G-Nut software library and its applications within context of EPOS

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Abstract

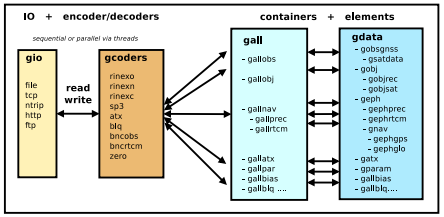
We present the G-Nut software library aimed for the development of targeted end-user GNSS applications in various geoscientific fields - geodesy, seismology, meteorology, climatology end others in future. It has been developed since 2011 at the Geodetic Observatory Pecný (http://www.pecny.cz/).

The library is written in C++ applying the object oriented approach aiming for a flexible source code implementation, easy maintenance and future extension. Currently, the library supports the Precise Point Positioning technique, which is a highly efficient and autonomous method suitable for various accuracy-demanding tasks in GNSS online or offline processing. Specific user applications were developed - 1) the tool for GNSS data converting, cutting/splicing, editing and quantity and quality checking, 2) the application for troposphere monitoring (real-time or post-processing) and 3) the application for the precise positioning in a static or kinematic mode. The latest results are demonstrated including the capability and relevance for applications in inter-disciplinary domains. Although the G-Nut library is still in a testing stage, selected lite programs (beta versions) were already released (http://www.pecny.cz - GNSS - software). We expect that these could significantly contribute to a broad scientific community to be consolidated in the EPOS project, in particular to facilitate GNSS data collecting, monitoring and processing.

G-Nut software library

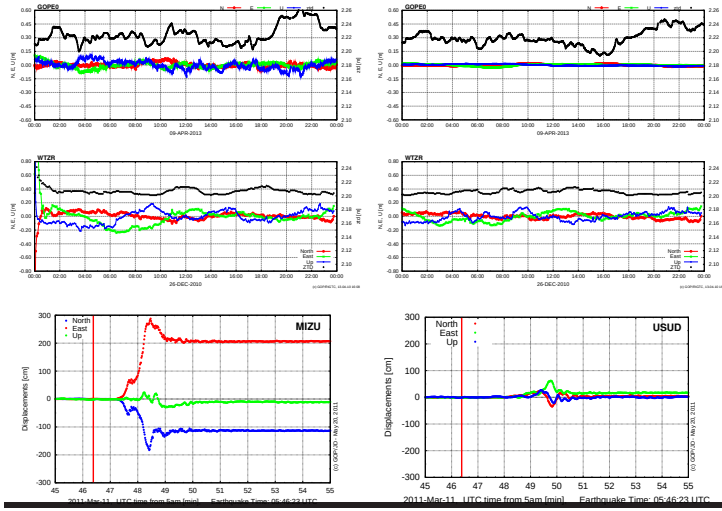
The G-Nut project was initiated in 2011 at the Geodetic Observatory Pecný, RIGTC for implementing core software library to support developments of various end-user applications. The library is written in C++ taking advantages of object-oriented design and supporting multi-thread processing. It is designed for Linux OS and providing command-line applications which are usually used for operational tasks. The G-Nut exploits the Boost's library for a platform independent threading implementation (this dependence is likely to be revised in future). For matrix representation and factorization methods, the G-Nut utilizes the New-Mat library developed by Davis (2009) and, for parsing XML configurations, the Pugixml light-weight C++ library by Kapoulkine (2012). The XML mark-up language was selected for user application settings due to its high flexibility and support by various other editing and viewing user-tools. Main characteristics are summarized as follows:

- C++ object-oriented design for multi-thread applications
- adaptable data containers for real-time and off-line batch processing
- multi-GNSS data handling and processing support,
- unique IO operations for various protocols (files, streams),
- inherited encoders/decoders for file/stream data formats,
- different adjustment models (LSQ, Kalman, Kalman/srcf, back-smoothing),
- dual-layer XML configurations (for library classes and for user applications),
- command-line, GUI to be implemented for prominent applications.



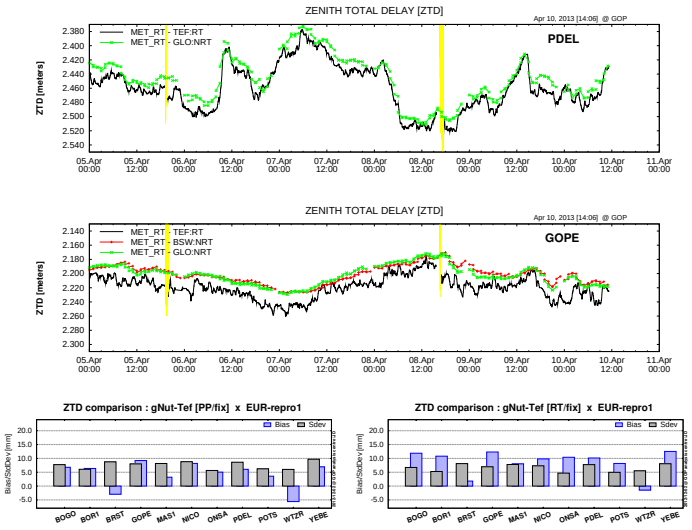
Geb - positioning tool

Two top figures below display real-time positioning in a kinematic (left) and static (right) mode in a routine solution, April 9, 2013 (site GOPE). Kalman filter with a square root covariance modification was used. Two middle figures show post-processing daily solutions (30s) with a) a forward filter applied only characterized by an initialization period (left), b) additional back-smoothing algorithm applied (right) providing similar results (without initialization) like a least-square batch processing. Finally, two figures at bottom demonstrate a capability to track position displacements during the earthquake Tohoku-Oki, Japan, 11th March, 2010 (5:46:23 UTC, Mg9.0). Two stations were processed offline with a high-rate data sampling and in different distances from the epicentre - MIZU (140 km) and USUD (430 km). While the first site was shifted at a meter level (after showing strong initial earthquake shock waves), the second didn't show significant displacement, but only small waves with a delay after earthquake.



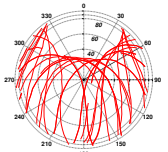
Tefnut - troposphere monitoring tool

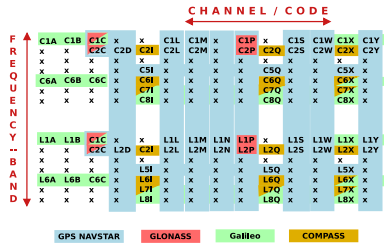
Two figures below display the Zenith Total Delays (ZTD) from a routine real-time analysis based on PPP technique supported by IGS real-time products. GOP real-time ZTDs (TEF:RT) are compared to GOP near real-time regional (BSW:NRT) and global (GLO:NRT) ZTD solutions. The yellow lines indicate ZTDs filtered out according to exceeding formal accuracy (usually due to re-initialization etc). The results demonstrate a high quality of real-time ZTDs in support of severe weather monitoring. Some systematic errors still occur, which are due to some modeling simplifications (not all precise models has been already implemented), however, a priority interest is to achieve stable ZTD standard deviations based on real-time data and products. Two additional figures (bottom) show the statistics achieved in a preliminary benchmark of a post-processing mode (IGS final products) and simulated real-time mode (IGS RTS products).



Anubis - data QC and editing tool

Tool for data and navigation message editing, splicing/cutting, quality monitoring (clock jumps, cycle slips, multipath, SNR, ...) and quantity monitoring (number of satellites, systems, obs-gaps/types/percentages, ...) has been developed along with the PPP applications when utilizing common functions. Currently, a post-processing mode is supported, but real-time could be derived easily too. Implementations of a multi-GNSS capability in RINEX V3.01/V2.11 data formats were tested using dataset from the IGS multi-signals tracking campaign - MGEX. Although some capabilities are still under development (e.g. RINEX encoder for supporting saving modified files), the tool is already tested for GNSS data and navigation message handling at the GOP data center. (Note: the application hasn't yet been released since still defining an optimal output in ASCII, XML or figs).





Newest information about the library development is maintained at: http://www.pecny.cz/ (GNSS, software) with possibility to join G-Nut mailing list. Or contact us at gnss@pecny.cz.

Acknowledgments:

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