AFREF

Permanent Stations Guidelines

Requirements and Installation

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1. Preamble

This document describes the necessary requirements and procedures that should be considered by interested agencies in order to qualify their stations to be part of the AFREF network. Considering the voluntary nature of such commitment and the current phase of the AFREF project where the densification of the network is a major objective, the use of many strict rules is avoided. However, the AFREF stations must satisfy minimum standards in order to ensure the quality of the entire network.

This document is mainly based on the IGS guidelines (http://igscb.jpl.nasa.gov/network/guidelines/guidelines.html) since many new AFREF stations will also qualify to be part of the IGS network. Nevertheless, in the initial phase, the rules to be imposed will be less strict.

This document will cover both installation and operational aspects that should be considered during the planning of a new AFREF station or submission of a existing station. This document will be become official after approval of the AFREF Steering Committee.

2. Site Selection

This section provides general guidelines for installation of new AFREF sites. It is clear that it is very difficult to satisfy all site requirements, nevertheless, agencies are encouraged to select potential new sites which meet most of the described criteria, and to work toward these requirements at existing sites.

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

In order to avoid loosing the relationship between geodetic reference frames currently being used in countries, the connection between the national reference frame(s) and the AFREF (ITRF based) frame must be a major additional consideration in site selection.

2.1. Site location

In order to have the highest possible value to support the reference frame definition, the site location should:

a) Be on a stable regional crustal block, away from active faults or other sources of regional or local deformation, subsidence, etc.

b) Be on firm, stable material, preferably basement outcrop.

c) Have a clear horizon with minimal obscurations above 5 degrees elevation in all directions. No modification of the surroundings (changes to buildings or trees; new construction, etc) should be expected in the future.

In particular, the site location should not:

a) Be located on soil that might slump, slide, heave, or vary in elevation (e.g. because of subsurface liquid variations).

b) Be located on instable buildings.

c) Have excessive radio frequency (RF) interference.

d) Have excessive RF reflective surfaces (fences, walls, etc.) and other sources of signal multipath.

e) Have excessive natural or man-made surface vibrations from ocean waves or heavy vehicular traffic.

2.2. Site monument

The GPS monument should:

a) Be of ultra-stable design. Examples of installations can be found at IGS (http://igscb.jpl.nasa.gov/network/monumentation.html) and UNAVCO (.http://www.unavco.org) web sites.

b) Be isolated from unstable surface material and extend into stable subsurface formation remain durable, maintainable, accessible, and well-documented. old

c) If necessary to install on man-made constructions, pillars and stabilized (aged) structures should be selected. If a building site is selected, it is preferred to mount the

antenna directly on top of outside walls or columns that form part of the main building structure. Antennas should not be mounted on unsupported roof sections.

d) Additional stable monuments or reference marks should be installed for local geodetic control, reference, azimuth, parallel operation of replacement antennas, and especially for recovery in the event that the primary monument is destroyed.

e) Moving to another monument must be avoided except in extreme circumstances, requiring prior announcement and submission of overlapping data sets starting one year in advance if possible.

f) When antenna change is unavoidable, minimize position discontinuities by first operating the new antenna on a nearby ancillary monument

2.3. Site infrastructure

The site infrastructure must include:

a) Access to reliable electrical power source.

b) Access to reliable telecommunications that could be dedicated telephone lines, cellular phone connections or satellite based telecommunication to ensure access to the data. General access to the data either directly from the station or a central controlling centre where a network of stations is being managed by a single agency should be ensured through reliable internet connectivity.

c) Physical site security appropriate to local necessity for the entire system (including antenna).

d) Restricted access to the equipment.

3. System

The entire system is formed by the receiver and antenna plus all support equipment such as UPS units etc, which also includes human resources. Namely, it must:

a) Have a second backup system for power supply (e.g., solar panels) besides rechargeable batteries.

b) Have permanent access with a static IP is favored in order to enable reliable data transfer and remote login to the station. (However, the direct access can be restricted to the responsible agency. They have to guarantee the regular data transfer to a public AFREF data server).

c) Have a local technician responsible for regular maintenance of the station, if located at a remote location.

d) 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.

e) The eccentricities (easting, northing, height) from the primary physical marker to the antenna reference point (defined for the antenna type in ftp://igscb.jpl.nasa.gov/pub/station/general/antenna.gra) must be surveyed and reported in site logs and RINEX headers to ≤1 mm accuracy. The antenna reference point ideally will be mounted directly vertically above the marker (i.e., horizontal eccentricities ideally are zero).

f) Each eccentricity component must be less than 5 m.

g) 3-dimensional local ties between the GNSS marker, collocated instrumentation (e.g., DORIS, SLR, VLBI, gravity, tide gauge) and other monuments should be re-surveyed regularly to an accuracy of 1mm and reported in ITRF.

h) Precise meteorological instrumentation is encouraged. Data should be sent in meteorological RINEX format.

i) High-quality frequency standards are desirable.

4. Equipment

The following standards should be accomplished in order to classify a GNSS station to be part of the AFREF network. Eventual exceptions have to be a priori evaluated by the AFREF Scientific Advisory Group.

4.1. Receivers

The GNSS receivers

Must:

a) Be capable of acquiring GPS codes and phases on L1 and L2 under non-AS (Anti Spoofing) as well as AS conditions.

b) Record data from at least 10 satellites in view, simultaneously.

c) Synchronize the actual instant of observation with true GPS time within ±1 millisecond of the full second epoch.

d) Be listed in the IGS table of tested receivers (can be checked at ftp://igscb.jpl.nasa.gov/pub/station/general/igs.snx).

And desirably, they should:

e) Be capable of tracking all visible GNSS satellites ("all-in-view" tracking): GPS + GLONASS.

f) Be capable of recording the new signals already available (GPS-L2C) or expected to be available in near future (GPS-L5 and GALILEO).

g) Receivers should be set to record data from all satellites, including those newly launched or set 'unhealthy'.

h) The S1 and S2 observables should be included in daily RINEX files.

4.2. Antenna

The GNSS antennas

Must:

a) (The pair antenna model + radome model) be represented accurately in the phase center variation file provided by IGS in the antex file: http://igscb.jpl.nasa.gov/igscb/station/general/igs05_1402.atx (ideally each individual antenna should have its own values).

b) Be leveled and oriented to True North using the North reference mark and/or antenna RF connector

c) Be rigidly attached, such that there is not more than 0.1mm motion with respect to the antenna mounting point.

And desirably,:

d) Dorne-Margolin antenna elements and choke ring antennas are recommended, although antennas listed in the IGS table can also be accepted (in particular more recent models).

4.2.1. Radomes

e) Avoid using radomes unless required operationally, for instance due to weather conditions, antenna security, wildlife concerns, etc.

f) Non-hemispherical radomes especially must be avoided when the shape is not required by site characteristics.

g) If a radome must be used, an entry for antenna+radome pair must be in the phase center variation file http://igscb.jpl.nasa.gov/igscb/station/general/igs05_1402.atx.

5. Operational characteristics

In order to be included and maintain the status as an AFREF sites there are some items that the station must fulfill.

5.1. Generic Conditions

a) Be permanent and continuously operating.

b) The data should be made available and transferred to an AFREF Data Center as soon as possible (ideally less than 2hours after 00h00UTC).

c) The station should have a unique 4-character ID and an IERS DOMES number (requested at http://itrf.ensg.ign.fr/domes_request.php).

d) The operating agency must always have the capability to repair or improve the station and its software systems.

5.2. Data acquisition

a) The receiver tracking cutoff should be set to 0 degrees, especially for "all in view" receivers (never higher than 10 degrees).

b) Even if the receiver sampling interval is less than 30 seconds, the data submitted to the Data Centers must have a 30 second interval, with observations aligned to :00 and :30 epochs.

c) Receivers and RINEX converters should not be set to smooth data.

5.3. Data files

a) All data handling, including receiver communication, reformatting, quality check, and transmission to Data Centers, should be automated as far as possible and managed by the ‘‘owner agency’’.

b) The station operating agency must archive the raw (native binary) GNSS data.

c) GNSS data (observations and broadcast ephemeris) are to be prepared and distributed in RINEX 2.00 (ftp://igscb.jpl.nasa.gov/pub/data/format/rinex2.txt) or greater.

d) The observation files should be exchanged in the Hatanaka Compact form and ordinarily compressed (.Z) for transmission to Data Centres.

e) A navigation file in RINEX format should be sent for each daily observation file.

f) The header information, especially the 4-character site ID, receiver and antenna information, IERS DOMES number (in MARKER NUMBER field), and antenna eccentricities, must be up-to-date and strictly follow the agreed-upon conventions (check ftp://igscb.jpl.nasa.gov/pub/station/general/rcvr_ant.tab).

g) After a communications outage, all recovered daily data files must be submitted to a Data Center.

5.4. Site logs

Excellent documentation of site history is particularly critical for these stations, and the station position time series must be free of jumps whose cause or magnitude is not well understood.

a) Whenever there is a change to the site information as documented in the station log, the log must be updated. Instructions how to create and maintain a detailed site log are available at ftp://igscb.jpl.nasa.gov/pub/station/general/sitelog_instr.txt.

b) Updates must be distributed within one business day following any change.

c) Survey measurements, field notes, and reduced results should be preserved and be made publicly accessible.