G-Nut Software Library Development and its Application Examples

J. Douša, P. Václavovic and G. Györi

(jan.dousa@pecny.cz)

Geodetic observatory Pecný,
Research Institute of Geodesy, Topography and Cartography

EUREF Symposium, Paris
June 5-7, 2012

outline

- Motivation
- Core library – G-Nut
- List of applications
- First results of positioning (G-Geb)
- First results of troposphere monitoring (G-Tefnut)
- Summary and outlook

Research Institute of Geodesy, Topography and Cartography
Geodetic Observatory Pecný (GOP)

Motivation

- to be able to keep the state-of-art models and to support all GNSS
- to be ready for in-house modifications for specific projects
- to provide alternative for existing software packages
- to exploit the development effort as a learning process
- to support easy development for applications tailored for specific tasks in various communities
- …

- by developing and maintaining GNSS core library in C++
- being flexibly, but uniquely implemented with easy use and extensions
- supporting easy implementations of specific software packages (applications) for usage in various areas - geodetic, meteorology, geophysics, …
- as possibly as apply open-source licence (for basic applications at least)

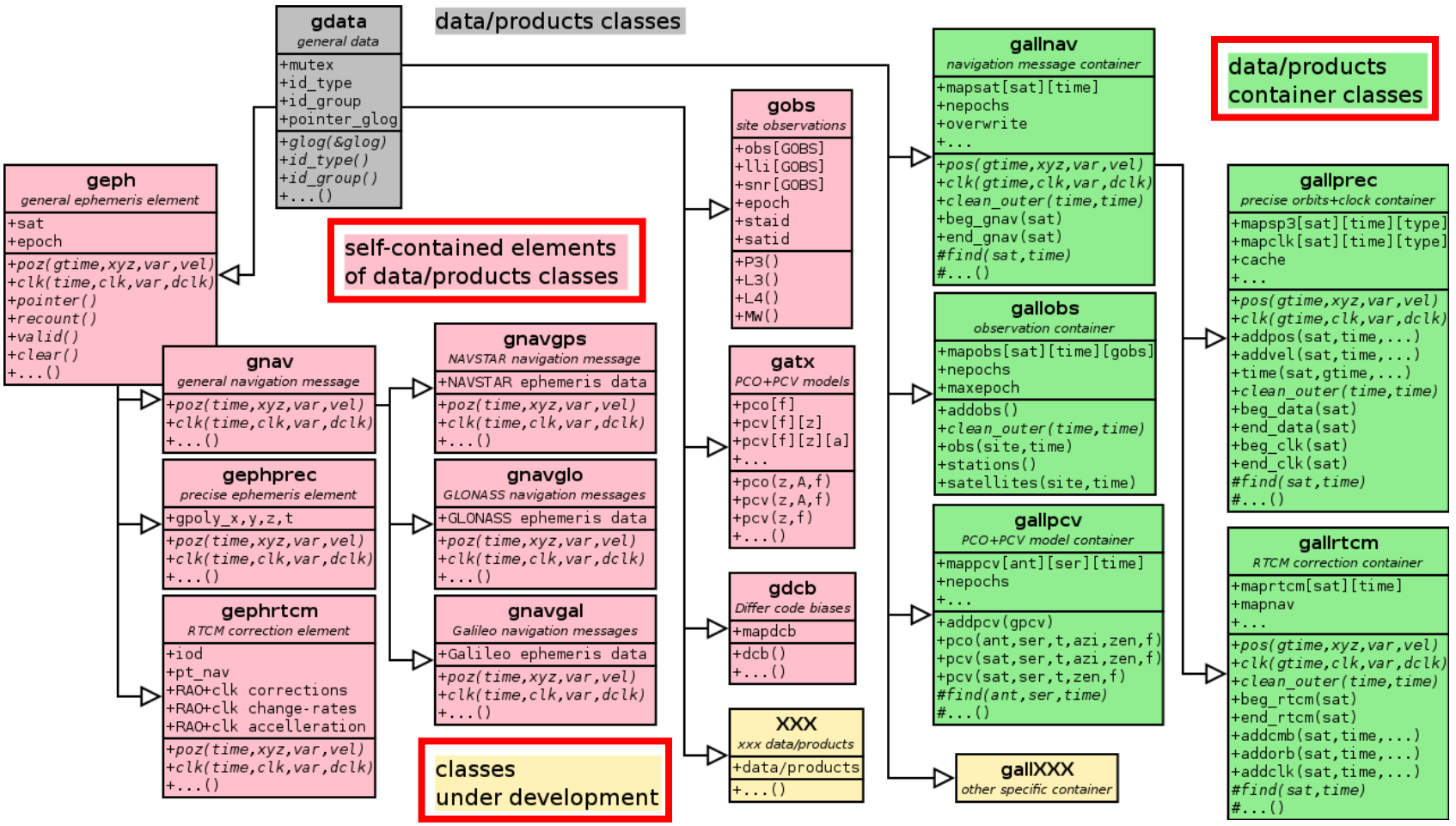
Research Institute of Geodesy, Topography and Cartography
Geodetic Observatory Pecný (GOP)
VÚGTK

Core Library – G-Nut

- ANSI C++ with object-oriented approach
- developed independently from a GUI, using XML input format only
- for some applications GUI will be implemented independently
- multi-thread support (currently depends on Boost's library)
- multi-platform (Linux, Windows)
- multi-GNSS (GPS, GLONASS, Galileo, ...)
- models for undifferenced GNSS observations processing (currently PPP)
- IO unique approach for file, tcp, http, ntrip, ftp, ...
- flexible data and product self-content elements and collecting containers
  - IO and data structures doesn't not distinguish real-time streams and data files
- support various adjustments methods, currently:
  - Least square adjustement (with efficient sparse matrix calculation)
  - Kalman filter (with back-smoothing)
  - Square Root Covariance filter (or Information filter)

G-Nut – data structures

gdata – G-Nut base data class, all derived data structures are implemented via self-content elements and their containers



5

G-Nut - IO implementation

gio – G-Nut Input/Output

-> gfile

-> gtcp -> gntrip

gcoder – G-Nut encoders and decoders

-> sp3

-> rinexo

-> rinexn

-> rinexc

-> bncrtcm

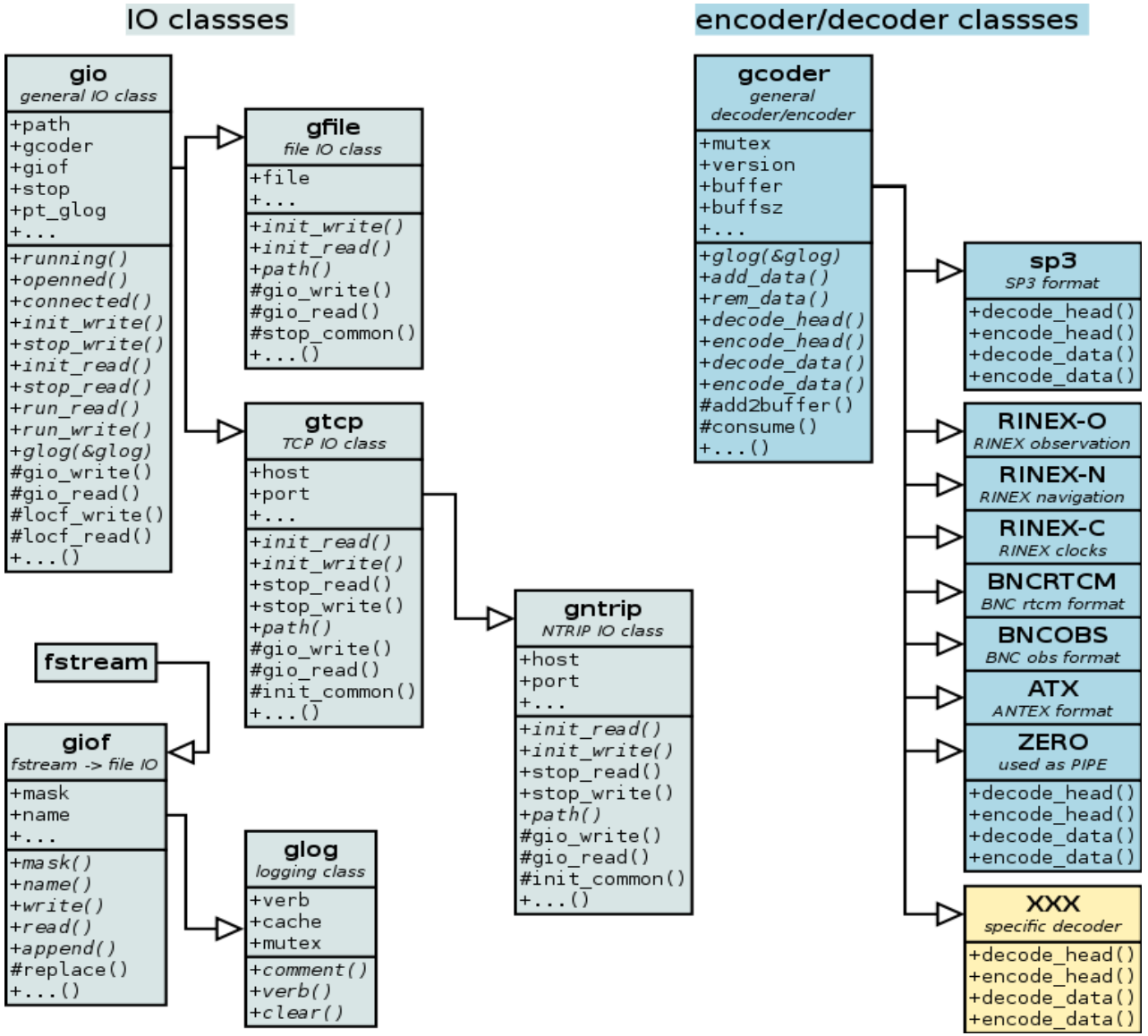
-> bncobs

-> atx

-> zero

giof – G-Nut file

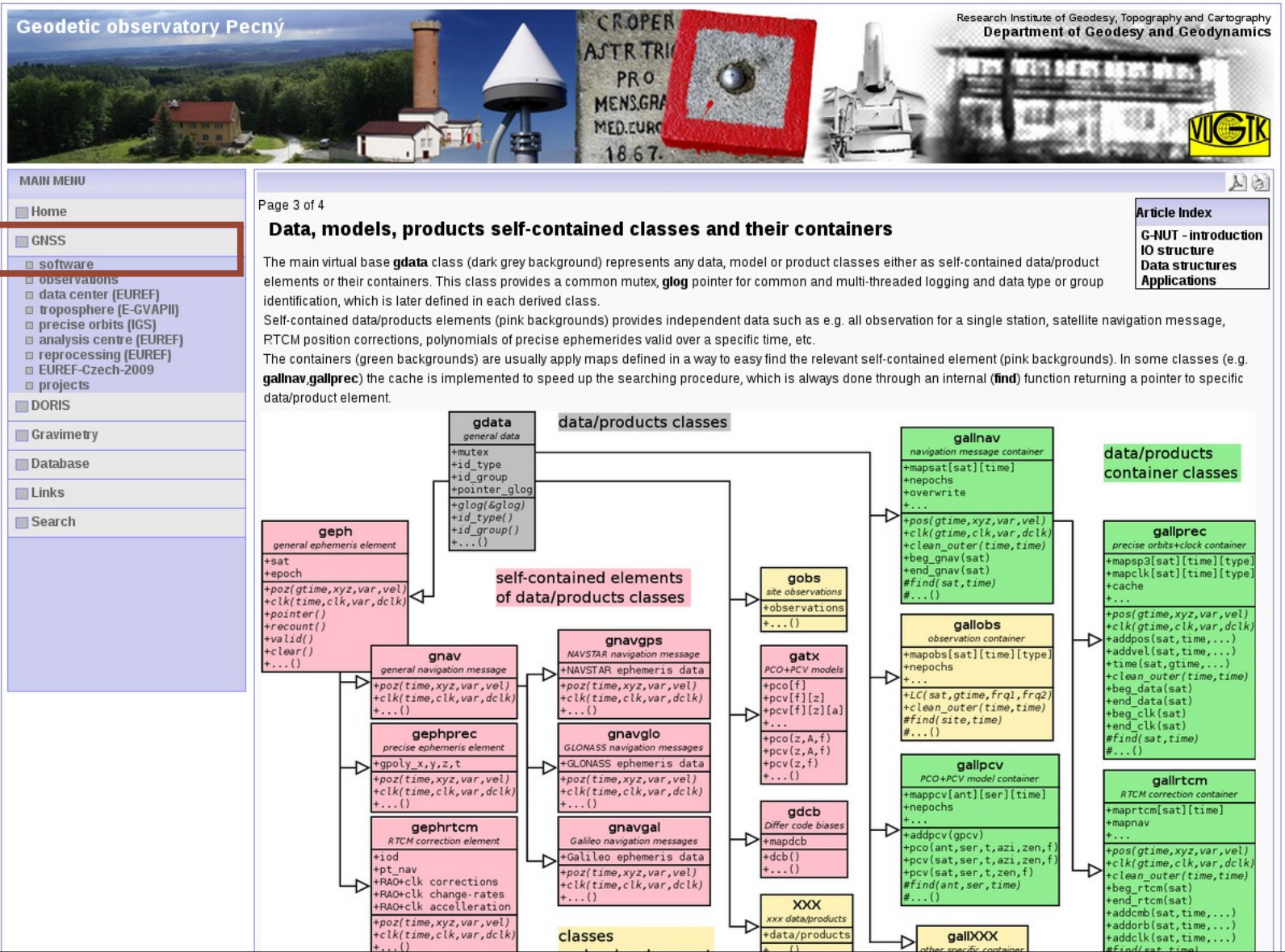
-> glog



6

G-Nut software library web

- http://www.pecny.cz/ (GNSS, software)



Applications (based on G-Nut)

Various level of current developments (future plans not considered)

- **Coordinates and Positioning**
  - **G-Geb – static or kinematic positioning, real-time (RT) or post-processed (PP)**
- **Water Vapour in Troposphere**
  - **G-Tefnut – water vapor monitoring in near real-time or ultra-fast real-time, RT, PP**
- **NTRIP**
  - **G-Nut-ntrip_client - collect NTRIP/TCP streams to a file**
  - **G-Nut-ntrip_server – disseminate (rotate) file to NTRIP/TCP as stream**
  - **G-Nut-ntrip_pipe - forward from one NTRIP caster to another**
- **Broadcast RINEX (RINEX 3.x, RINEX 2.x)**
  - **G-Nut-navMonitor - broadcast navigation check, GPS satellite manoeuvres detection, concatenation, format conversions**
- **Data RINEX (RINEX 3.x, RINEX 2.x)**
  - **G-Nut-rnxMonitor - content monitoring, editing, format conversions, quality checking**
- **PRODUCTS (SP3c)**
  - **G-Nut-orbMonitor – orbit quality monitoring via comparisons, conversions**
- **.....**

Example setting – class parsing XML configuration supported by DTD

```
<?xml version="1.0" encoding="UTF-8" standalone="yes" ?>
<!DOCTYPE config SYSTEM "G-Geb.dtd" >

<config>
    <ppp> <settings
                phase="true"
                tropo="true"
                static="true"
                filter="SRF"
                smooth="kalman"
                save4smt="false"
                aprioriX="0.0"
                aprioriY="0.0"
                aprioriZ="0.0"
                crd_init="100"
                crd_pred="0.01"
                ztd_init="0.1"
                ztd_rndw="2.5"
                ztd_mapf="GMF"
            />
            <inputs
                observ="ID0|file://RINEX/gope0980.12o|rinexo"
                orbits="ID1|file://SP3/1682/igs16826.sp3|sp3"
                clocks="ID2|file://SP3/1682/igs16826.clk_30s|rinexc"
                pcopcv="ID3|file://GEN/epn_08_1685.atx|atx"
                result="CRD_PP/gope_12098.dat"
alternatively
                observ="ID0|ntrip://GOPE0/user:pasw@ntrip.pecny.cz:2101|bncobs"
                broadc="ID1|tcp://localhost:10400|rinexn"
                bncrtc="ID2|tcp://localhost:10500|bncrtcm"
                pcopcv=""
                result="CRD_RT/gope_<yr><doy>.dat"
            />
     </ppp>
</config>
```

General settings for PPP solution

Post-processing configuration

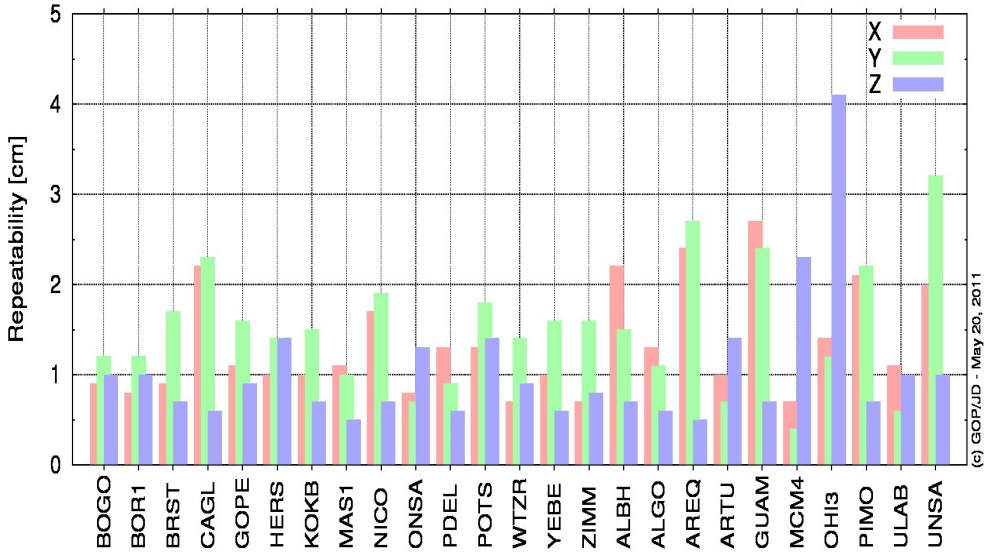
Real-time configuration

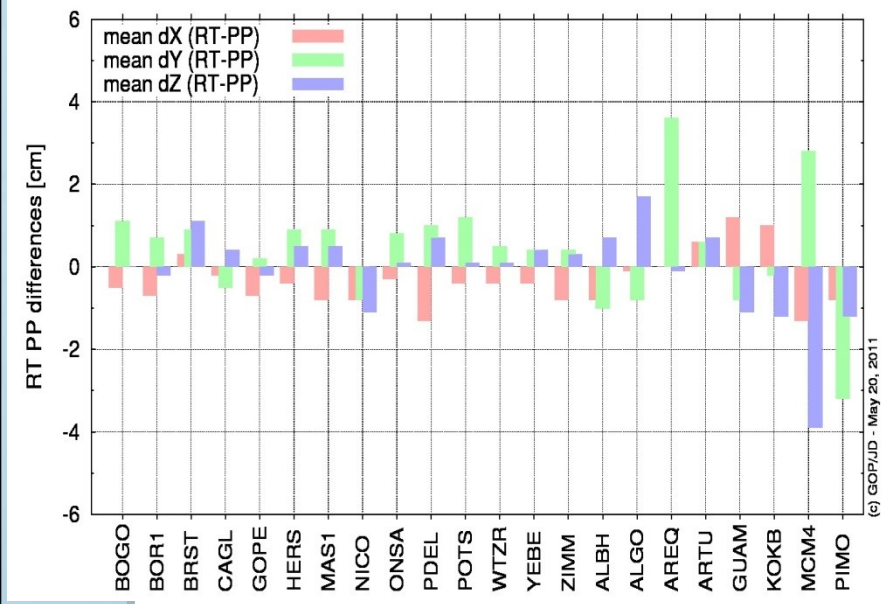
9

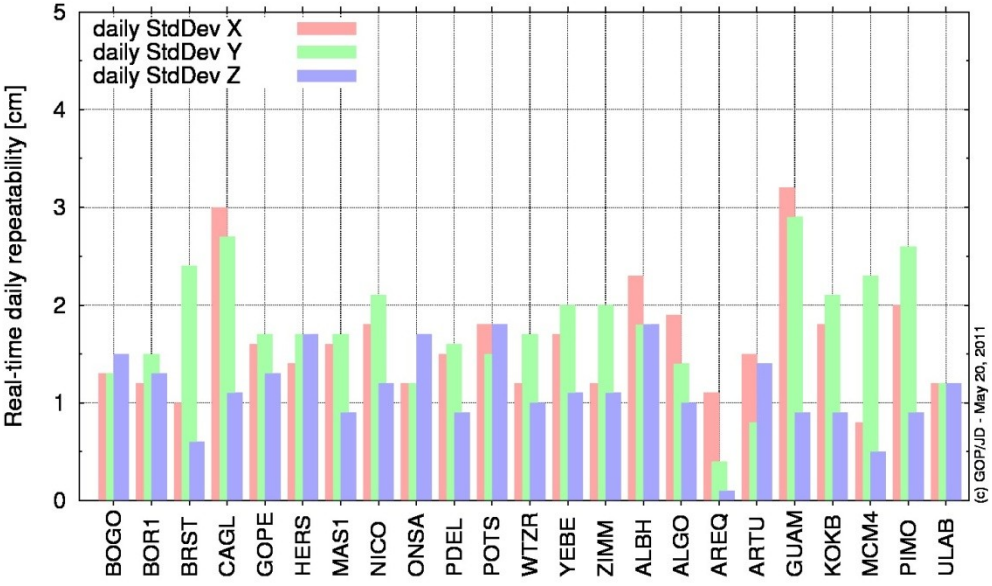
G-Geb - static positioning

Daily XYZ coordinate repeatability from
1.post-processing solution (SP3+CLK) - - (left top)
2.simulated real-time solution (RTCM) - - (left below)
over 1.5 months daily data

(Simulated) static real-time minus post-processing coordinates differences - (below)







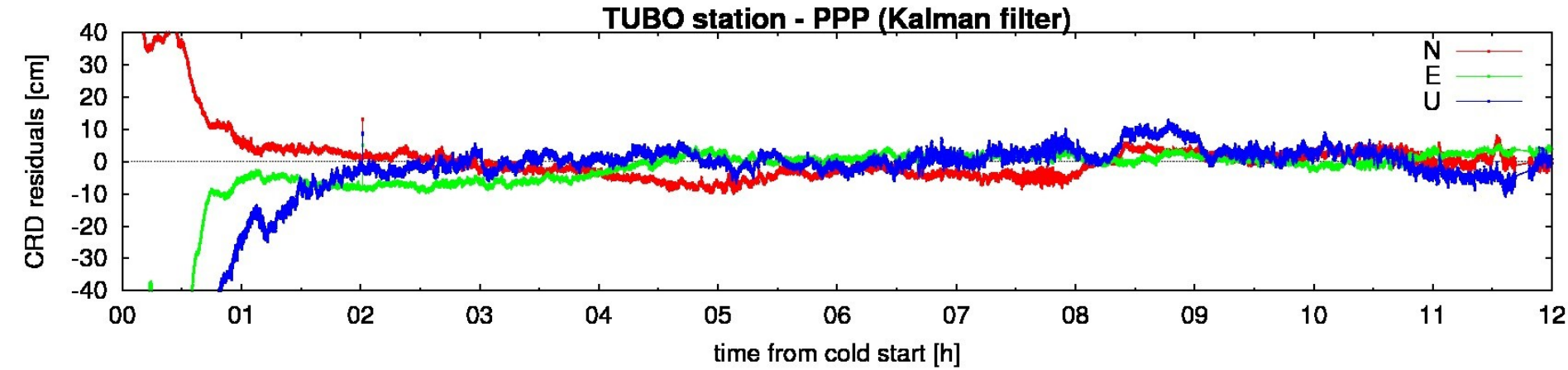
G-Geb - kinematic positioning

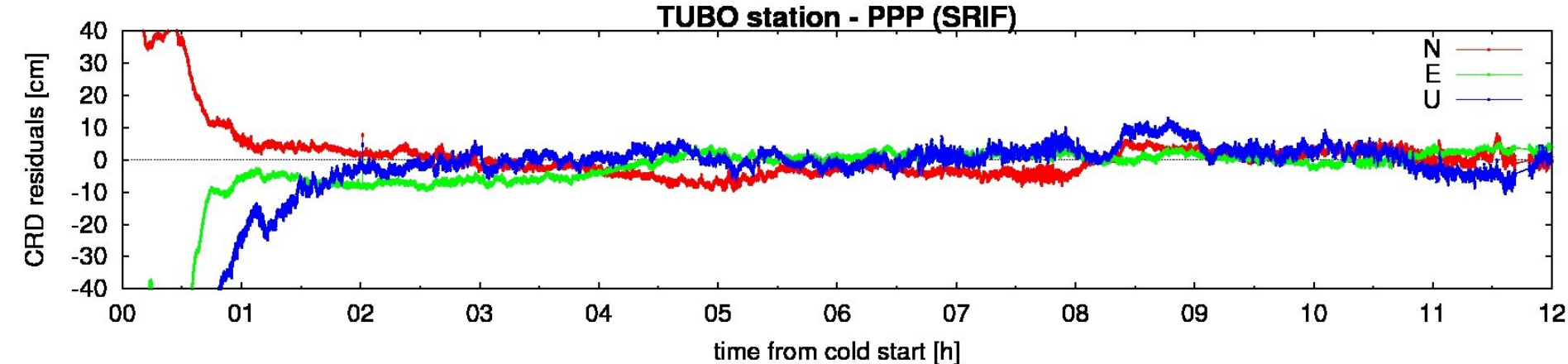
Kinematic solution using SRCF and Kalman filter

Still long initialization for station TUBO (~hour)

NEU coordinate residuals from mean (+- 10cm/coordinate) after initialization

Ambiguity float solution



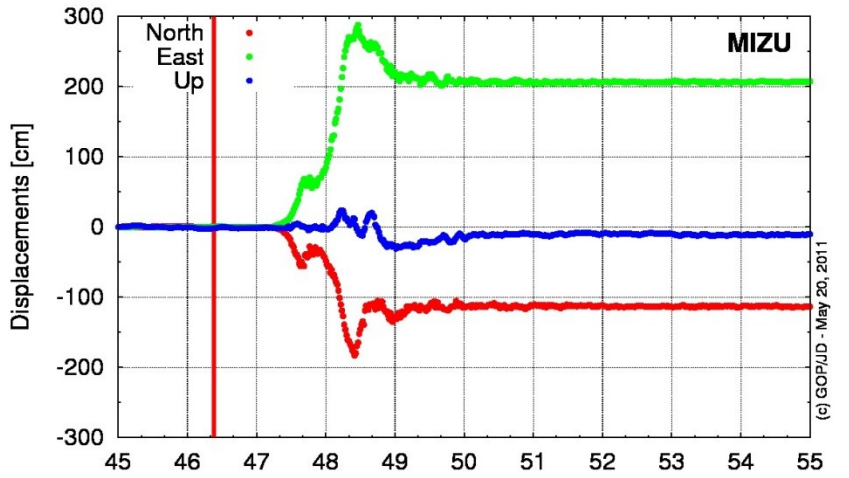


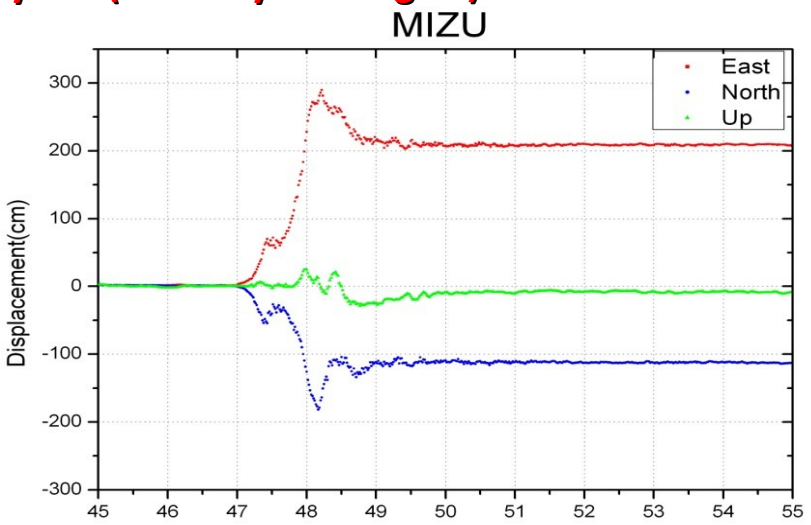
G-Geb - Tohoku-Oki EQ (Japan, 2011)

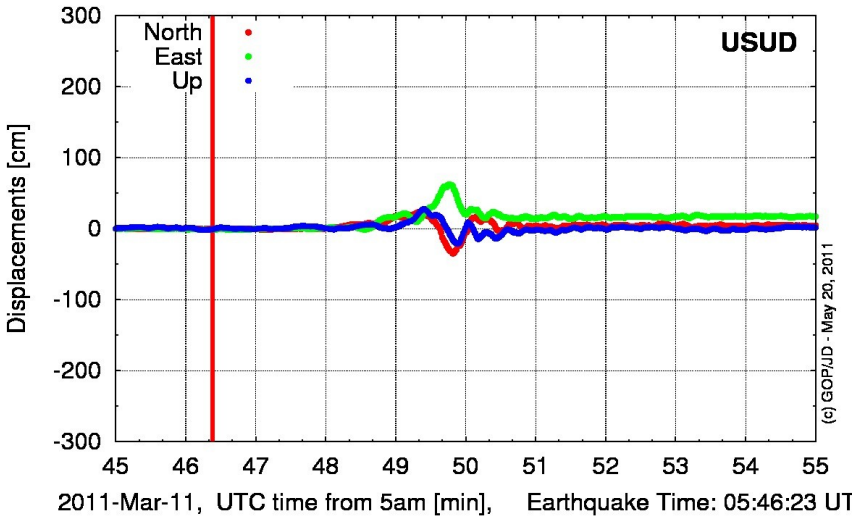
Tohoku-Oki Earthquake (Japan, Mar 11, 2011, 5:43:23 UTC)

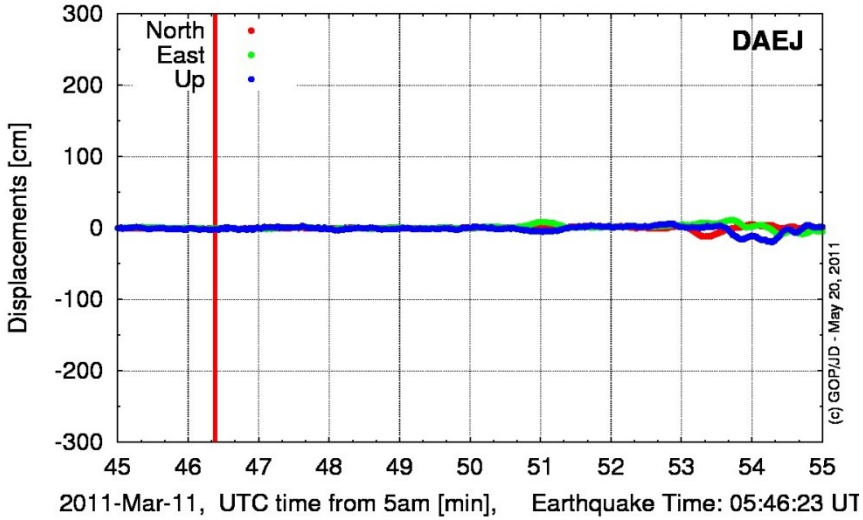
IGS stations MIZU (~100 km), USUD (~250 km), DAEJ (>1000 km)

Left – MIZU solution based on Wuhan University sw (courtesy of Rongxin)

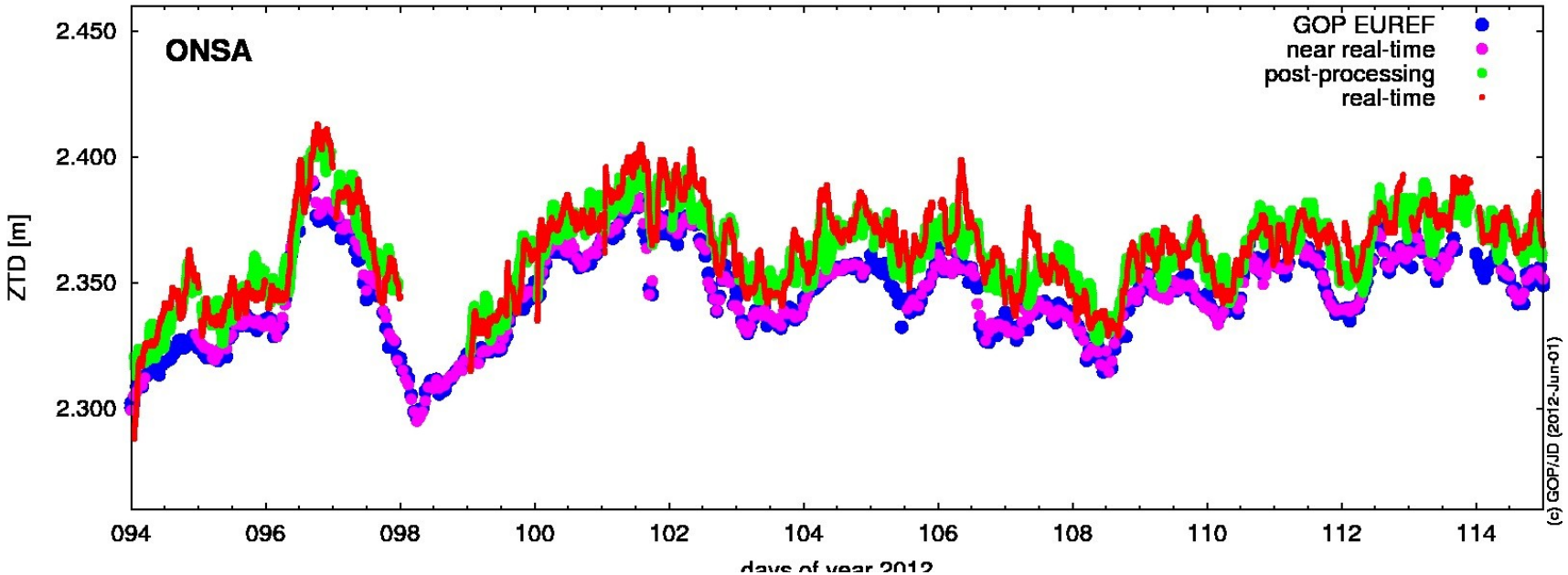


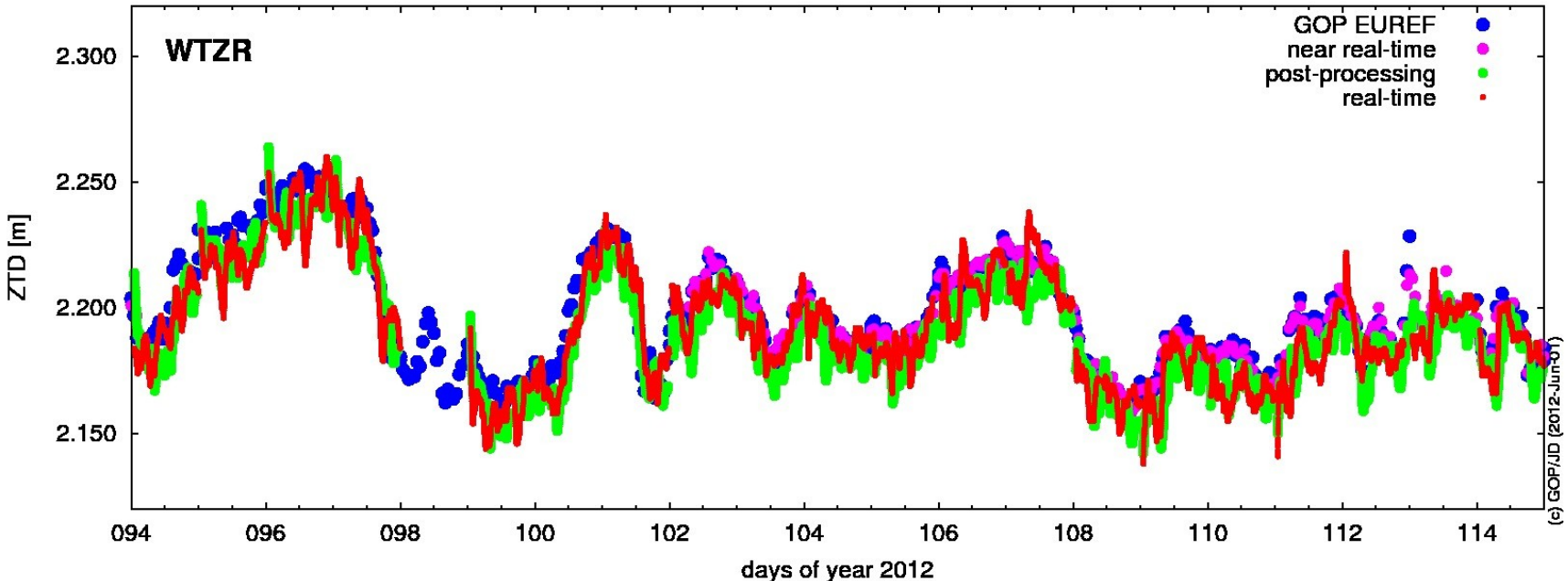






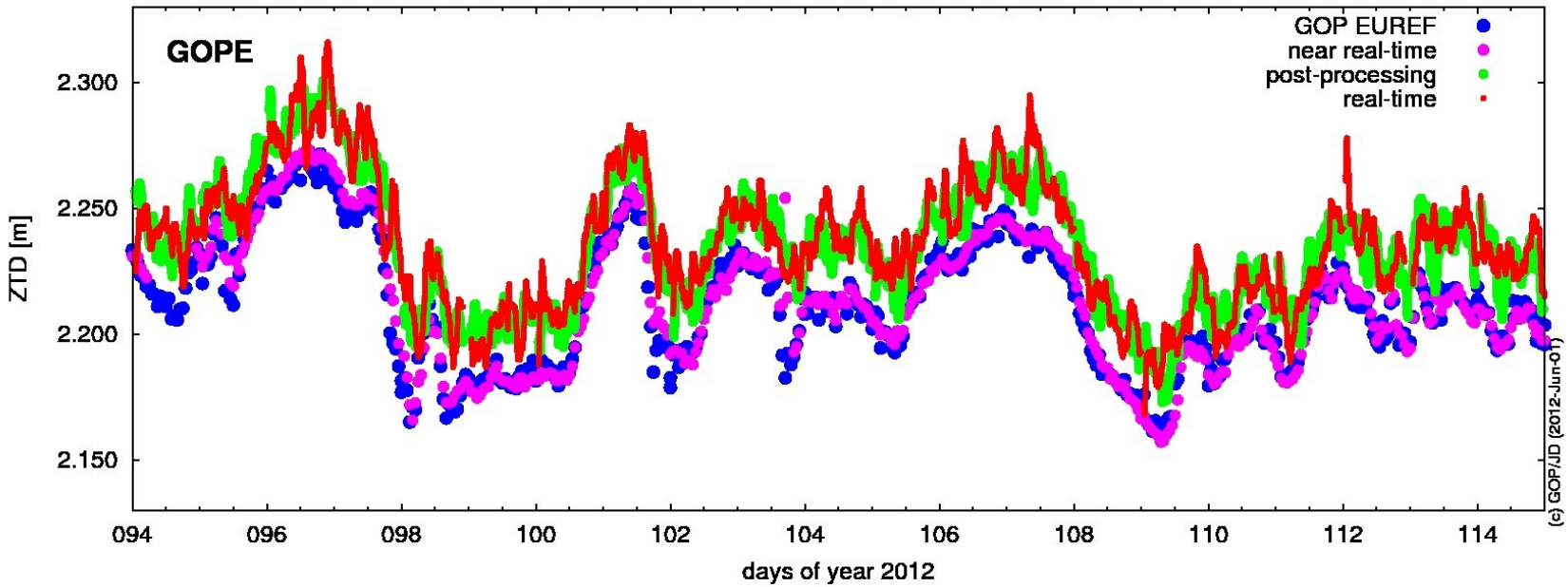
G-Tefnut – water vapor monitoring

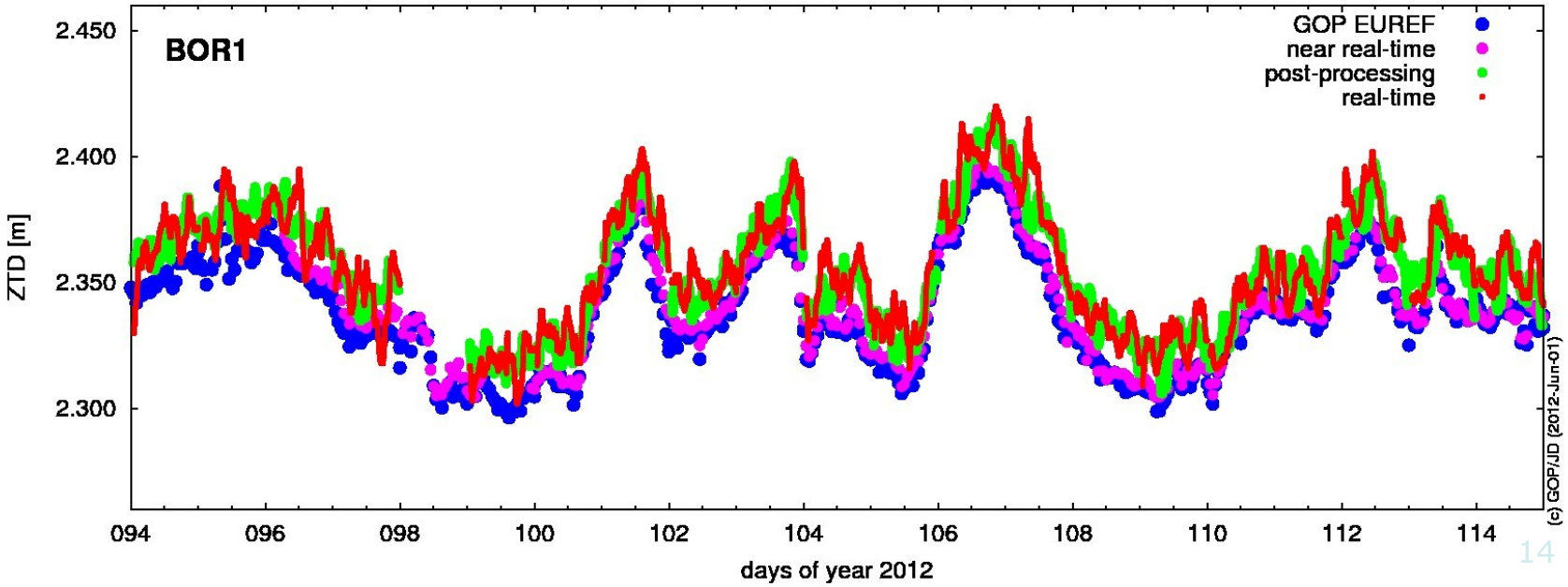




Research Institute of Geodesy, Topography and Cartography
Geodetic Observatory Pecný (GOP)

G-Tefnut – water vapor monitoring





Research Institute of Geodesy, Topography and Cartography
Geodetic Observatory Pecný (GOP)

Summary

- G-Nut core library in development and applications implemented
  - G-Geb, G-Tefnut
  - G-Nut-ntrip_client, G-Nut-ntrip_server, G-Nut-ntrip_pipe
  - G-Nut-RnxMonitor, G-Nut-NavMonitor, G-Nut-orbMonitor
- G-Nut still under development, core-library will be consolidated within a few months (hopefully before IGS workshop 2012)
- Some basic applications will be then available for the community with open-source code at http://www.pecny.cz (GNSS, software)
- Currently we have a long-term development plan (at least 3-4 years) and sequence of targets:

  real-time, offline PPP in static & kinematic modes

  troposphere estimation in quasi real-time for severe weather monitoring

  other small applications … (communication, monitoring, QC, …)

  precise satellite clock estimations (for PPP service support)

  products for PPP ambiguity resolution (in Europe)

  regional augmentation

Research Institute of Geodesy, Topography and Cartography
Geodetic Observatory Pecný (GOP)
VÚGTK

Thank for your attention !

Acknowledgements:

Various parts of presented work has been supported by

the Czech Science Foundation (P209/12/2207),

and

the European Regional Development Fund (ERDF), project "NTIS - New Technologies for Information Society", European Centre of Excellence, CZ.1.05/1.1.00/02.0090