



GNSS-PW Progress

Session 5: Other GRUAN products

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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

GCOS Reference Upper-Air Network



- 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

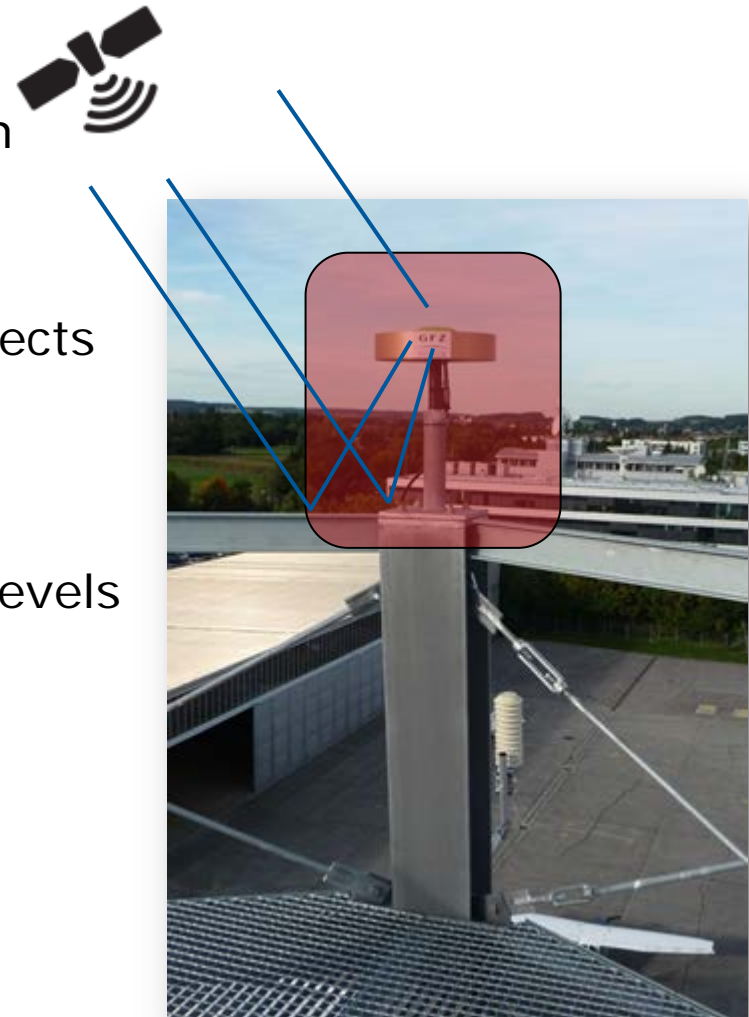
Monumentation

- 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



GNSS Station Installation

Monumentation examples



Lauder, NZL



Boulder, CO, USA



Sutherland, ZAF



Kitab, UZB

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

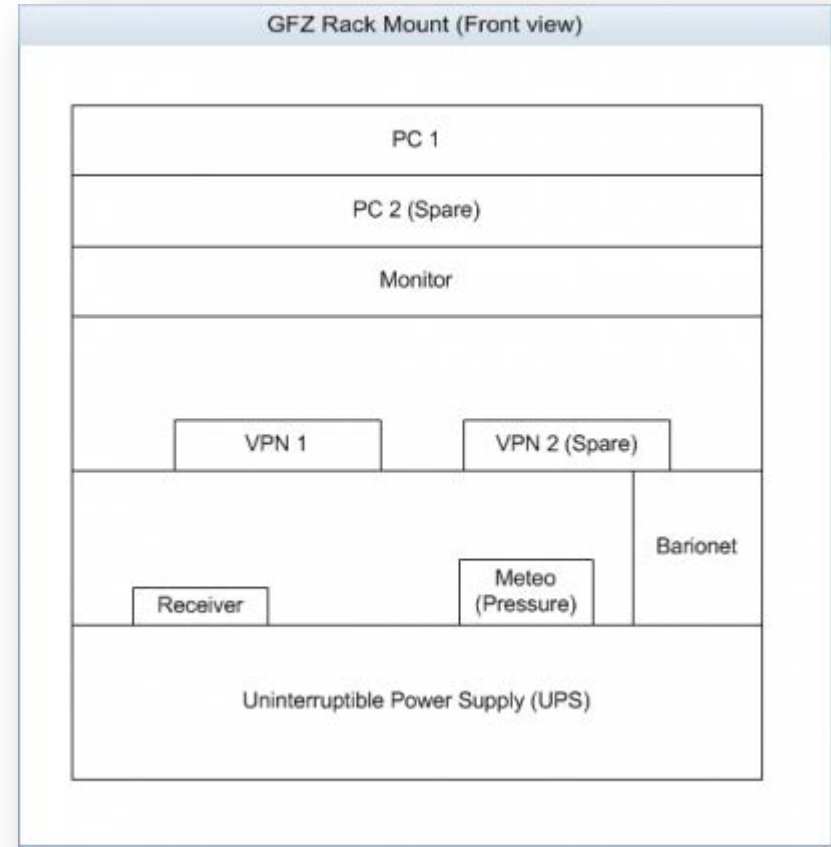
Meteorological Sensors

- 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

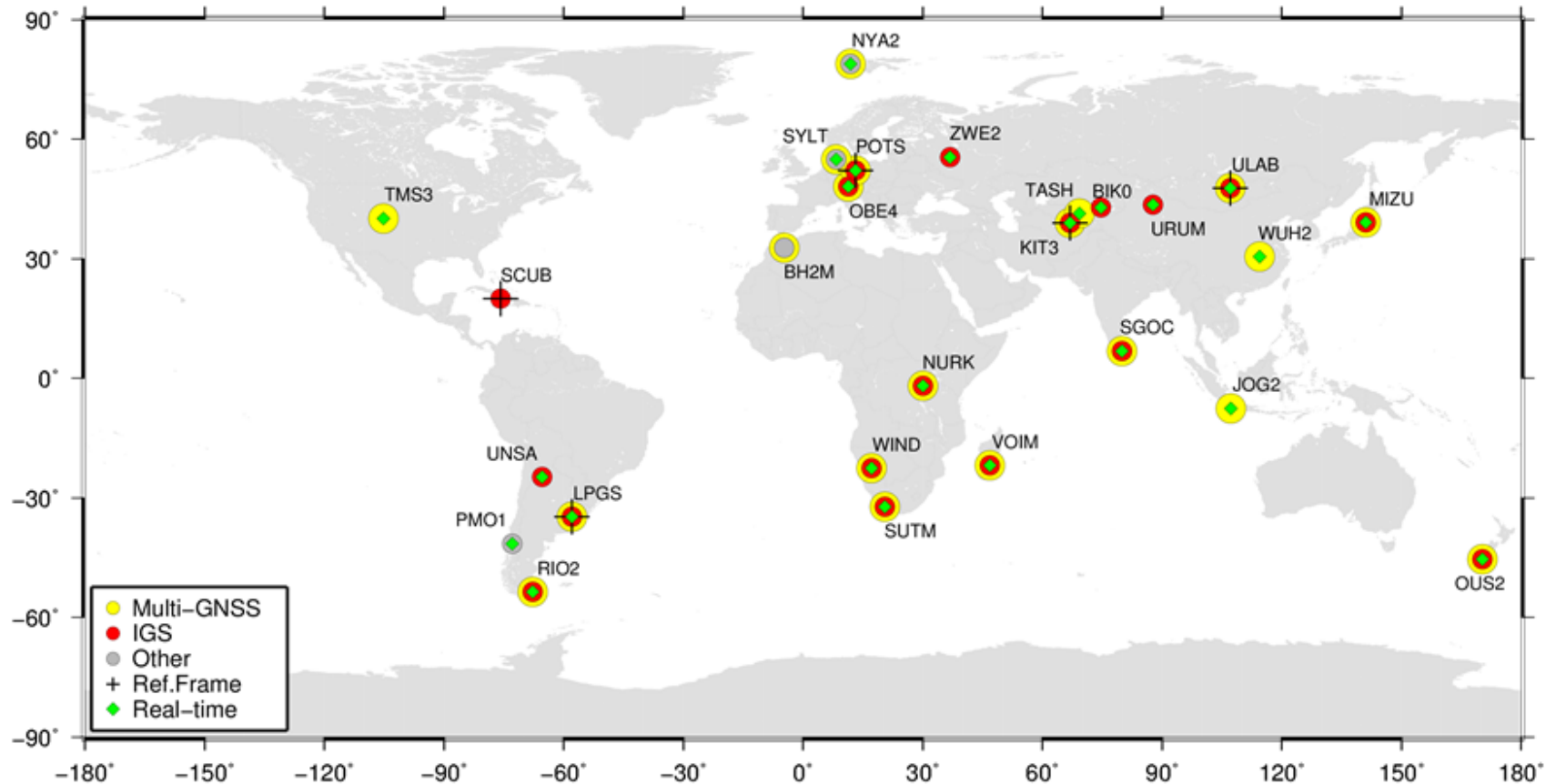
What else?

- 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)



GFZ GNSS Data Centre

Global GNSS Network



GM 2014 Oct 21 11:08:12

GFZ

Helmholtz Centre
POTSDAM

HELMHOLTZ
ASSOCIATION

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

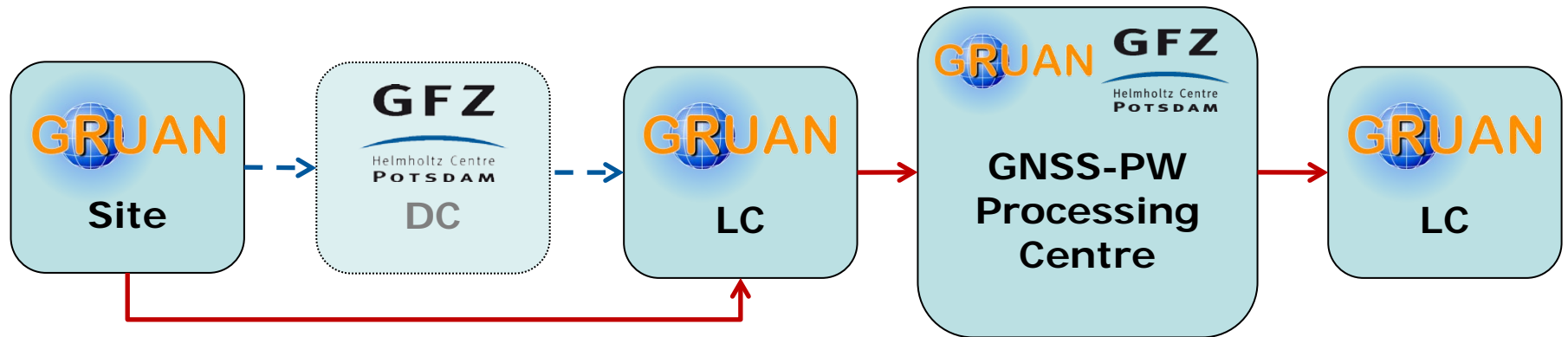
Processing of GNSS data

- 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

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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 (**S**ensor **M**eta **I**nformation **S**ystem)
- 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

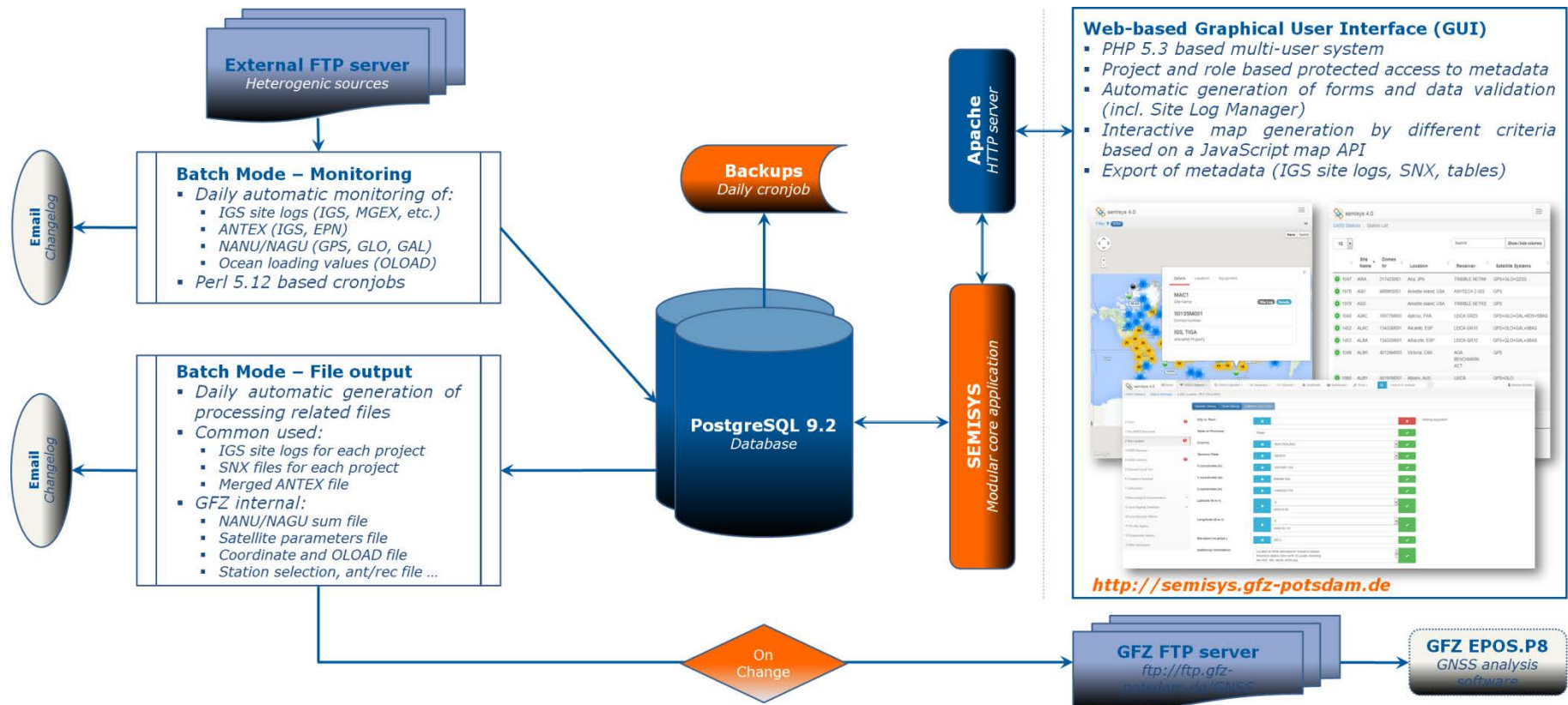


Fig.: Basic system design of semisys, data flow and client/server communication.

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)

semisys 4.0

GNSS Stations / Station List

10

Search

Show / hide columns

	Site Name	Domes Nr	Location	Receiver	Satellite Systems	
	1047	AIRA	21742S001	Aira, JPN	TRIMBLE NETR9	GPS+GLO+QZSS
	1978	AIS1	49998S001	Annette Island, USA	ASHTECH Z-XII3	GPS
	1979	AIS5	Annette Island, USA	TRIMBLE NETRS	GPS	
	1048	AJAC	10077M005	Ajaccio, FRA	LEICA GR25	GPS+GLO+GAL+BDS+SBAS
	1452	ALAC	13433M001	Alicante, ESP	LEICA GR10	GPS+GLO+GAL+SBAS
	1453	ALBA	13452M001	Albacete, ESP	LEICA GR10	GPS+GLO+GAL+SBAS
	1049	ALBH	40129M003	Victoria, CAN	AOA BENCHMARK ACT	GPS
	1980	ALBY	50191M001	Albany, AUS	LEICA GRX1200GGPRO	GPS+GLO
	1454	ALCI	12371S001	Alchevsk/Mikhailovka, UKR	TRIMBLE 5700	GPS
	1981	ALDI	Dauphin Island, USA	LEICA GRX1200GGPRO	GPS+GLO	

Showing 21 to 30 of 1,364 entries

1

2

3

4

5

...

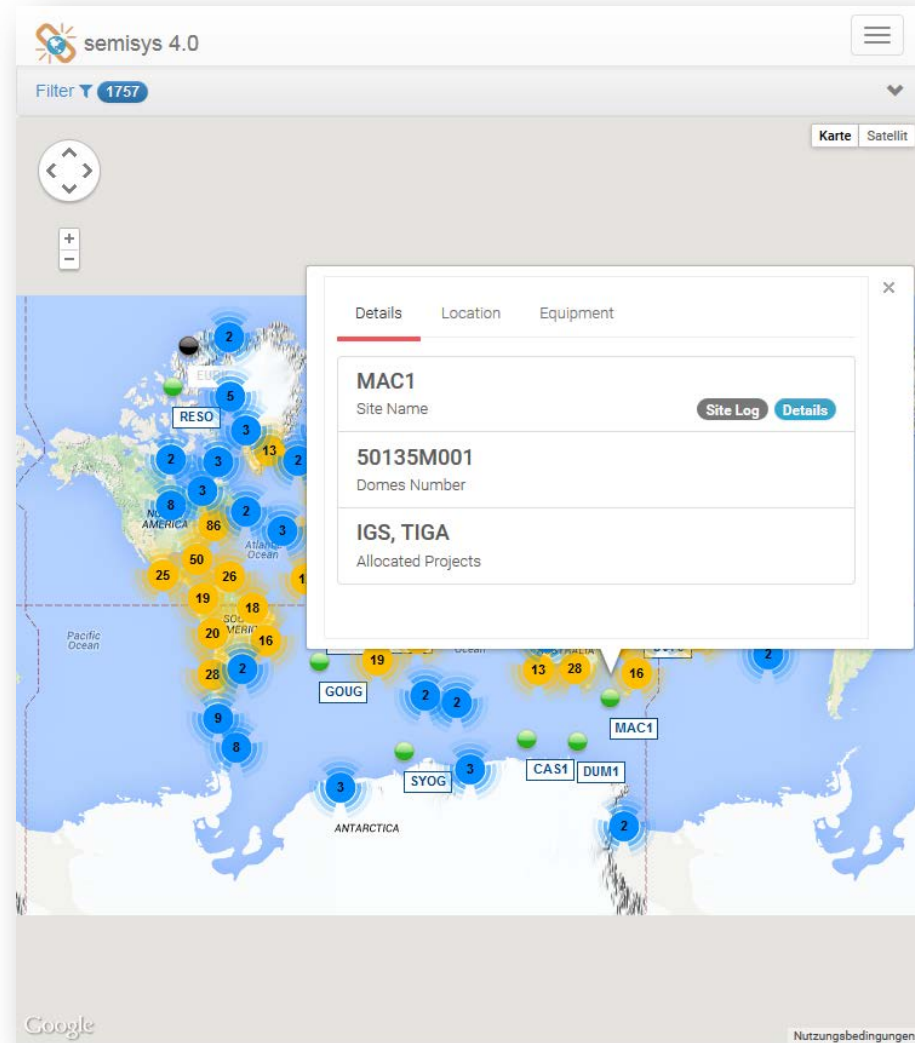
137

GFZ GNSS Metadata Handling

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GNSS Station Map

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

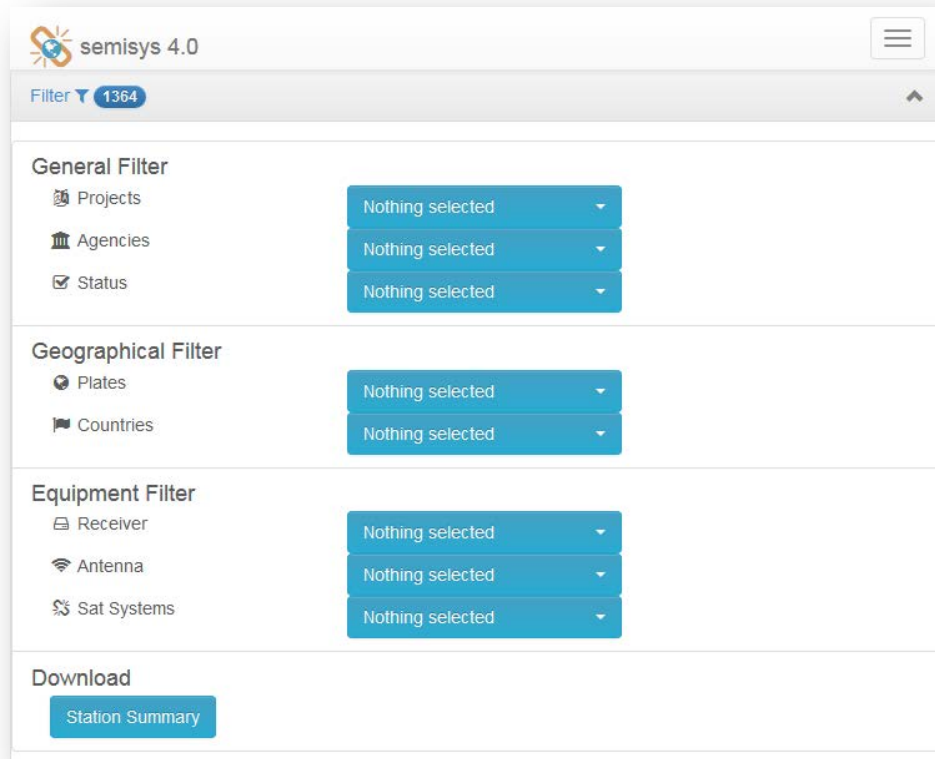


GFZ GNSS Metadata Handling

semisys Portfolio

GNSS Station Map

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



The screenshot displays the 'semisys 4.0' web application interface. At the top, there is a header with the 'semisys 4.0' logo and a filter count of '1364'. Below the header, the interface is divided into three main filter sections: 'General Filter', 'Geographical Filter', and 'Equipment Filter'. Each section contains a list of criteria with corresponding dropdown menus. The 'General Filter' section includes 'Projects', 'Agencies', and 'Status'. The 'Geographical Filter' section includes 'Plates' and 'Countries'. The 'Equipment Filter' section includes 'Receiver', 'Antenna', and 'Sat Systems'. All dropdown menus currently show 'Nothing selected'. At the bottom of the interface, there is a 'Download' section with a 'Station Summary' button.

Filter Category	Criteria	Selected Value
General Filter	Projects	Nothing selected
	Agencies	Nothing selected
	Status	Nothing selected
Geographical Filter	Plates	Nothing selected
	Countries	Nothing selected
Equipment Filter	Receiver	Nothing selected
	Antenna	Nothing selected
	Sat Systems	Nothing selected

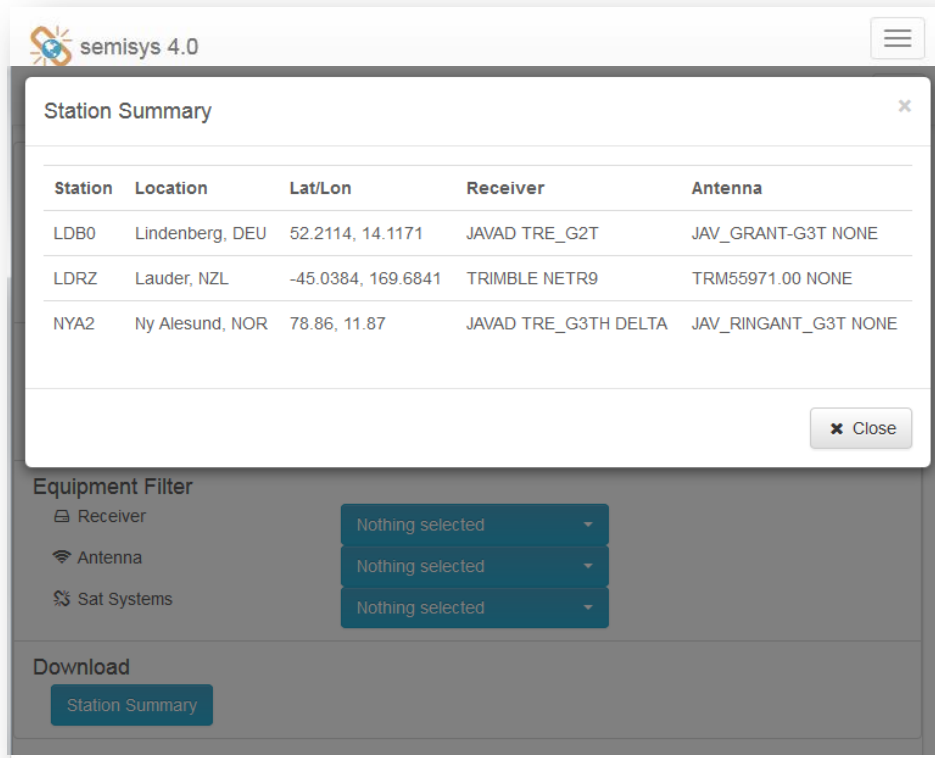
Download
Station Summary

GFZ GNSS Metadata Handling

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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



The screenshot displays the semisys 4.0 web application interface. At the top, the title "semisys 4.0" is visible. Below it, a "Station Summary" window is open, showing a table with the following data:

Station	Location	Lat/Lon	Receiver	Antenna
LDB0	Lindenberg, DEU	52.2114, 14.1171	JAVAD TRE_G2T	JAV_GRANT-G3T NONE
LDRZ	Lauder, NZL	-45.0384, 169.6841	TRIMBLE NETR9	TRM55971.00 NONE
NYA2	Ny Alesund, NOR	78.86, 11.87	JAVAD TRE_G3TH DELTA	JAV_RINGANT_G3T NONE

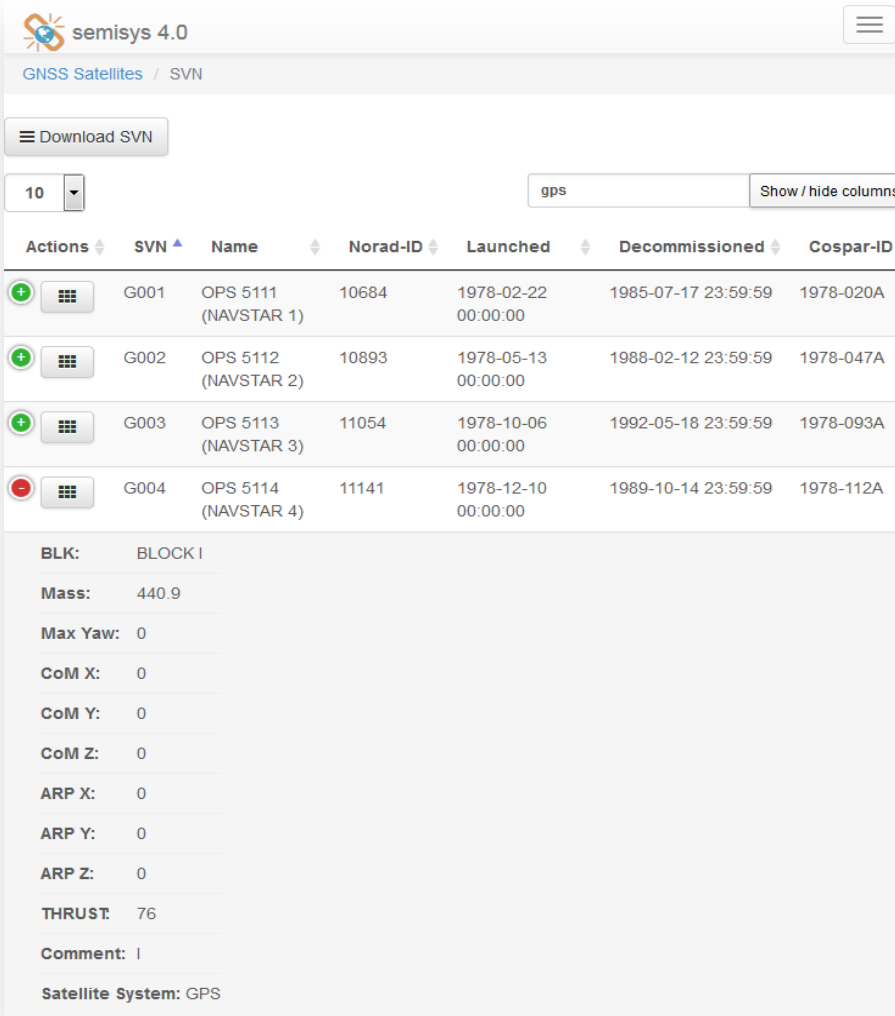
Below the table, there is a "Close" button. Underneath the summary window, the "Equipment Filter" section is visible, with three dropdown menus for "Receiver", "Antenna", and "Sat Systems", all currently set to "Nothing selected". At the bottom, there is a "Download" section with a "Station Summary" button.

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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



The screenshot shows the 'semisys 4.0' web application interface. At the top, there's a header with the semisys logo and version '4.0', and a breadcrumb 'GNSS Satellites / SVN'. Below the header is a 'Download SVN' button. A dropdown menu is set to '10' items, and a search filter 'gps' is applied. A 'Show / hide columns' button is on the right. The main table lists four GPS satellites (G001 to G004) with columns for Actions, SVN, Name, Norad-ID, Launched, Decommissioned, and Cospas-ID. Below the table, a detailed view for 'BLOCK I' is shown, including fields for Mass, Max Yaw, CoM X, CoM Y, CoM Z, ARP X, ARP Y, ARP Z, THRUST, Comment, and Satellite System (GPS).

Actions	SVN	Name	Norad-ID	Launched	Decommissioned	Cospas-ID
 	G001	OPS 5111 (NAVSTAR 1)	10684	1978-02-22 00:00:00	1985-07-17 23:59:59	1978-020A
 	G002	OPS 5112 (NAVSTAR 2)	10893	1978-05-13 00:00:00	1988-02-12 23:59:59	1978-047A
 	G003	OPS 5113 (NAVSTAR 3)	11054	1978-10-06 00:00:00	1992-05-18 23:59:59	1978-093A
 	G004	OPS 5114 (NAVSTAR 4)	11141	1978-12-10 00:00:00	1989-10-14 23:59:59	1978-112A

BLK:	BLOCK I
Mass:	440.9
Max Yaw:	0
CoM X:	0
CoM Y:	0
CoM Z:	0
ARP X:	0
ARP Y:	0
ARP Z:	0
THRUST:	76
Comment:	I
Satellite System:	GPS

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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)

The screenshot displays the 'semisys 4.0' web application interface. At the top, there is a navigation bar with 'semisysAPI beta', 'FTP Area', and 'GFZ Software'. Below this, a breadcrumb trail shows 'Introduction / Read me'. The main content area contains three selection sections: 'Select Action' with a dropdown menu set to '[1001] Station Summary', 'Select Filter' with two dropdown menus set to 'GRUAN' and 'LDRZ', and 'Select Format' with a dropdown menu set to 'xml'. Below these sections is an 'API Key' field with a red error message: 'No API Key found.' At the bottom of the form is a blue 'Send Request' button.

GFZ GNSS Metadata Handling

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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

Mit dieser XML-Datei sind anscheinend keine Style-Informationen verknüpft. Nachfolgend wird die Baum-Ansicht des Dokuments angezeigt.

```
- <station_info>
  - <siteIdentification>
    <fourCharacterID>LDRZ</fourCharacterID>
    <iersDOMESNumber>50256M001</iersDOMESNumber>
  </siteIdentification>
  - <siteLocation>
    <city>Lauder</city>
    <country>NEW ZEALAND</country>
    <tectonicPlate>PACIFIC</tectonicPlate>
    <xCoordinate>-4441865.748</xCoordinate>
    <yCoordinate>808496.368</yCoordinate>
    <zCoordinate>-4490629.776</zCoordinate>
    <latitude>-450218.06</latitude>
    <longitude>1694102.79</longitude>
    <elevation>380.2</elevation>
  </siteLocation>
  - <gnssReceiver>
    <receiverType>TRIMBLE NETR9</receiverType>
    <satelliteSystem>GPS+GLO</satelliteSystem>
    <serialNumber>5152K81077</serialNumber>
    <firmwareVersion>4.46</firmwareVersion>
    <dateInstalled>2012-04-28 00:00:00</dateInstalled>
  </gnssReceiver>
  - <gnssAntenna>
    <antennaType>TRM55971.00</antennaType>
    <antennaRadomeType>NONE</antennaRadomeType>
    <serialNumber>4711118212</serialNumber>
    <antennaReferencePoint>BAM</antennaReferencePoint>
    <markerArpUp>0.035</markerArpUp>
    <markerArpNorth>0</markerArpNorth>
    <markerArpEast>0</markerArpEast>
    <dateInstalled>2012-04-28 00:00:00</dateInstalled>
  </gnssAntenna>
  - <contactAgency>
    - <agency>
      National Institute of Water and Atmospheric---Research
    </agency>
    <preferredAbbreviation>NIWA</preferredAbbreviation>
  </contactAgency>
  - <responsibleAgency>
```


GFZ GNSS Metadata Handling

semisys Portfolio

GNSS Station Editor (in implementation)

- Web-based editing of site logs

The screenshot displays the 'semisys 4.0' web interface for editing GNSS station metadata. The top navigation bar includes links for News, GNSS Stations, GNSS Satellites, Hardware, General, Download, Dashboard, and Tools. A search bar and user profile (Markus Bradke) are also present. The main content area shows a form for editing site logs, with a sidebar on the left listing various form sections. The form fields include:

Form Section	Field	Value	Status
2 Site Location	City or Town	Lauder	✓
	State or Province	Otago	✓
	Country	NEW ZEALAND	✓
	Tectonic Plate	PACIFIC	✓
	X coordinate (m)	-4441665.748	✓
	Y coordinate (m)	808496.368	✓
	Z coordinate (m)	-4490629.776	✓
	Latitude (N is +)	S	✓
		450218.06	✓
	Longitude (E is +)	E	✓
		1694102.79	✓
	Elevation (m, ellips.)	380.2	✓
	Additional Information	Located at NIWA atmospheric research station. Research station 2km north of Lauder township. see IdR0 site aerial photo.jpg	

GFZ GNSS Metadata Handling

semisys Portfolio

GNSS Station Editor (in implementation)

- Web-based editing of site logs

The screenshot shows the 'GNSS Station Editor' web interface in the semisys 4.0 application. The interface includes a top navigation bar with links for News, GNSS Stations, GNSS Satellites, Hardware, General, Download, Dashboard, and Tools. A search bar and a user profile (Markus Bradke) are also present. The main content area is titled 'GNSS Stations / Station Manager / LORZ (Lauder, NEW ZEALAND)'. It features a sidebar with a list of form sections (0 Form, 1 The GNSS Monument, 2 Site Location, 3 GNSS Receiver, 4 GNSS Antenna, 5 Surveyed Local Ties, 6 Frequency Standard, 7 Collocations, 8 Meteorological Instrumentation, 9 Local Ongoing Conditions, 10 Local Episodic Effects, 11 On-Site Agency, 12 Responsible Agency, 13 More Information) and a main form area. The main form area has buttons for 'Validate Site Log', 'Show Site Log', and 'Submit to GFZ ODC'. The form fields include: 'City or Town' (empty), 'State or Province' (Otago), 'Country' (NEW ZEALAND), 'Tectonic Plate' (PACIFIC), 'X coordinate (m)' (-4441865.748), 'Y coordinate (m)' (808496.368), 'Z coordinate (m)' (-4490629.776), 'Latitude (N is +)' (S), 'Longitude (E is +)' (E), and 'Elevation (m, ellips.)' (380.2). Each field has a green checkmark icon indicating it is valid. The 'Additional Information' field contains text: 'Located at NIWA atmospheric research station. Research station 2km north of Lauder township. see ldr0 site aerial photo.jpg'. A 'Missing argument!' error message is visible next to the 'City or Town' field.

Form Section	Field Name	Value	Status
0 Form	City or Town		Missing argument!
1 The GNSS Monument	State or Province	Otago	✓
2 Site Location	Country	NEW ZEALAND	✓
3 GNSS Receiver	Tectonic Plate	PACIFIC	✓
4 GNSS Antenna	X coordinate (m)	-4441865.748	✓
5 Surveyed Local Ties	Y coordinate (m)	808496.368	✓
6 Frequency Standard	Z coordinate (m)	-4490629.776	✓
7 Collocations	Latitude (N is +)	S	✓
8 Meteorological Instrumentation	Longitude (E is +)	E	✓
9 Local Ongoing Conditions	Elevation (m, ellips.)	380.2	✓
10 Local Episodic Effects	Additional Information	Located at NIWA atmospheric research station. Research station 2km north of Lauder township. see ldr0 site aerial photo.jpg	✓

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

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References

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- 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>
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