



**GCOS
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GRUAN Technical Document 6

GRUAN Ground-based GNSS Site Guidelines

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Abstract

The GRUAN GNSS-PW Task Team has developed this GRUAN GNSS (GG) site guidelines that closely follow the recommendations listed in the “IGS Site Guidelines”. It provides strictly required and additionally desired requirements on equipment and operational characteristics, surface meteorological data and GPS/GLONASS receivers. It also includes detailed instructions on how to propose a new GG site and fill out GG site logs.

Editor Remarks

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There are some specific formats in the digital form of this document (pdf document) which can help to navigate easy through the document: click-able links, e.g.

- Bookmarks in pdf document → complete table of contents
- Internal links → jump to a relevant point in the document, e.g. [IGS-GL](#)
- External links → open linked website or show/download linked document, e.g. <http://igs.org>

Acknowledgements

Much of this document originated from IGS site guidelines (see [IGS-GL](#)).

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1 Introduction

1.1 Background

The retrieval of accurate atmospheric parameters using data from Global Navigation Satellite Systems (GNSS) requires the analysis of GNSS data using methods that are typically associated with precise satellite geodesy applications. The International GNSS Service (see [IGS](#)) is a collection of volunteer satellite geodesy organizations whose efforts support a broad range of geoscience applications. The IGS is widely regarded as the highest precision GNSS community in the world. The GRUAN GNSS (GG) Precipitable Water Vapour (PW) Task Team recognizes the efforts and success of the IGS and has developed the following GG site guidelines that closely follow their recommendations (see [IGS-GL](#)).

Ground-based GNSS (Global Navigation Satellite Systems) PW was identified as a Priority 1 measurement for GRUAN. Ground-based GNSS observations are used to estimate the equivalent excess propagation path in the zenith direction, which is referred as zenith total delay (ZTD). Inferring the atmospheric PW from the ZTD requires a value of the ground pressure (P_s) at the site in order to infer the Zenith Wet Delay (ZWD) and a mean temperature of the atmosphere (T_m) defined by weighting the temperature profile with the profile of the wet refractivity above the site ([Figure 1.1](#)). The resulting precipitable water (also called as Integrated Water Vapour (IWV)) is approximately 6.5 times smaller than the ZWD.

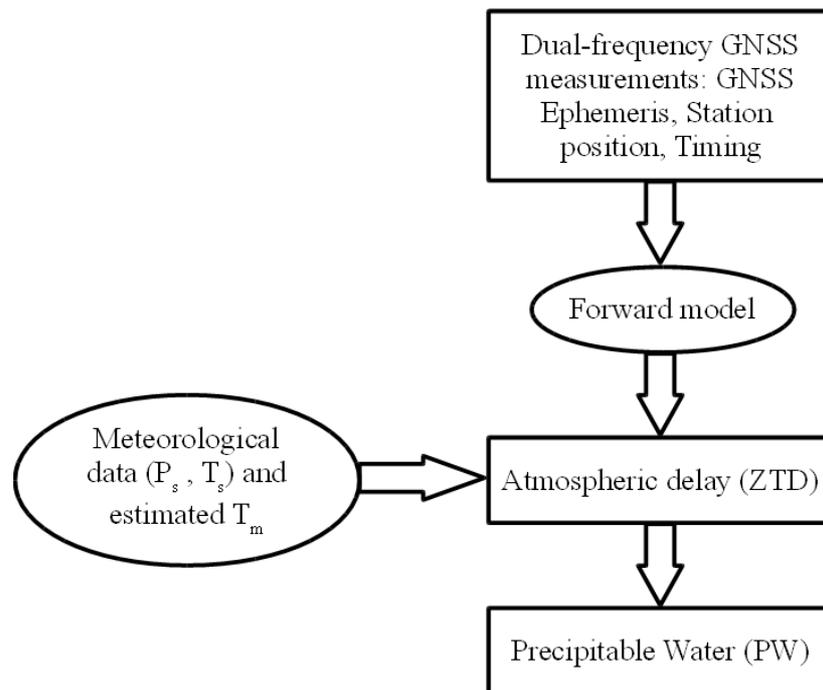


Figure 1.1: The schematic plot shows how PW is derived from GNSS measurements.

As with the IGS community, the voluntary nature of the GG (GRUAN GNSS) sites makes it impossible to enforce strict rules regarding the installation, operation, and maintenance of GG sites. However, participating stations must agree to adhere to certain standards and conventions to ensure the quality of the GRUAN Network. This document lists the conventions that all GG sites must follow, as well as additional desirable characteristics that, where present, enhance a station's value to

the GG sites. These standards and conventions are intended to be useful both in the site-planning phase and as a reference during ongoing operations, to implementation engineers as well as managers at site operation agencies.

The Atmospheric Observation Panel on Climate (AOPC) Working Group on Atmospheric Reference Observations (WG-ARO) approved the guidelines in January 2012 and directed the GNSS-PW TT to maintain the document under a program of periodic review and improvement.

Suggestions for additions or changes, which will be discussed with advisers appropriate to the subject, are welcome at GRUAN Lead Centre (email at gruan.lc@dwd.de).

1.2 Organization of this document

The document is organized as follows. Chapter 2 contains items relevant to every GG site. It is divided into a minimum requirements section (section 2.1), a preferred equipment and operations section (section 2.2), and a preferable site physical characteristics section (section 2.3). The remaining portions of the document address requirements and preferred characteristics for sites able to participate in the collection of various other types of data (in addition to the basic daily GNSS data).

1.3 For operators of existing GG sites and existing stations which are potential GG sites

Operators of existing GG sites should first ensure that their site(s) meet the minimum requirements listed in section 2.1. Operators are also encouraged to develop sites that incorporate as many elements of sections 2.2 and 2.3 that are both logistically and financially feasible. Operators are requested to review these requirements annually to verify that the strictly required items (section 2.1) are being met, and to become familiar with the other desired features, for the purpose of planning future station operation and development.

1.4 For agencies proposing new GG sites

Agencies proposing new GG sites, and existing GRUAN participants that are installing new GNSS equipment, should follow step-by-step instructions on how to propose a new station listed in chapter 5.

2 Guidelines for GG sites

2.1 *Strictly required equipment and operational characteristics*

The GNSS equipment, and its surroundings (up to a radius of ~100 meters), must not be disturbed or changed unless a clear benefit from the change under consideration outweighs the potential for discontinuities in the time series. Obvious examples include replacing failed equipment, a planned replacement of obsolete equipment, clearance of encroaching vegetation, and the routine installation of vendor-recommended firmware updates. All changes should follow GRUAN “Management of Change” guidelines detailed in the GRUAN manual. The following requirements are for geodesy use and adopted from the “IGS site guidelines” ([IGS-GL](#)). They might be revised in the future based on GRUAN specific analyses by the TT later specifically to meet GRUAN needs.

2.1.1 GNSS receiver requirements

In general, the requirements specified below are typical equipment and operating characteristics of geodetic quality GNSS sites. They are specified here for specificity and completeness.

- 2.1.1.1:** The receiver must track both code and phase on L1 and L2 under non-AS (anti-spoofing) as well as AS conditions (Hofmann-Wellenhof et al. 1992). Required observables are L1, L2, P2, and at least one of C1 or P1. Equipment capable of reporting both C1 and P1 should do so. A full description of GNSS observables can be found through the RINEX data format specification (see table A1 on [IGSCB-R210](#)).
- 2.1.1.2:** The receiver must be capable of, and set to, record data simultaneously from at least 8 satellites in view.
- 2.1.1.3:** The receiver must track with a sampling interval of 30 seconds or smaller.
- 2.1.1.4:** The receiver must be configured with an elevation mask of 10 or less.
- 2.1.1.5:** Synchronize the actual instant of observation with true GNSS time to within 1 millisecond of the full second epoch.

2.1.2 GNSS antenna requirements

- 2.1.2.1:** Have well-defined phase (and gain) pattern to allow mixing with other standard antennas with negligible errors. The antenna phase centre variation should be reproducible, with absolute phase centre repeatability of 0.5 mm in the horizontal and 1 mm in the vertical. The antenna type should be approved by the IGS antenna working group and have its phase centre variation calibrated and available following IGS guidelines (see [IGSCB-AR](#) and [IGSCB-08](#)).
- 2.1.2.2:** Be levelled and oriented to True North using the North reference mark and/or antenna cable connector.
- 2.1.2.3:** Be rigidly attached, such that there is not more than 0.1 mm motion with respect to the antenna mounting point under all circumstances.
- 2.1.2.4:** The eccentricities (easting, northing, height) from the primary station marker to the antenna reference point (defined for the antenna type in [IGSCB-A](#)) must be surveyed and reported in site logs and RINEX headers to 1 mm accuracy. Each eccentricity component must be less than 5 m.
- 2.1.2.5:** When antenna changes are planned, operate both the new and old antennas at the same

time first (if an additional monument and receiver are available), and announce to the Lead Centre how users may get the test data set. Such changes have to follow GRUAN guidelines on “Management of Change” described in GRUAN manual.

2.1.3 Antenna radome requirements

- 2.1.3.1: The use of radomes should be avoided unless required operationally, for instance due to weather conditions, antenna security, wildlife concerns, etc.
- 2.1.3.2: Non-hemispherical radomes especially must be avoided when the shape is not required by site characteristics (e.g. for snow rejection).
- 2.1.3.3: If a radome must be used, the antenna and radome pair used must be documented in the IGS phase centre variation file (see [IGSCB-08](#)), with zenith- and azimuth-dependent calibration values down to the horizon. If it is not, contact the GRUAN Lead Centre. An absolute calibration from an independent recognized laboratory is required (see [IG-SCB-AR](#)).
- 2.1.3.4: If you remove an uncalibrated antenna and radome pair, please make it available to a calibration laboratory for calibration. Contact the GRUAN Lead Centre for assistance.
- 2.1.3.5: Only radomes directly connected to the antenna are allowed.

2.1.4 Surface meteorological instrument requirements

- 2.1.4.1: Precise surface meteorological instrument is required for PW estimation. See chapter [3](#) for further guidance.

2.1.5 Required station operation characteristics

- 2.1.5.1: Stations must be permanent and continuously operating.
- 2.1.5.2: The station will have obtained a unique 4-character ID following the procedures in the station check list (chapter [5](#)).
- 2.1.5.3: The operating agency must always have the capability to repair or improve the station and its software systems, including if the original technical staff are no longer available.

2.1.6 Required data reporting characteristics

- 2.1.6.1: The agency operating the station will archive the raw (native binary) GNSS data, or arrange for this archiving to be undertaken at NCDC/NOAA.
- 2.1.6.2: GNSS data (observations and broadcast ephemeris) are to be prepared and distributed in the RINEX format, version 2.10 or greater, as specified in [IGSCB-R210](#) or [IGSCB-R2](#).
- 2.1.6.3: Observation files will normally be exchanged in the Hatanaka Compact format. See the RINEX specification [IGSCB-R210](#) and confirm with GRUAN Lead Centre.
- 2.1.6.4: All files are ordinarily Unix compressed (.Z).
- 2.1.6.5: File naming conventions set forth in the RINEX specification [IGSCB-R210](#), section 4, "The Exchange of RINEX files", will be followed.
- 2.1.6.6: The RINEX header information, especially the 4-character site ID, receiver and antenna information, and antenna eccentricities, must be up-to-date and strictly follow the agreed-upon conventions.

- 2.1.6.7:** Specifically, they must match the information in the GG site log and therefore observe the same equipment naming conventions found in [IGSCB-RA](#).
- 2.1.6.8:** A radome identifier code from [IGSCB-RA](#) must be found in the ANT TYPE field, in columns 17-20 of this field.
- 2.1.6.9:** The RINEX headers must be updated to reflect actual times of all equipment changes.
- 2.1.6.10:** If an advisory of RINEX header inconsistencies is received from the GRUAN Lead Centre, the headers must be corrected as soon as possible.
- 2.1.6.11:** The minimum requirement for data submission is daily (24 hour) files with a 30 second sampling interval.
- 2.1.6.12:** Metadata correctness for daily (24 hour) data files must be minimally verified prior to transmission to a GRUAN Lead Centre. This includes verification of site name, observation types, time of first epoch, epoch interval, equipment types, as well as station and antenna eccentricities.

2.1.7 Required site log characteristics

- 2.1.7.1:** Whenever there is a change to the site information as documented in the station log, the log must be updated. Refer to chapter 6 for detailed site log preparation instructions.
- 2.1.7.2:** Include the URL to a web page for the site, if one exists. Contact the GRUAN Lead Centre if you have site photos that cannot be made available on a web page.
- 2.1.7.3:** Site photos should include a panorama photograph of the entire site (see an example given in [Figure 2.1](#)) and instrument photos (receivers, antennas, radomes, surface met sensors and other relevant instruments). The photos should be updated annually and whenever the changes are made to the sites.

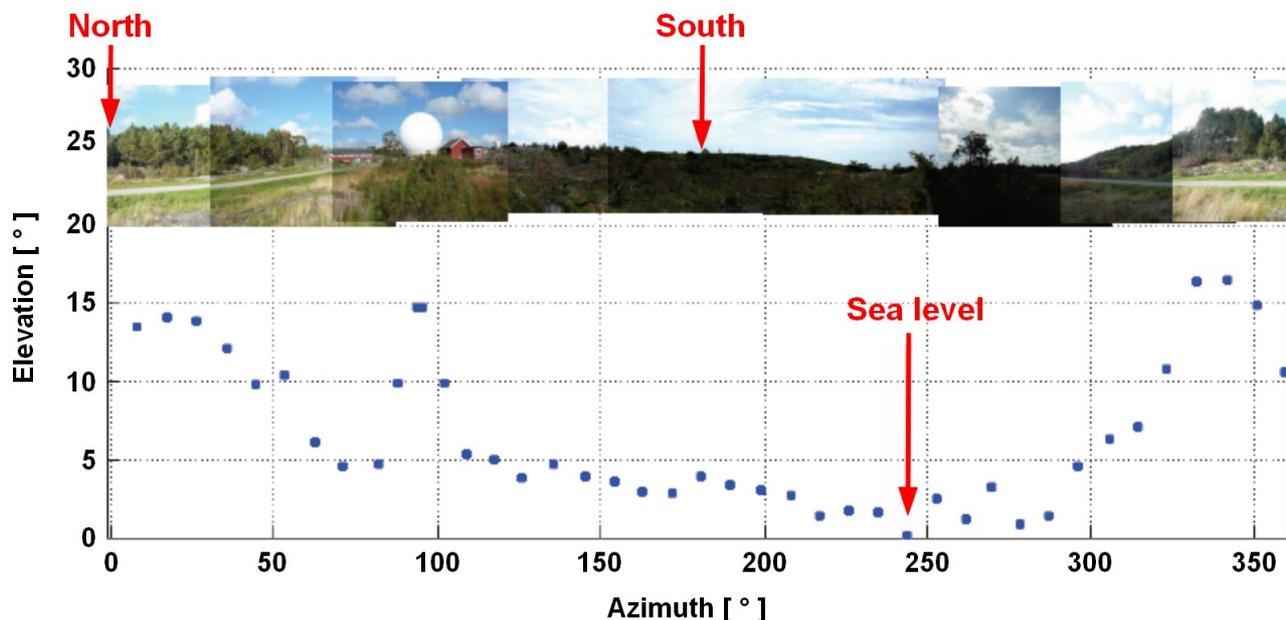


Figure 2.1: A panorama photograph of the new Onsala site with elevation information shown in the lower panel. The photos are courtesy of Gunnar Elgered.

- 2.1.7.4: Updates must be sent to the GRUAN Lead Centre within one business day of any change.
- 2.1.7.5: If an advisory of site log inconsistencies is received from the GRUAN Lead Centre, the site log must be corrected as soon as possible.

2.2 Optional, but desired equipment and operational characteristics

In addition to the items listed here, please review section [2.3](#) “Desired physical characteristics” for physical characteristics desirable for GG stations.

2.2.1 Desired equipment characteristics

- 2.2.1.1: Receiver should support for "all-in-view" tracking.
- 2.2.1.2: The receiver tracking cut-off is ideally 3 degrees or less, especially for "all in view" receivers.
- 2.2.1.3: GNSS receivers and ideally other station equipment such as computers should be protected against power failures by providing surge protection and backup power wherever feasible.
- 2.2.1.4: Antenna types which are already present in the GG network in reasonable numbers are generally preferred over novel types (A list of acceptable antenna types can be found in [IGSCB-08](#)).
- 2.2.1.5: Radomes uniformly manufactured with less than 1 mm variability in thickness are preferred.
- 2.2.1.6: Support for GLONASS observations is desirable. See chapter [4](#), “Guidelines for GG sites with GPS/GLONASS receivers“ below for further guidance.
- 2.2.1.7: Equipment never used before in the GG should be avoided until tested and approved by the GRUAN Lead Centre. The Lead Centre should be immediately informed of instances where new equipment (receiver or antenna and radome combination) is used that are not contained in [IGSCB-RA](#). Situations where unapproved equipment is used should only occur when a parallel site (within 100 meters) operates with an approved equipment configuration.
- 2.2.1.8: Test data sets, and analysis of test data, will be helpful. Inform the GRUAN Lead Centre whether these will be available.
- 2.2.1.9: The antenna reference point ideally will be mounted directly vertically above the marker (i.e., horizontal eccentricities ideally are zero).

2.2.2 Operational characteristics

Additional monuments are desirable for surveys and testing, but it is preferable to maintain one antenna + radome pair as the best site for the GG, rather than to submit more than one "site" to the GG.

- 2.2.2.1: The full Signal-to-Noise ratio (S1 and S2) observables should be included in daily RINEX files.
- 2.2.2.2: Anticipate upgrades to new equipment types, including supporting new GNSS signal types, while paying attention to data overlap to avoid discontinuity and following GRUAN “Management of Change” guidelines.
- 2.2.2.3: Receivers should be set to record data from all satellites, including those newly launched

or flagged 'unhealthy'.

2.2.2.4: Receivers and RINEX converters should not be set to smooth data.

2.2.2.5: RINEX version 2.10 (see [IGSCB-R210](#)) is preferred.

2.2.2.6: It would be ideal to have a web camera archiving daily pictures of the antenna monument and the local environment around. It would be also desirable to have hourly day time vertical sky condition views as additional metadata.

2.3 Desired physical characteristics

While not being strict requirements for each GG site, detailed care regarding the physical characteristics of a site improves its overall value as a long-term monitoring location. The following specifications should be considered for both the planning of new sites and the long-term improvement of existing sites. Agencies are encouraged to select potential new sites that have the majority of these features, and work toward these characteristics at existing sites.

2.3.1 Desired characteristics of site location

2.3.1.1: The site should be on a stable regional crustal block, away from active faults or other sources of deformation, subsidence, etc. Contact the GRUAN Lead Centre for assistance in determining the stability of a particular area, if it is not clear.

2.3.1.2: The site should be on firm, stable material, preferably a bedrock outcrop. The site should not be located on soil that might slump, slide, heave, or vary in elevation (e.g. because of subsurface liquid variations).

2.3.1.3: The site should have a clear horizon with minimal obstructions above 5 degrees elevation.

2.3.1.4: The site should not have significant changes to the surroundings (changes to buildings or trees; new construction, etc.) foreseen or likely.

2.3.1.5: The site should not have excessive radio frequency interference.

2.3.1.6: The site should not have excessive radio frequency (RF) reflective surfaces (fences, walls, etc.) and other sources of signal multipath.

2.3.1.7: The site should not have excessive natural or man-made surface vibrations from ocean waves or heavy vehicular traffic.

2.3.2 Desired characteristics of monument

2.3.2.1: The monument should be of ultra-stable design. See [IGSCB-M](#) for additional information. See [Figure 2.2](#) for examples of sites with good and bad monumentation.

2.3.2.2: The monument should be isolated from unstable surface material (e.g. freezing/melting cycles in cold climates) and extend into stable subsurface formation.

2.3.2.3: The monument should remain durable, maintainable, accessible, and well-documented.

2.3.3 Desired station infrastructure

2.3.3.1: The station should have reliable power and communications (preferably Internet) to enable consistent data transfer.

2.3.3.2: The station should have appropriate security to ensure uninterrupted operation and prevent vandalism.

2.3.4 Other desirable instrumentation

2.3.4.1: Other geophysical systems – such as SLR, VLBI, DORIS, absolute or superconducting gravimeters, Earth tide gravimeters, seismometers, strain meters, ocean tide gauges – are also desirable and will enhance the value of the station for multi-disciplinary studies.

2.3.4.2: Co-location with scientific systems that rely on accurate positioning, such as timing labs, is recommended when feasible.

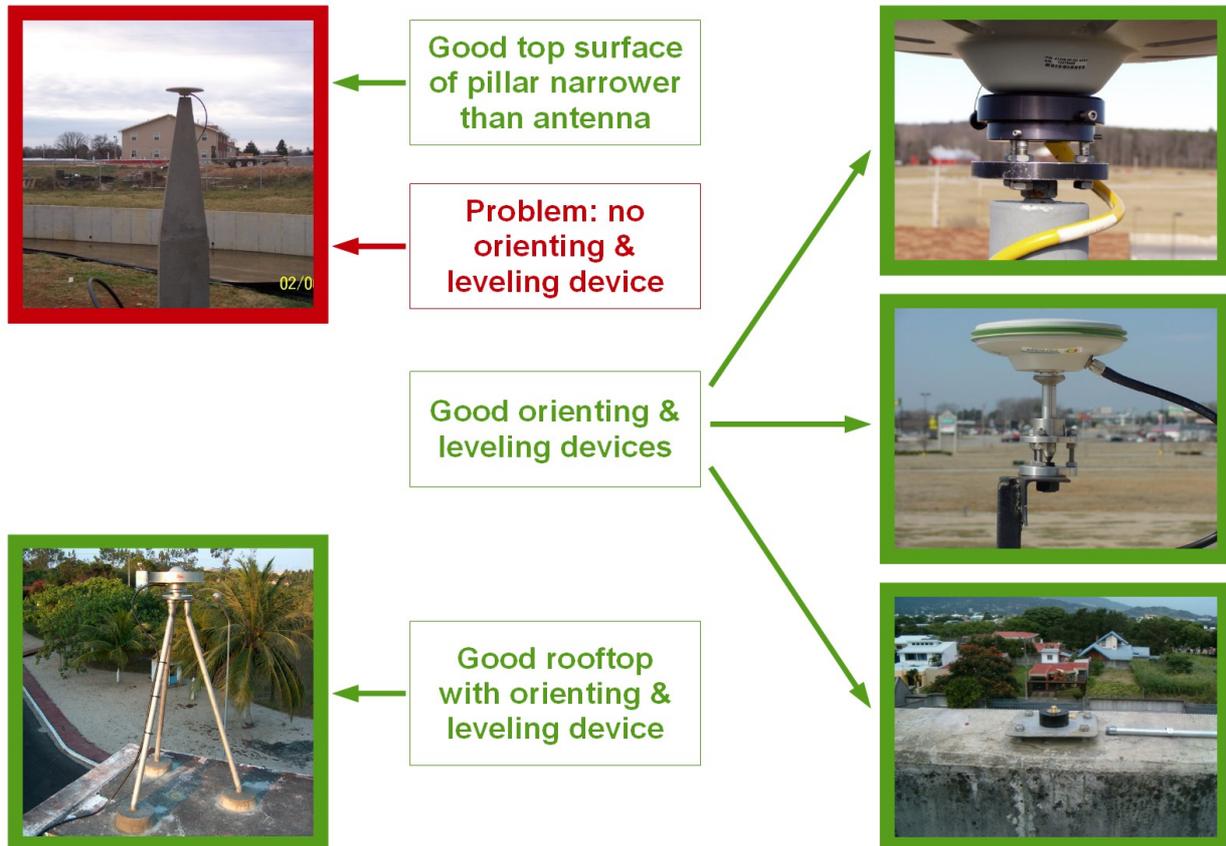


Figure 2.2: Example of good and bad GNSS sites. Pictures are courtesy of NGS – Giovanni Sella.

3 Guidelines for surface meteorological data

GRUAN has specific guidelines for surface meteorological data including instrumentation, data collection methods, and calibration. The requirements below are intended to support the derivation of PW from GNSS measurements.

3.1 *Strictly required*

- 3.1.1.1: The minimum set of observables is pressure and temperature.
- 3.1.1.2: Pressure sensor accuracy must be at least 0.5 hPa.
- 3.1.1.3: Temperature sensor accuracy must be at least 0.1 Kelvin.
- 3.1.1.4: Instrument drift and bias must be minimized through the routine calibration as specified in the manufacturer's recommendations and any supplementary GRUAN procedures.
- 3.1.1.5: Temperature effects on the pressure measurements should be minimized, e.g. with solar shielding or by placing the sensor in a nearby building if necessary.
- 3.1.1.6: Data are to be prepared in RINEX files. See the RINEX specification ([IGSCB-R210](#)).
- 3.1.1.7: Observation interval must be no more than 60 minutes.
- 3.1.1.8: Meteorological data is to be transmitted with the same schedule and method as the RINEX observation files (hourly for hourly sites; otherwise daily).
- 3.1.1.9: The height difference between the surface pressure sensor and the GPS antenna must be measured with an accuracy of 1 m or better.

3.2 *Additionally desired*

- 3.2.1.1: An observation interval of 10 minutes or less is preferred.
- 3.2.1.2: Calibration, operation, and uncertainty assessment for temperature and pressure sensors adheres to GRUAN guidelines for temperature and pressure measurement.
- 3.2.1.3: Regular water vapour profiling measurements are made with a measurement system (sonde or remote sensed) operating according to GRUAN recommendations and located within a distance which makes sense climatologically to ensure a meaningful collocation for intercomparison.

4 Guidelines for GG sites with GPS/GLONASS receivers

All stations with GNSS instrumentation are expected to meet the minimum requirements specified in chapter 2. The requirements listed here are in addition to those required for a GPS station.

4.1 *Strictly required*

- 4.1.1.1: The receiver must tag observations in GNSStime (not UTC or GLONASS), and time tags for all satellites must be identical (simultaneous observations).
- 4.1.1.2: Data must be submitted in M(MIXED) RINEX files. See the RINEX specification at [IG-SCB-R210](#).

4.2 *Additionally desired*

- 4.2.1.1: The characteristics described in section 2.2, “Optional, but desired equipment and operational characteristics“ are also desired for stations that are GPS/GLONASS stations.

5 Guidelines for new GG sites

Agencies proposing new GG sites, and existing GRUAN participants that are installing new GNSS equipment, should follow these instructions when proposing that a new station be considered as a GG site. The proposing agency should carefully review the guidelines in section 2 to determine the suitability of the location as a potential GG site.

5.1 General requirements

5.1.1 Qualification

- 5.1.1.1: Carefully review the GG Site Guidelines detailed in sections 2 to 4 and the “GRUAN site assessment and certification” document.
- 5.1.1.2: The responsible agency must have every expectation that the station will operate for at least 3 years.
- 5.1.1.3: Confirm that the proposed station meets the requirements and adds value to the GG network.

5.1.2 Questions for new GG sites

Contact the GRUAN Lead Centre (email at gruan.lc@dwd.de) with a message addressing the following questions and additional ones listed in the “GRUAN site assessment and certification” document.

- 5.1.2.1: Where is the station located?
- 5.1.2.2: Is the station currently operating, or planned? If planned, when will it become operational? Does it operate additional equipment? Is this equipment already GRUAN certified? If not is it planned to incorporate these measures into GRUAN also?
- 5.1.2.3: What agencies are responsible for installing, managing, operating, and maintaining the station?
- 5.1.2.4: Is there a GRUAN quality upper air sounding station within a reasonable distance of the GG site? Are there any studies on PW comparisons between radiosonde and GNSS data to quantify the influence of spatial separation between the radiosonde and GG site?
- 5.1.2.5: What is the expected operational lifetime of the station? How secure is the funding?
- 5.1.2.6: Will the station replace an existing GG station? If so, what is the scheduled date of de-commissioning? Does the new station offer more capability than the old one? Will there be an overlap period and analysis undertaken?
- 5.1.2.7: Does/will the station meet all of the strictly required GG site guidelines specified in sections 2 and 3 of this document?
- 5.1.2.8: What is the data delivery schedule?
- 5.1.2.9: Can the receiver be configured to operate in an "all in view" tracking mode (including tracking of satellites flagged as unhealthy)?
- 5.1.2.10: What GG product or project will this site benefit, based on its location, instrumentation, and latency?
- 5.1.2.11: Is there a web page associated with this site (please specify)? If not, please include a site

photo or two with this application including panorama.

- 5.1.2.12:** Is data available on a public server (please specify)? Does data also contribute to other networks, and if so which?
- 5.1.2.13:** Please complete and include a draft site log according to the instructions given in section 6.
- 5.1.2.14:** The proposed four character identifier should also be included, but it remains proposed until confirmed by the GRUAN Lead Centre and the IGS. Allowed characters are A-Z and 1-9 (numerals may not be used in the first character).
- 5.1.2.15:** A new four character ID is required if a site is moved to a new monument. The four character ID has a one-to-one relationship with a monument, except in the case that more than one receiver records data from one antenna.

5.1.3 Technical iterations of documentation

Following technical iterations of documentation with the Lead Centre the WG-ARO will be notified of the proposal as outlined in the site assessment and certification documentation.

5.1.4 Additional questions

If the site requested is certified to be added by the WG-ARO, you will be asked to:

- 5.1.4.1:** Contact the GRUAN Lead Centre to confirm that they can accept the data and learn about the transfer mechanisms.
- 5.1.4.2:** Revise the site log, if necessary. Logs should then be sent to the GRUAN Lead Centre as plain ASCII text. Notify the GRUAN Lead Centre where a recent RINEX file may be downloaded, or include a sample RINEX header (header only!) in the email to the GRUAN Lead Centre.
- 5.1.4.3:** When the site log becomes available, the GRUAN Lead Centre will announce the station to the GRUAN community and the data will be added to the GRUAN data stream served through NCDC.

6 Instructions for filling out GRUAN GNSS site logs

These instructions are modelled after IGS site log instruction ([IGSCB-SL](#)). Modifications will be made to this instruction in order to be specialized to GRUAN GNSS (GG) sites in the future after some of GRUAN unique practices are established. You can find a blank log form at [IGSCB-SLB](#) and an example at [IGSCB-SLE](#).

6.1 General

6.1.1 Format and line length

- Please prepare site logs in plain ASCII.
- Line length is limited to 80 characters.
- Date and time
 - Date and time formats within the site log follow the basic format from ISO 8061: "CCYY-MM-DDThh:mmZ"
 - CC2 digit century (e.g. 20)
 - YY ...2 digit year (1 – 99)
 - MM ...2 digit month (1 – 12)
 - DD ...2 digit day of month (1 – 31; depending on month)
 - Tdate/time separator
 - hh2 digit hour (0 – 23)
 - mm2 digit minutes of hour (0 – 59)
 - ZUTC indicator
 - /separator when begin and end times are given
 - A date without a time is specified like "2003-07-30", not "2003-07-30Thh:mmZ"
- Latitude/Longitude
 - Latitude/Longitude formats are aligned to ISO 6709:
 - Lat+/-DDMMSS.SS
 - Long ..+/-DDDMMSS.SS
 - A + or - sign is required. Leading zeroes must be used as appropriate to maintain the DDMMSS and DDDMMSS format. Valid latitude range is from -180 degrees to (infinitesimally less than) +180 degrees. Valid longitude range is -90 degrees to +90 degrees.
- “etc”
 - "etc" indicates you may enter any relevant answer, not just a choice of the suggestions shown.
- FOTRAN-style format
 - "F7.4," "A4" and so on indicate the FORTRAN-style format which the response should

have. Example:

- F7.1 ...12345.7
- A4ABCD
- Blocks which have a "N.x" definition (namely sections 3-10) should always have the complete historic set of information; when a change is made, the previous information is left (for example in section 3.1) and the new information is placed in a new block numbered 3.2. Please leave the .x sections uncompleted to remind yourself of the format when the next change occurs. Please remove the response hints such as "(F7.4 N/S)" as you fill out the log (except in the .x sections and Date Removed fields for currently installed equipment, which you will not alter).
- If an answer for an optional field is unknown, try to learn the answer for the next log update.

6.1.2 Submission of site logs

When ready, submit site logs by sending as a plain text email message to GRUAN Lead Centre (email at gruan.lc@dwd.de). Site logs are usually handled by the GRUAN Lead Centre within about one business day.

6.1.3 Questions

If you have any questions not answered here, please feel free to contact the GRUAN Lead Centre.

6.2 Form (0.)

6.2.1 Previous Site Log

: (ssss_CCYYMMDD.log)

If the site already has a log at the GRUAN Lead Centre archive (<http://xxxx.xxxx.xxxx>), enter the filename currently found under <ftp://xxxx.xxx.xxxx.xxx/pub/station/log/> (ssss = 4 character site name).

6.2.2 Modified/Added Sections

: (n.n,n.n,...)

Enter the sections which have changed from the previous version of the log.

6.3 Site Identification of the GNSS Monument (1.)

6.3.1 Monument Description

: (PILLAR/BRASS PLATE/STEEL MAST/FICTIVE/etc)

Enter one or more elements as necessary to describe the monument.

6.3.2 Additional Information

: (multiple lines)

Suggestions are electrical isolation

6.4 Site Location Information (2.)

Approximate Position (ITRF) should be to be to precision of one meter precision (F7.1) at a minimum. The elevation may be given to more decimal places than F7.1 with a maximum of (F7.4). F7.1 is a minimum for the SINEX format.

6.5 GNSS Receiver Information (3.)

6.5.1 Receiver Type

: (A20, from rcvr_ant.tab; see instructions)

Please find your receiver in file “rcvr_ant.tab” ([IGSCB-RA](#)) and use the official name, taking care to get capital letters, hyphens, etc. exactly correct. If you do not find a listing for your receiver, please notify the GRUAN Lead Centre ([→ LC](#)).

6.5.2 Serial Number

: (A20)

Keep the 5 significant characters of the serial number field in SINEX in mind: do not enter "S/N 12345" instead of "12345" since valuable information will be lost.

6.5.3 Firmware Version

: (A11)

Keep the 11 significant characters of the field in SINEX in mind.

6.5.4 Elevation Cut-off Setting

: (deg)

Please respond with the tracking cut-off as set in the receiver, regardless of terrain or obstructions in the area.

6.5.5 Temperature Stabiliz.

: (none or tolerance in degrees C)

This refers to the temperature of the room in which the receiver is housed.

6.5.6 Date Removed

: (CCYY-MM-DDThh:mmZ)

In the block for the receiver currently in operation, leave this line as is to remind yourself of the format when the next receiver change is made.

6.6 GNSS Antenna Information (4.)

6.6.1 Antenna Type

: (A20 from rcvr_ant.tab; see instructions)

Please find your antenna in file "rcvr_ant.tab" ([IGSCB-RA](#)) and use the official name, taking care to get capital letters, hyphens, etc. exactly correct. If you do not find a listing for your antenna, please notify the GRUAN Lead Centre ([→ LC](#)). Please do not use antenna names from a "Previously valid" section. Choose the corresponding new antenna name instead. The radome code from [IGSCB-RA](#) must be indicated in columns 17-20 of the Antenna Type, use "NONE" if no radome is installed. The antenna+radome pair must have an entry in [IGSCB-05](#) with zenith- and azimuth-dependent calibration values down to the horizon. If not, notify the GRUAN Lead Centre ([→ LC](#)).

6.6.2 Serial Number

: (A20)

Keep the 5 significant characters of the serial number field in SINEX in mind: do not enter "S/N 12345" instead of "12345" since valuable information will be lost.

6.6.3 Antenna Reference Point

: (BPA/BCR/XXX from "antenna.gra"; see instructions)

Locate your antenna in the file "antenna.gra" (see [IGSCB-A](#)). Indicate the three-letter abbreviation for the point which is indicated equivalent to ARP for your antenna. Contact the GRUAN Lead Centre at ([→ LC](#)) if your antenna does not appear.

6.6.4 Marker → ARP Up Ecc (m)

: (F8.4)

This is the antenna height measured to an accuracy of 1 mm and defined as the vertical distance of the ARP from the marker described in section 1.

6.6.5 Marker → ARP North Ecc (m)

: (F8.4)

6.6.6 Marker → ARP East Ecc (m)

: (F8.4)

These must be filled in if non-zero.

6.6.7 Alignment from True North

: (deg; + is clockwise/east)

The positive direction is clockwise, so that due east would be equivalent to a response of "+90".

6.6.8 Antenna/Radome Type

: (A4 from rcvr_ant.tab; see instructions)

Place a radome code from file "rcvr_ant.tab" ([IGSCB-RA](#)). "NONE" indicates there is no external radome. If an antenna has a cover which is integral and not ordinarily removable by the user, it is considered part of the antenna and "NONE" is to be used for the radome code. The radome code used here has to be the same as the one in the columns 17-20 of the antenna type.

6.6.9 Date Removed

: (CCYY-MM-DDThh:mmZ)

In the block for the antenna currently in operation, leave this line as is to remind yourself of the format when the next antenna change is made.

6.7 Surveyed Local Ties (5.)

Local ties to other markers on the site should be determined in ITRF coordinates to 1 mm precision in all 3 dimensions. Offsets are given in geocentric Cartesian coordinates (ITRF).

6.8 Meteorological Instrumentation (8.)

6.8.1 Height Difference to Antenna

: (m)

The difference in height between the GNSS antenna and the pressure sensor for the meteorological instrument should be measured and supplied. Positive numbers indicate that the pressure sensor is ABOVE the GNSS antenna.

6.9 Responsible Agency (12.)

The primary contacts listed here should always be the first choice for questions about operation of the site. This person will receive automated emails regarding site log or RINEX errors and should be someone who can answer questions about the configuration and data delivery for this site.

6.10 More Information (13.)

6.10.1 Primary Data Centre

6.10.2 Secondary Data Centre

- Please list the DC where the station's data ordinarily goes first as "Primary".
- Use "Secondary" either for a second location where the station's data always goes, or would go in the case of a long-term failure with the Primary DC.
- Select primary and secondary data centres via centers.html and enter the abbreviation of the DC name.
- A geographically-or functionally-related centre is generally preferred.
- The secondary DC is where data would be sent if the primary were unavailable for an extended period.
- The switchover does not need to be automated, but data transfer procedures should be verified.

6.10.3 URL for More Information

- This will be linked on the GRUAN Lead Centre page for this site.
- It is not necessary to include "http://".
- Photos are mandatory. See paragraph [2.1.7.3](#) on requirements for site photos. Send all available photos of antenna, radome, placement and all relevant photos to the GRUAN Lead Centre (→ LC).
- Contact the GRUAN Lead Centre at if you have photos which cannot be hosted on a site web page.

6.11 Additional Information

- Anything you feel is important.
- Some possibilities to consider are:
 - Elevation mask table indicating physical mask effects such as

AZ	ELEV	AZ	ELEV	AZ	ELEV	AZ	ELEV
10	8	20	12	30	10	40	8
50	5	60	12	70	8	80	8
90	5	100	5	110	5	120	5
130	5	140	5	150	8	160	8
170	5	180	3	190	5	200	8
210	8	220	8	230	5	240	5
250	5	260	8	270	10	280	12

290	12	300	12	310	12	320	8
330	5	340	5	350	8	360	8

- (This could also be kept at your local website and referred to by URL in the log).

7 References

7.1 Reviewed Articles

Bevis, M., S. Businger, T. A. Herring, C. Rocken, R. A. Anthes, and R. H. Ware (1992), GPS meteorology— Remote-sensing of atmospheric water vapor using the Global Positioning System, *J. Geophys. Res.*, 97(D14), 15,787–15,801.

Dow, J.M., Neilan, R. E., and Rizos, C., The International GNSS Service in a changing landscape of Global Navigation Satellite Systems, *Journal of Geodesy* (2009) 83:191–198, DOI: 10.1007/s00190-008-0300-3.

Hofmann-Wellenhof, B., H. Lichtenegger, and J. Collins, *GPS Theory and Practice*, Springer-Verlag, Wien, New York, pp. 326, 1992.

7.2 Links to Relevant Documents and Websites

- IGS – Homepage of International GNSS Service – <http://igs.org>
- IGS-GL – IGS Site Guidelines – <http://igs.org/network/guidelines/guidelines.html>
- IGSCB-05 – Satellite antenna and receiver antenna corrections (as ANTEX file: The Antenna Exchange Format, Version 1.4) – <ftp://igscb.jpl.nasa.gov/pub/station/general/igs05.atx>
- IGSCB-08 – GPS/GLONASS satellite antenna and receiver antenna corrections (as ANTEX file: The Antenna Exchange Format, Version 1.4, see [ANTEX](#)) – <ftp://igscb.jpl.nasa.gov/pub/station/general/igs08.atx>
- IGSCB-A – Definition file for antenna reference points and physical antenna dimensions – <ftp://igscb.jpl.nasa.gov/pub/station/general/antenna.gra>
- IGSCB-AR – Readable summary of all IGS antenna files (13 Sep 2011) – ftp://igscb.jpl.nasa.gov/pub/station/general/antenna_README.pdf
- IGSCB-M – Monumentation Design and Implementation Recommendations – <http://igscb.jpl.nasa.gov/network/monumentation.html>
- IGSCB-R2 – RINEX: The Receiver Independent Exchange Format Version 2 – <ftp://igscb.jpl.nasa.gov/pub/data/format/rinex2.txt>
- IGSCB-R210 – RINEX: The Receiver Independent Exchange Format Version 2.10 – <ftp://igscb.jpl.nasa.gov/pub/data/format/rinex210.txt>
- IGSCB-RA – Naming conventions for IGS equipment descriptions in site logs, RINEX headers, and SINEX – ftp://igscb.jpl.nasa.gov/pub/station/general/rcvr_ant.tab
- IGSCB-SL – Instructions for filling out IGS site logs (Apr 2011) – ftp://igscb.jpl.nasa.gov/pub/station/general/sitelog_instr.txt
- IGSCB-SLB – Blank Site Information Form (site log) – <ftp://igscb.jpl.nasa.gov/pub/station/general/blank.log>
- IGSCB-SLE – TSKB Site Information Form (prepared at 2012-03-05) – http://igscb.jpl.nasa.gov/igscb/station/log/tskb_20120305.log

7.3 Additional Links

- ANTEX – <ftp://igscb.jpl.nasa.gov/pub/station/general/antex14.txt>