GNSS data quality control with G-Nut/Anubis in large research infrastructures

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Abstract

Since 2013, the G-Nut/Anubis has been developed for a complex quality control (QC) of all modern GNSS observations and navigation messages. Recently, the tool has been modified for the use within the European Plate Observing System (EPOS) large research infrastructures for handling RINEX files disseminated through newly developed system, GLASS (Fernandes et al. 2017). The CzechGeo/EPOS contribution and other infrastructures will serve as a prototype for development of monitoring of historical archives as well as multi-GNSS data. For this purpose, new QC XML format has been developed for the exchange of principal QC metadata. The latest G-Nut/Anubis is released under the GNU General Public Licence v3 providing pre-compiled binaries for Linux, Windows, and Mac systems and the source code at http://www.pecny.cz.

New QC XML format

Settings and Inputs
Metadata on QC format, used program and user settings.

Header metadata
Metadata from RINEX file header to enable cross-validation of actual data or nominal information.

Ephemeris support
Characteristics of the constellation ephemeris for a reliable full QC.

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```

G-Nut/Anubis - Characteristics and Functionalities

Purpose: G-Nut/Anubis is a tool providing scalable view on RINEX 2.XX/3.XX observations and navigation messages without a need of comprehensive data processing. It is useful for the data quality checking such as identifying incomplete or low quality data immediately after the data collection by GNSS receiver. It provides quantitative and qualitative analyses, standard point positioning, and meta data checking. Since version 2.0, it has been extended by the new QC XML format for key parameter statistics.

Availability:

- Latest release: 2.0.1 (November 7, 2016)
- Upcoming release: 2.1.0 (August/September, 2017)
- Open source (GPLv3): **http://www.pecny.cz (GNSS, software, Anubis)**

Basic characteristics:

- C++ development for use in command-line mode at Linux, Windows and Mac OS-X platforms.
- GNSS (GPS, GLONASS, Galileo, BeiDou) and regional augmentations (QZSS, SBAS, IRNSS).

Inputs/Outputs:

- Configuration: in XML-format
- Inputs: observation and navigation RINEX 2.XX and 3.XX, ephemeris in SP3 format
- Outputs: G-Nut/Anubis's (XTR) easy-to-grep plain format; EPOS standard QC XML format

Processing modes and involved algorithms:

- Sequential or parallel processing, full/light-qc-mode operation, verbosity for individual sections.
- Expected observations counted for the horizon and user cut-off, elevation-dependent histograms.
- Standard point positioning independent for all GNSS global constelations.
- Phase cycle slips detection, clock jumps detection and phase and code synchronicity check.
- Code multipath and noise estimates, signal-to-noise ratio statistics.
- Processing/reporting signals for all bands/frequencies, satellite constellations.

New QC XML Format for Key QC Parameters

The new QC XML format was designed to accomodate key QC parameters (i.e. no epoch/satellite specific) from which various indicators for GNSS data quality can be generated. The aim was to design the format more or less equivalent with the EPOS GNSS database structure in support of pan-european GNSS data dissemination and monitoring service. The key parameters characterize:

- Quantitative control (countable measures without using specific algorithms)
- Qualitative control (navigation messages and some approximations needed)
- Complex control (standard point positioning)

System-independent QC key parameters:

- **data/beg,end**: actual data start/end (independently from QC window)
- **data/smpl**: qc data sampling rate (but no higher than QC sampling request)
- **data/nepo**: # of epochs
- **data/ngap**: # of epoch data gaps (larger than 300s)
- **tot/elev**: minimum elevation angle estimated from available observations
- **tot/expt**: # of expected phase observations – sum over GNSS (no elevation cut-off mask)
- **tot/have**: # of existing phase observations – sum over GNSS (a signal with max count)
- **tot/expt_usr**: as above, but applied for user cut-off elevation mask
- **tot/have_usr**: as above, but applied for user cut-off elevation mask
- **tot/cyc_slps**: # of phase cycle slips – sum over GNSS (the same signal as tot/have)
- **tot/clk_jmps**: # of inconsistencies in phase and code observations due to clock jumps
- **exl/xbeg,xend,xsmp**: # of filtered data for QC due to expected interval and sampling
- **exl/xsys,xsat,xsig**: # of filtered data for QC due to requested systems, satellites and signals

System/signal-dependent QC key parameters:

- **sys/type**: element identifier: GNSS constellation (GPS, GAL, GLO, BDS, SBS, QZS, IRN)
- **sys/nsat**: # of satellites observed
- **sys/xele**: # of all observations not supported with satellite position
- **epo/expt**: # of expected observation epochs
- **epo/have**: # of existing observation epochs (data completeness)
- **epo/dual**: # of dual-frequency usable epochs (four satellites at least)
- **amb/nepo,nsat**: # of phase interruptions due to missing epoch and satellite
- **amb/nsig,nslp**: # of phase ambiguities due to signal interruption or cycle slip
- **bnd/cod_xepo,cod_xsat**: # of epochs/satellites with single frequency pseudo-range data
- **bnd/pha_xepo,pha_xsat**: # of epochs/satellites with single frequency carrier-phase data
- **obs/type**: element identifier: GNSS observation type
- **obs/nsat**: # of satellites for specific observation type and system
- **tot/expt,expt_usr**: # of expected obs with/wout user elevation cut-off mask applied
- **tot/have,have_usr**: # of existing obs with/wout user elevation cut-off mask applied
- **tot/mpth**: mean code multipath (in cm) estimated for specific code signal
- **tot/slps**: # of cycle-slips identified for specific carrier-phase observation type
- **crd/x,y,z**: mean coordinates estimated using standard point positioning
- **crd/sx,sy,sz**: repeatabilities estimated from standard point positioning

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Vaclavovic P, Dousa J (2014), G-Nut/Anubis: Open-Source Tool for Multi-GNSS Data Monitoring with a Multipath Detection for New Signals, Frequencies and Constellations, In: IAG Symposia Series, Springer, Vol. 143

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