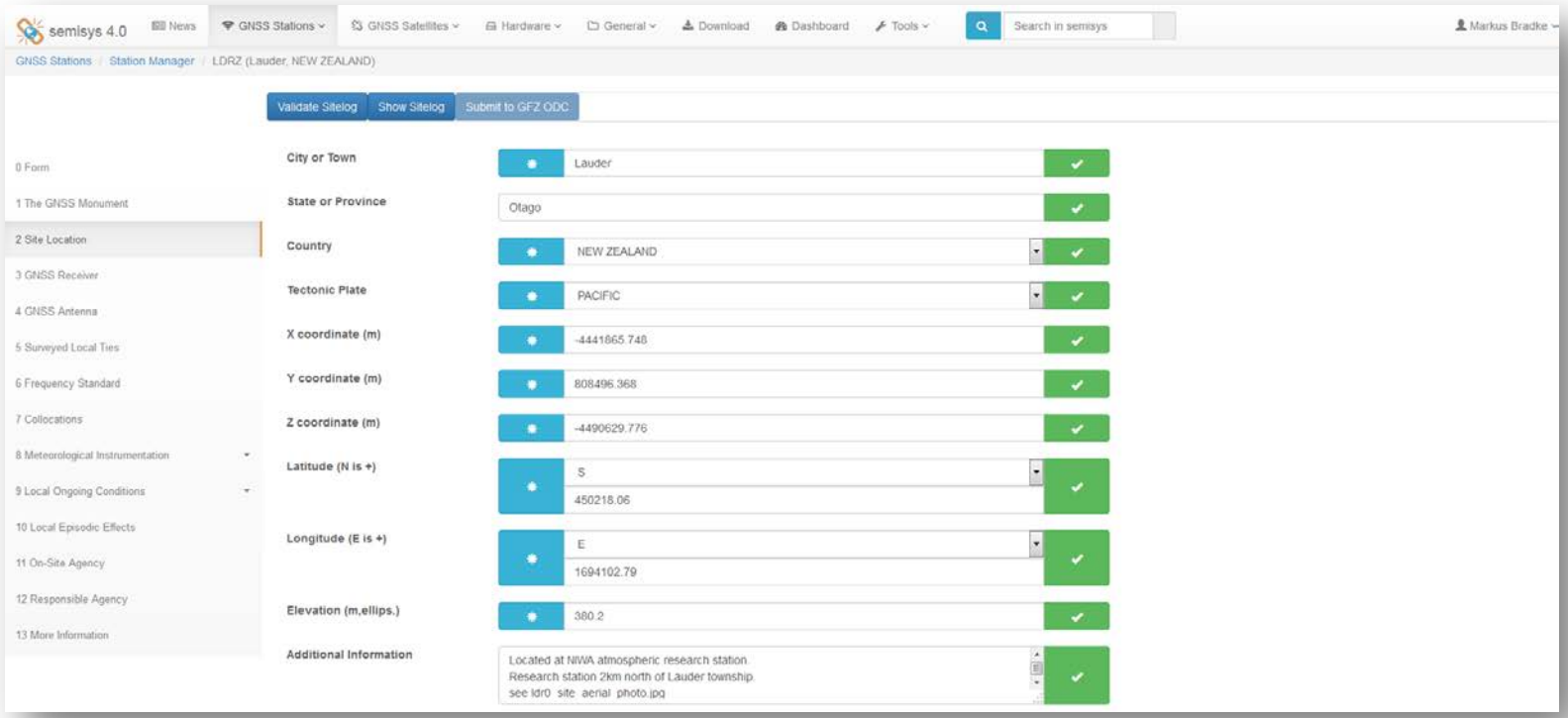


GFZ GNSS Metadata Handling

semisys Portfolio

GNSS Station Editor (in implementation)

- Web-based editing of site logs

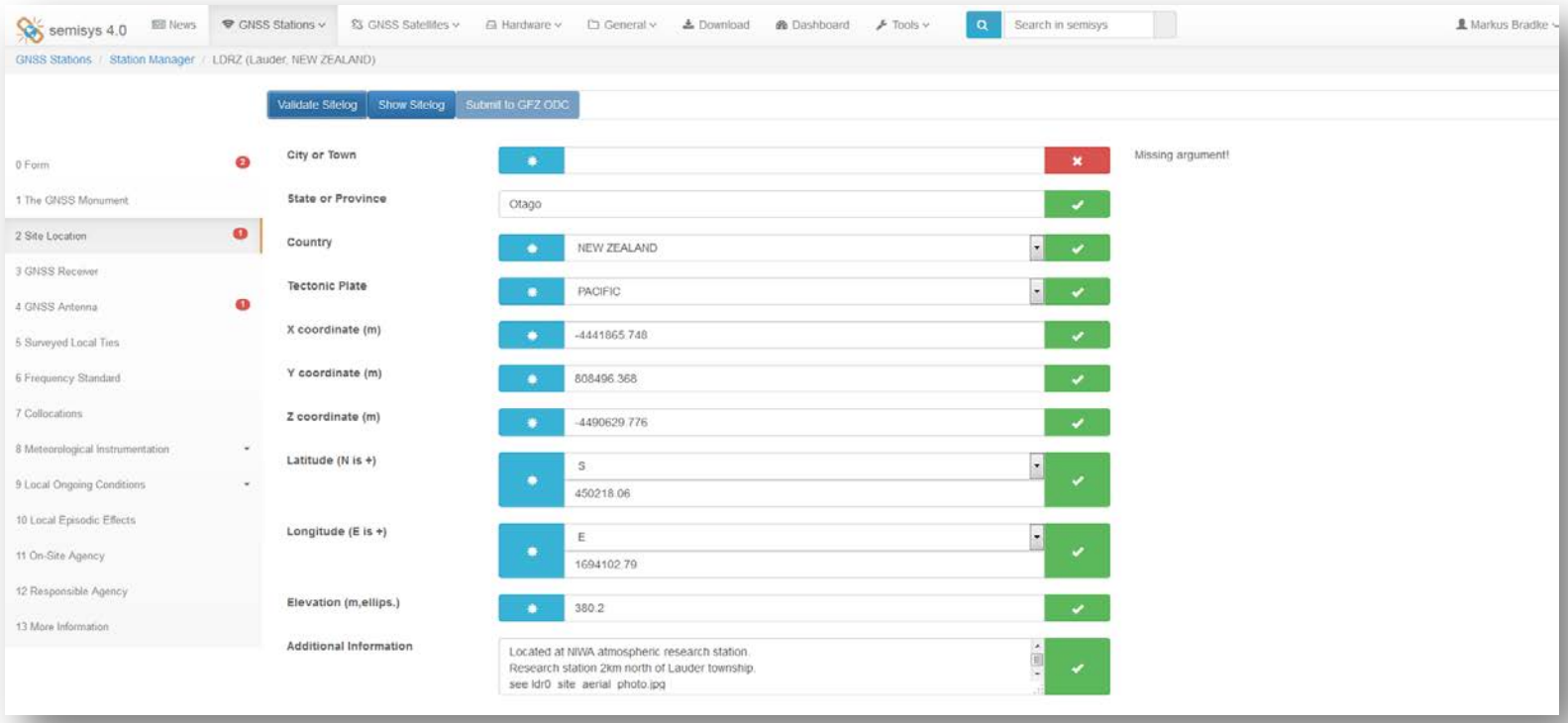


GFZ GNSS Metadata Handling

semisys Portfolio

GNSS Station Editor (in implementation)

- Web-based editing of site logs



GFZ GNSS Metadata Handling

Advantages and benefit

- semisys contains all relevant processing related metadata

- Advantages of database based approach wrt file based data handling
  - Central, easy and fast on-demand access to metadata
  - SQL (Structured Query Language) allows easy build-up of connections between metadata
  - Easy maintenance of station and satellite metadata based on a web editor
  - Validation of incoming metadata
  - Easy and flexible generation of processing relevant files

- semisys & GRUAN
  - Management of metadata via semisys
  - On-the-fly updates to GRUAN LC
  - Validity check RINEX header vs. site log information
  - Consistent metadata set

Contact

Operational Data Centre:

- Markus Bradke bradke@gfz-potsdam.de +49 331 288 1182
- Markus Ramatschi maram@gfz-potsdam.de +49 331 288 1746

GRUAN Analysis Centre:

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

References

- IGS_MON: http://igscb.jpl.nasa.gov/network/monumentation.html
- IGS_RATAB: http://igscb.jpl.nasa.gov/igscb/station/general/rcvr_ant.tab
- GRUAN_TD-6: http://www.dwd.de/bvbw/generator/DWDWWW/Content/Projekte/Gruan/Downloads/documents/gruan-td-6,templateId=raw,property=publicationFile.pdf/gruan-td-6.pdf
- J. Braun, B. Stephens, O. Ruud and C. Meertens: The Effect of Antenna Covers On GPS Baseline Solutions, University NAVSTAR Consortium, Boulder, CO, 1997