GOP LOCAL Analysis Centre Centre Report (2010-2013)

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Czech Republic

EUREF LAC Workshop
(May 15-16), Brussels, Belgium

Outline

- **Repro activities**
  - **GOP, full EPN, I05xI08, other studies**
  - **Long-term combinations**
- **Troposphere monitoring**
  - **Near real-time, real-time, reprocessing solutions**
  - **Multi-GNSS, global solution**
  - **Tropo evaluation, model testing and developments**
- **Software development**
  - **Real-time && offline CRD, TRP solutions**
  - **Data QC, EURv3 multi-GNSS monitoring**

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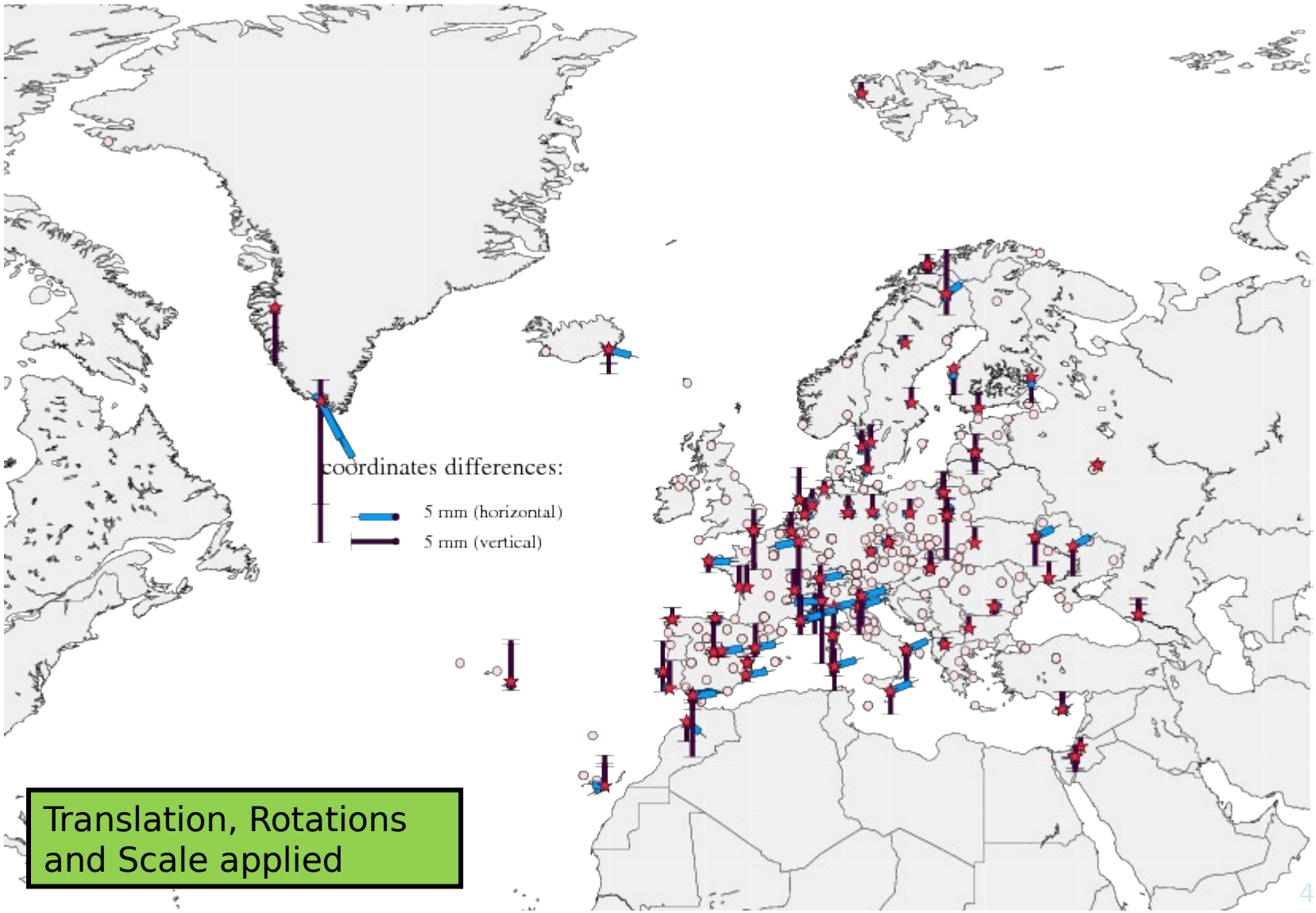
GOP Reprocessing

- 1996/01 – 2010/12: GOP Repro1
  - GOP sub-network, I05 models, contributed to EUREF repro1
- 1996/01 – 2011/04: GOP Repro1+ I05
  - Full EPN, I05 models & RF, assessment of EUREF repro1
- 1996/01 – 2012/12: GOP Repro1+ I08
  - Full EPN I08 models & RF, internal solution for comparison

- Relevant issues studied:
  - Datum definition in previous EPN densification
  - Comparison of I05 and I08 repro-results
  - Assessment of latest EUREF densification (CRD, VEL, DATUM, discontinuities)
  - Data check in historical archive
  - LAC's SINEXs - EPN station period validity, PCOs, ...

GOP Repro1+ I05 x I08 (combination)

Helmert residuals btw GOP IGS05 and IGS08 models (0836-1631), 2005.0



Translation, Rotations and Scale applied

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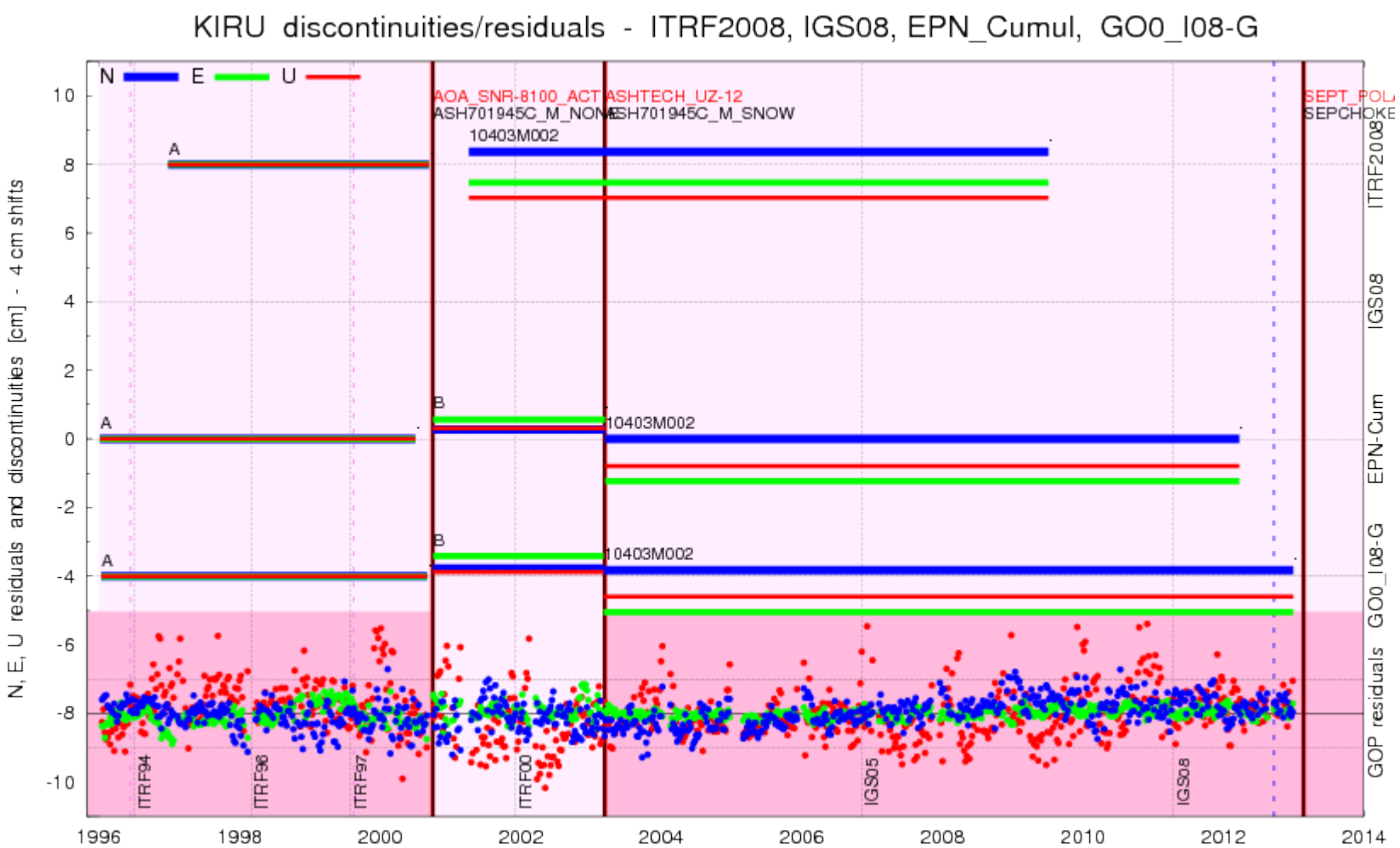
Discontinuity monitoring

Solutions: ITRF2008, IGS08, EPN-cumulative, GOP-Repro1+(I08)
Residuals: GOP-Repro1+ I08



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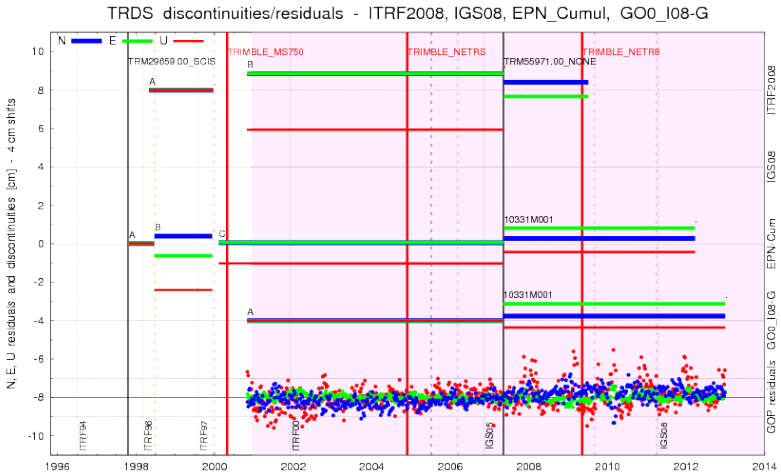
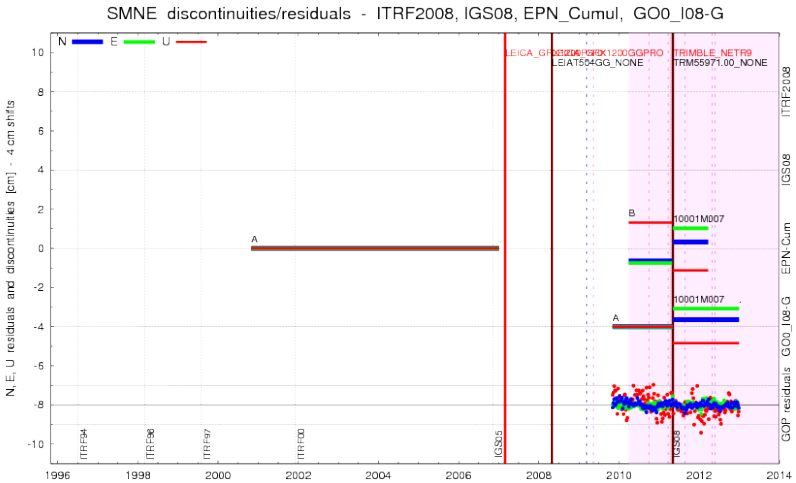
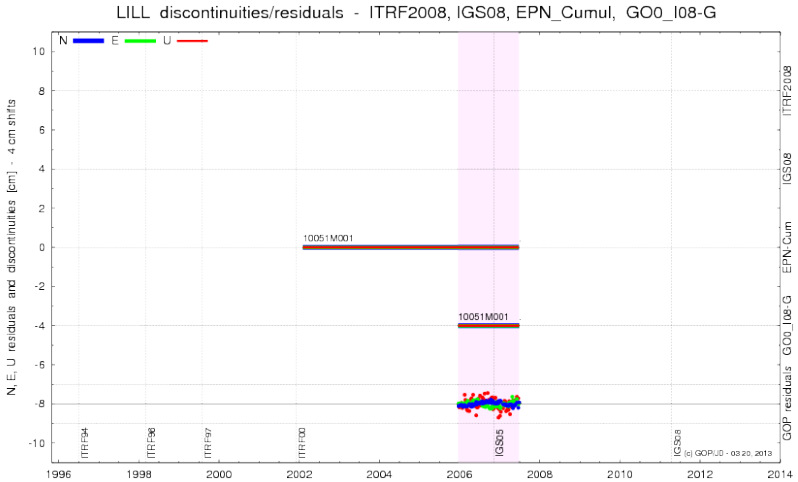
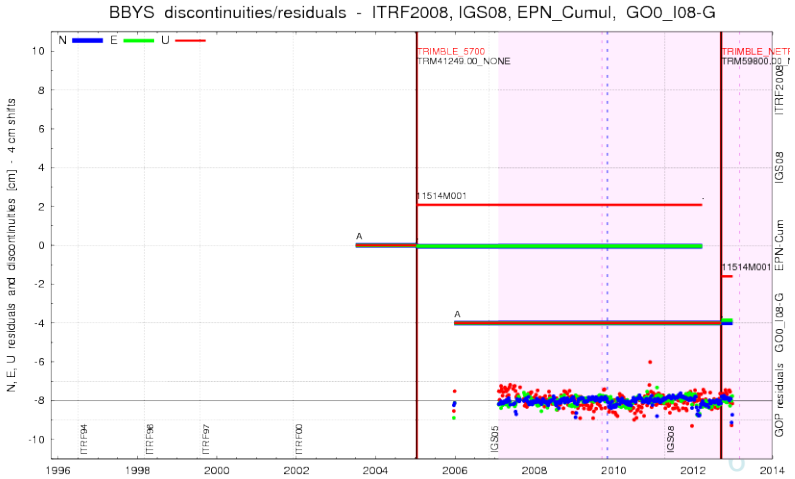
Different periods in EPN inclusion & DB

AXPV, BBYS, BADH, BSCN, CAEN, CEUT, COBA, CREI, EGLT, EVPA, GUIP, KHAR, KUNZ, LILL, M0SE, MAD2, MAN2, MDOR, MILO, MOPS, NEWL, OSLS, ROVE, SAAS, SCOA, SMNE, STAS, SUUR, TERC, TLFM, TRDS, TRFB, TROM, TUBI, UPAD, VARS, VCHM, VLNS, WARN, ZOUF,... (some very small)









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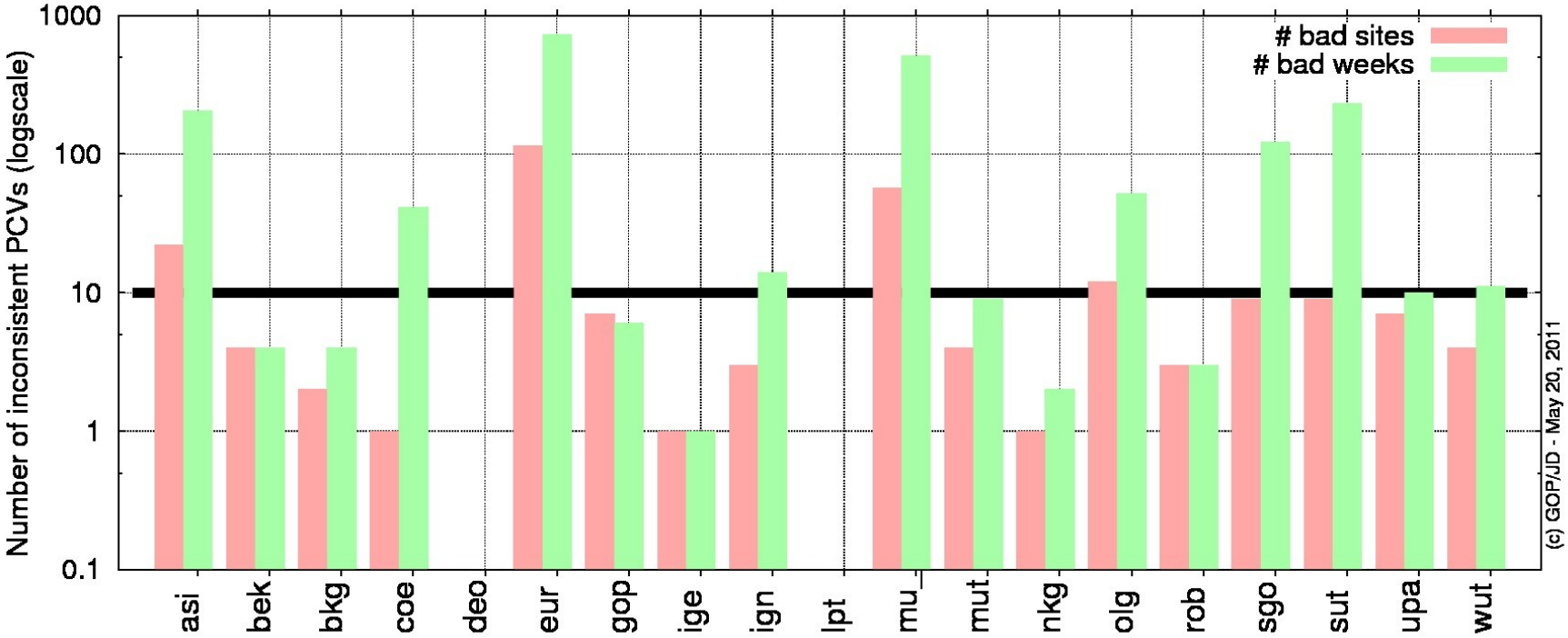
Checking individual SINEX information

- **Extracting weekly individual SNX contributions (and EUR combined)**
- **Identifying individual solution problem (considered as bad values)**
- **Figures for L1, L2 PCO and monumentation eccentricities**
- **Figures show various other information (LACs contribution, data-spans ...)**
- **http://www.pecny.cz/WWW_IMG/EPN-REPRO1/IMAGES/**

Bellow is a summary of identifications 'bad' PCV values in LACs' contributions



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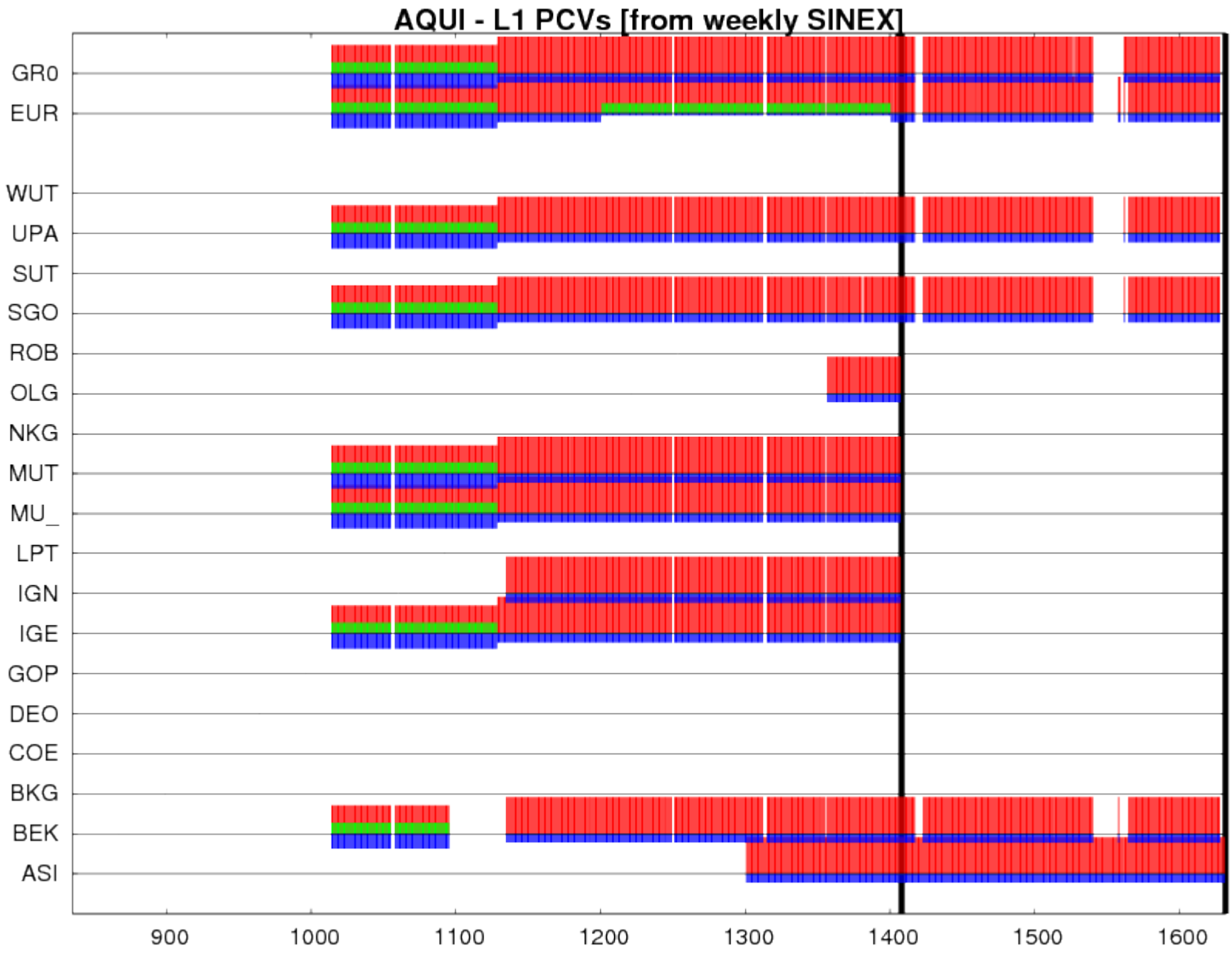
Checking individual SINEX information (examples)



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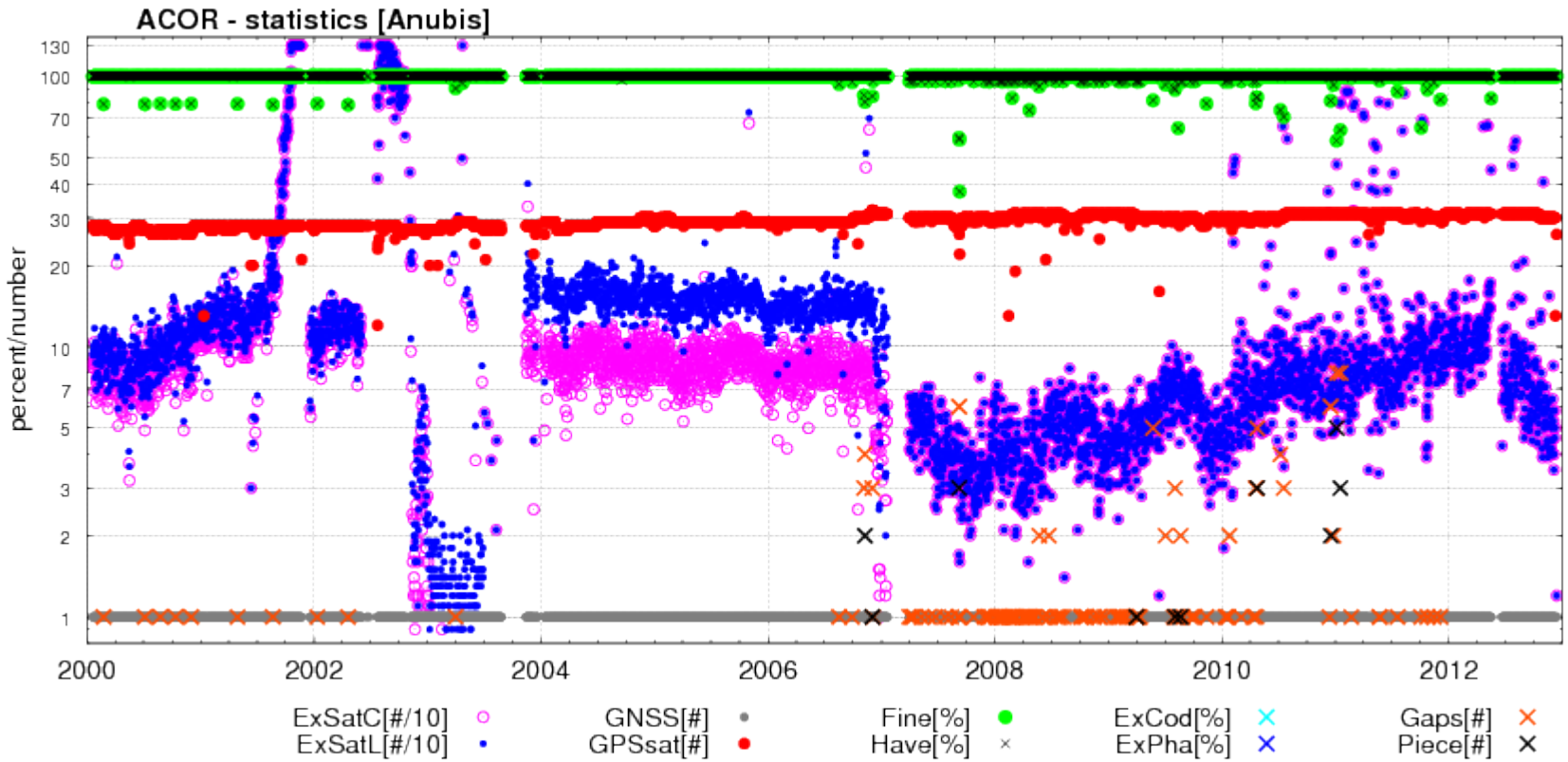
Checking station historical data quality

- From GOP Repro1+ combination we identified additional data problems:
  - ACOR, ANKR, BOGI, BYDG, CPAR, DRAG, GRAZ, GWWL, LROC, KIRU, MADR, MDVO, OBER, REDZ, SFER, SNEC, SWKI, TOIL, TRO1, USDL, VLNS
- Checking content and reliability of present data
- Data gaps usually handled within daily processing, but special cases showed, e.g.: a few satellites only collected over day, # gaps, etc.



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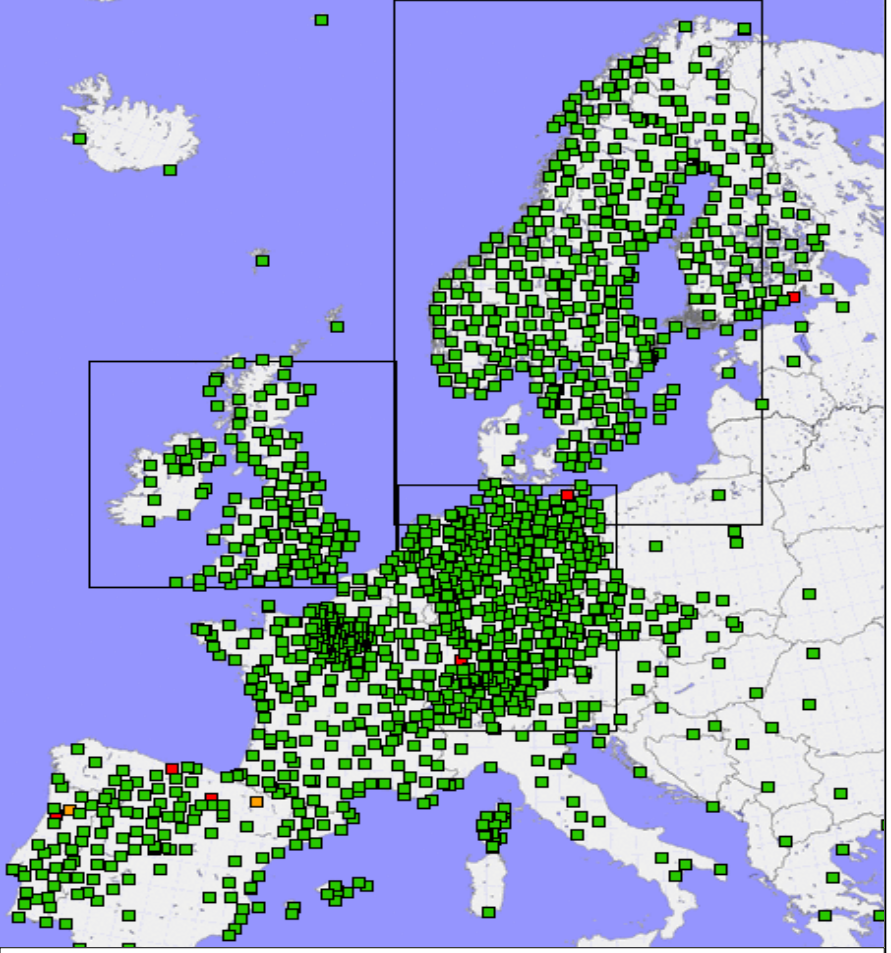
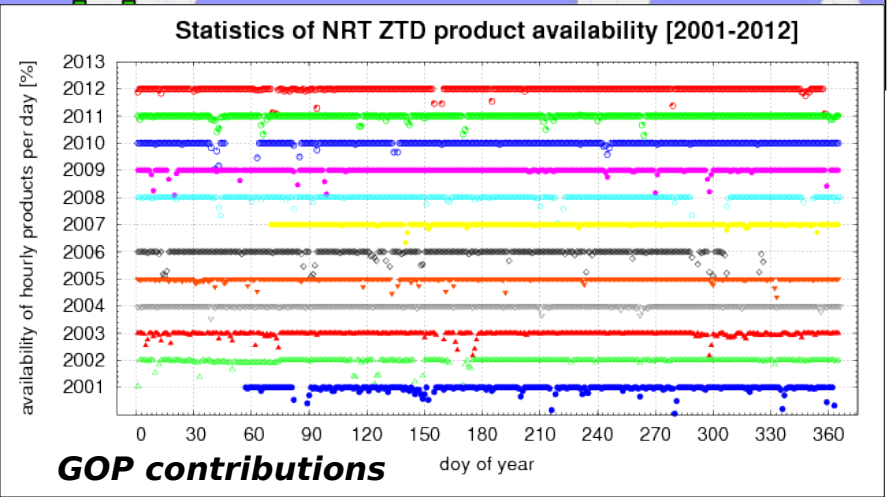




GOP contributions

GNSS-meteorology in Europe
(GOP contributions)

COST-716 Action (1998-2003): "Exploitation of Ground-Based GPS for Operational Numerical Weather Prediction and Climate Applications"

- **15 institutions, 7 ACs, > 200 GPS sites**

TOUGH (2003-2006): „Targeting Optimal Use of GPS Humidity Measurements in Meteorology"

- **15 institutions, 12 ACs, > 400 GPS sites**

E-GVAP I, II, III (2006-2016)

„The EUMETNET GPS Water Vapor Programme"

- **15 institutions, 15 ACs, > 1800 GNSS sites**

GNSS4SWEC - COST Action (2013-2016) !

„Advanced Global Navigation Satellite Systems tropospheric products for monitoring severe weather events and climate "

- **> 37 institutions (25 EU countries)**
- **Kick-off meeting in May 17, Brussels**

GOP tropospheric products

GOP NRT processing features (traditional approach)

NRT regional product (GPS) - Bernese GPS V5.0 (2001-today)

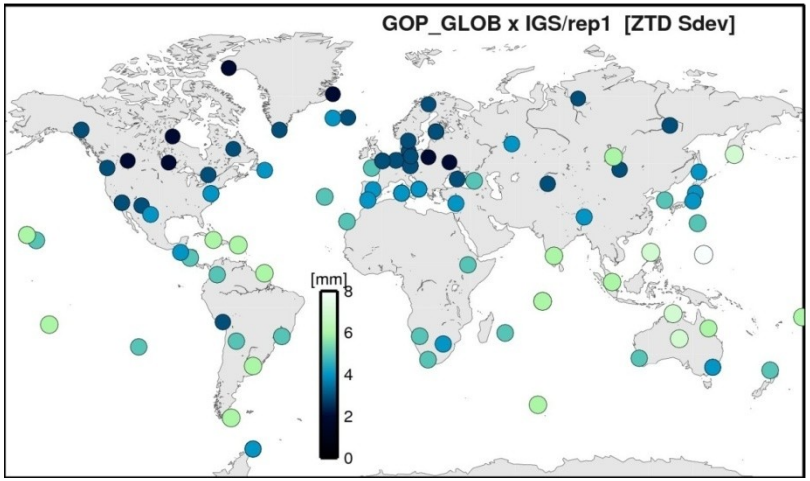
NRT global product (GPS) – Bernese GPS V5.0 (2010-today)

NRT regional product (GPS+GLONASS) – Bernese GPS V5.0 (2011-today)

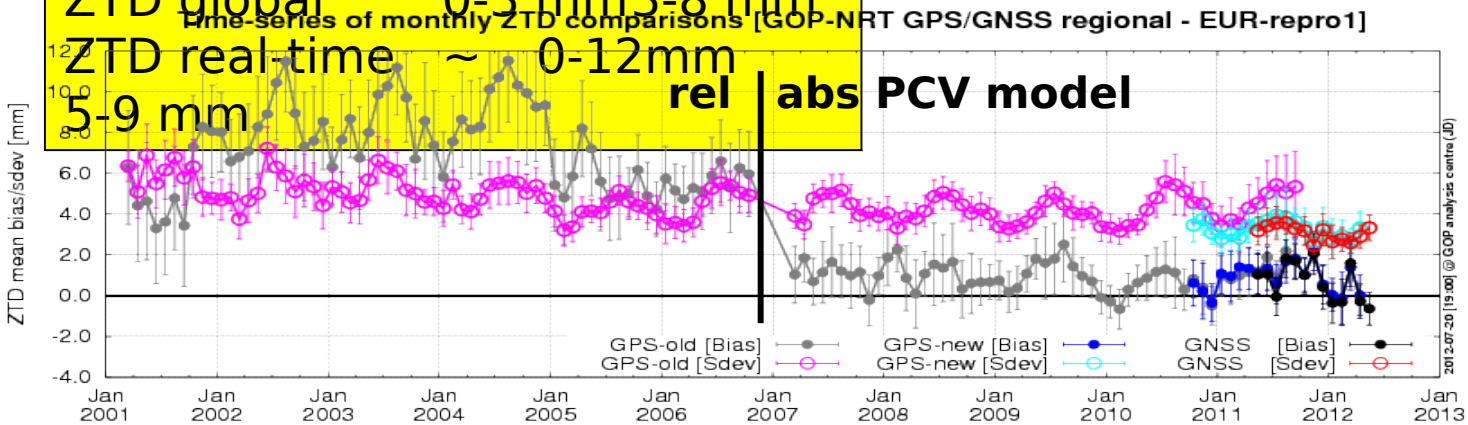
New products (PPP)

Real-time product (2013, testing phase)

Sub-hourly product (2013, development)



vs. final ZTD	AbsBias	StdDev
ZTD regional	0-1 mm	3-6 mm
ZTD global	0-3 mm	3-8 mm
ZTD real-time	~ 0-12mm	5-9 mm



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G-Nut software library, user applications

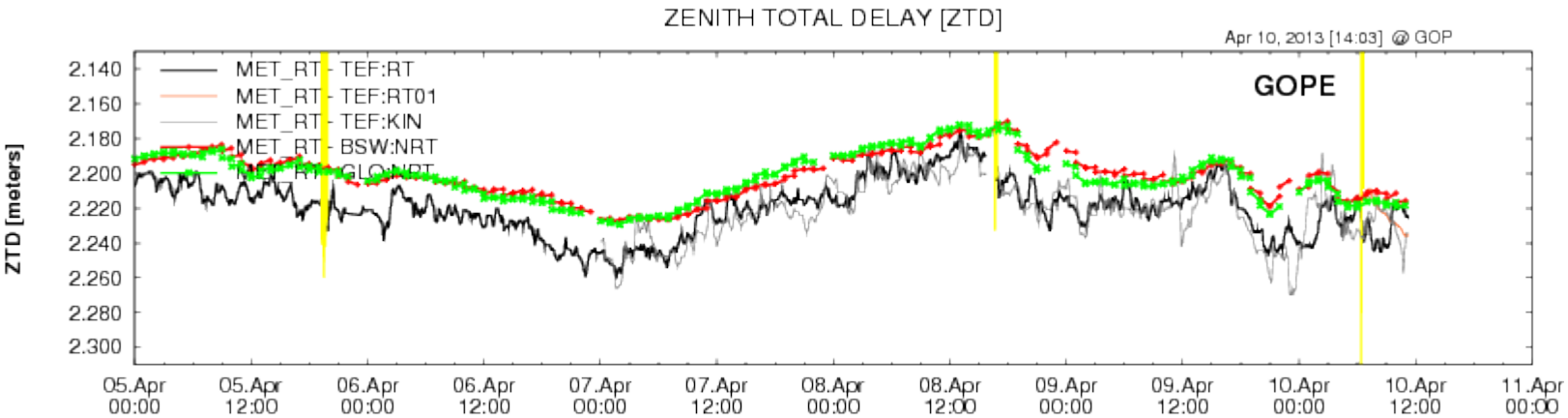
Goals & Status:

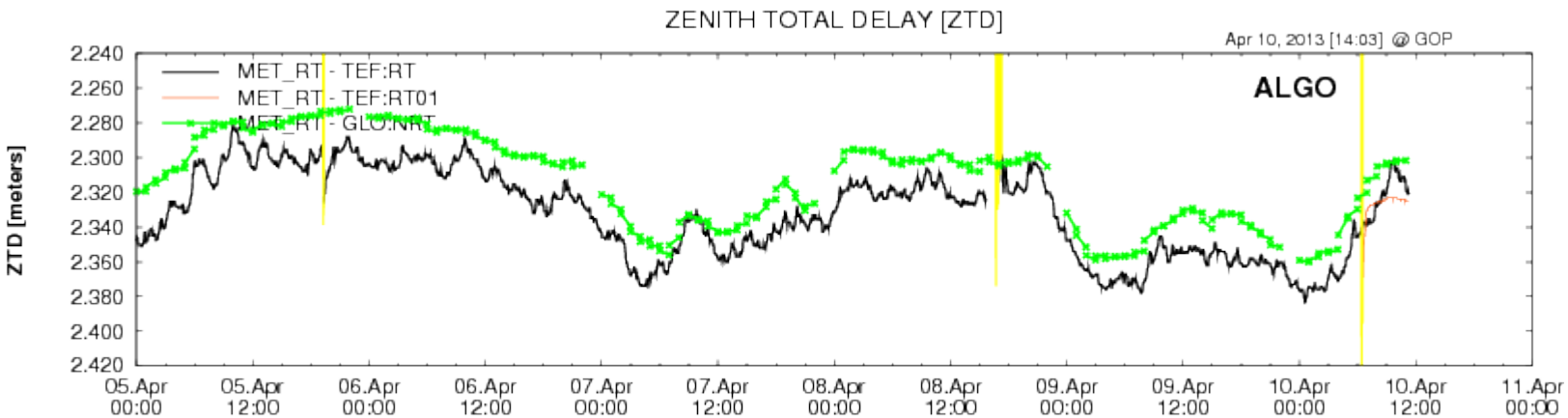
- *G-Nut generic library for developments of GNSS applications*
- *specific client & server end-user applications for multi-disciplinary field*
- *open-source for specific user applications (GNU GPLv3)*
  - ***Geb*** *– precise positioning (static/kinematic)*
  - ***Tefnut*** *– troposphere monitoring (real-time/post-processing)*
  - ***Anubis*** *– data editing, cutting/splicing, QC monitoring tool*

Main characteristics

- **written in C++, object oriented design, support of multi-thread apps**
- **for console, primarily design for Linux OS (support for Windows postponed)**
- **multi-GNSS support (currently data/product structure, pre-processing, PPP soon, …)**
- **various adjustment methods (LSQ, Kalman/srcf, back-smoothing, NEQ stacking, ..)**
- **real-time and offline processing in PPP mode**
- **precise models for undifferenced observations (still working on)**
- **flexible configuration via XML inputs (file, standard input)**

Tefnut: real-time benchmark





European and global station

BSW:NRT – GOP (BSW) NRT regional solution

GLO:NRT - GOP (BSW) NRT global solution

TEF:RT - GOP (Tefnut) real-time solution (coordinates static)

TEF:KIN – GOP (Tefnut) real-time solution (coordinates kinematic !!!)

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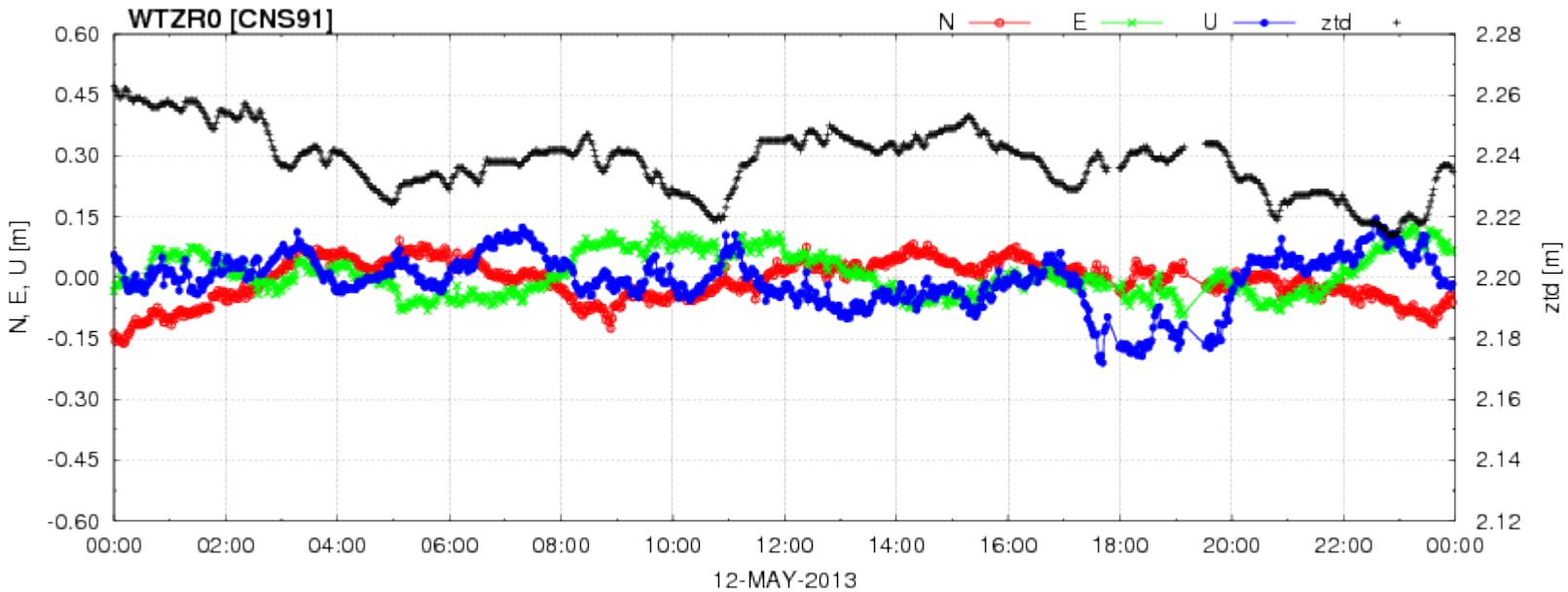
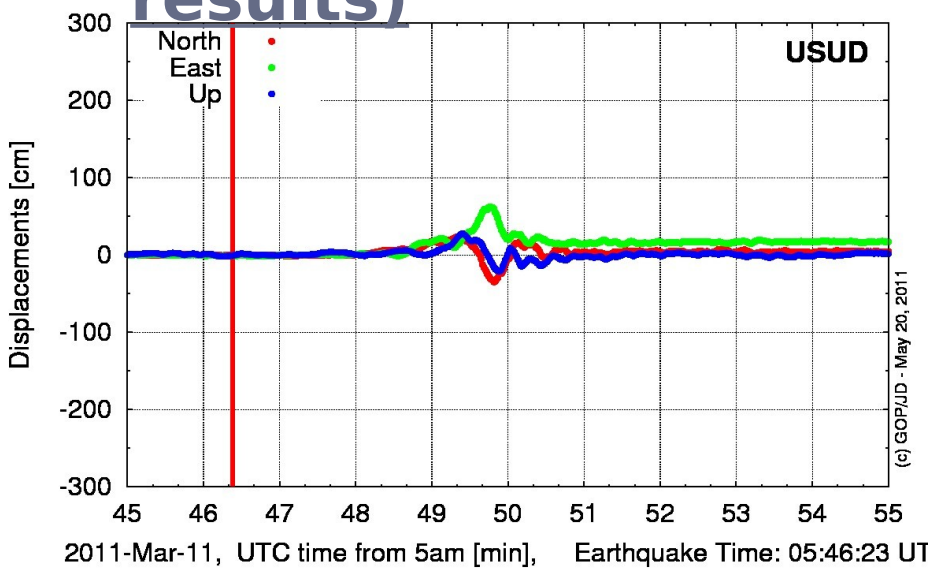
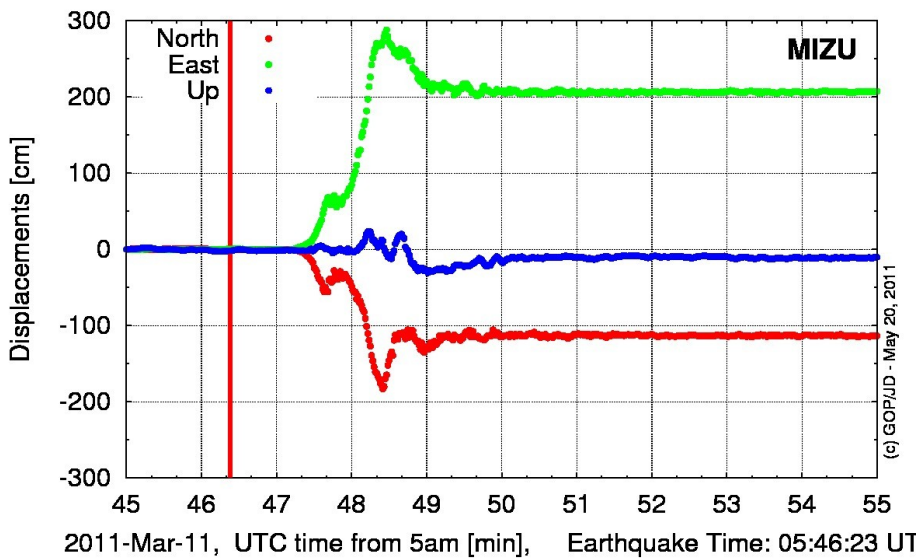
Geb: Real-time pseudo-kinematic positioning

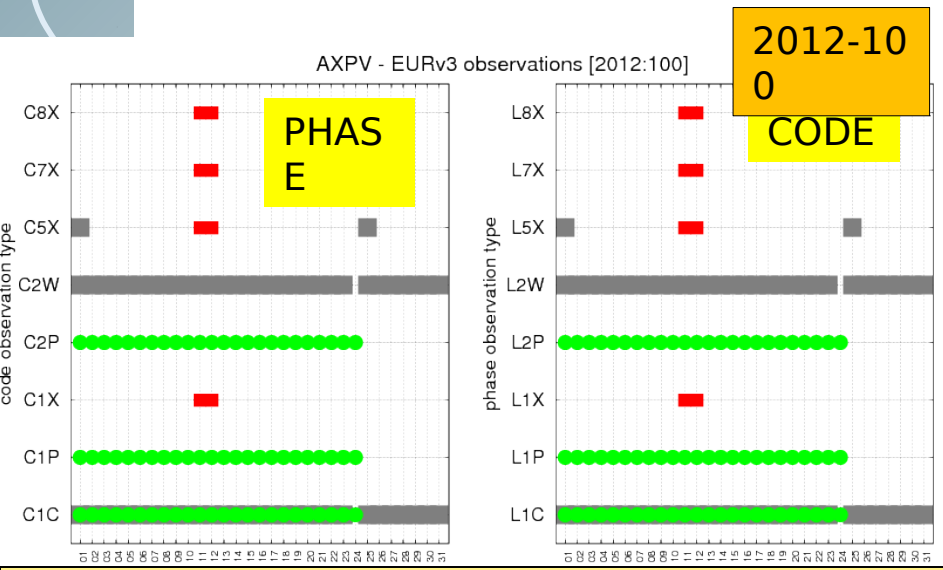


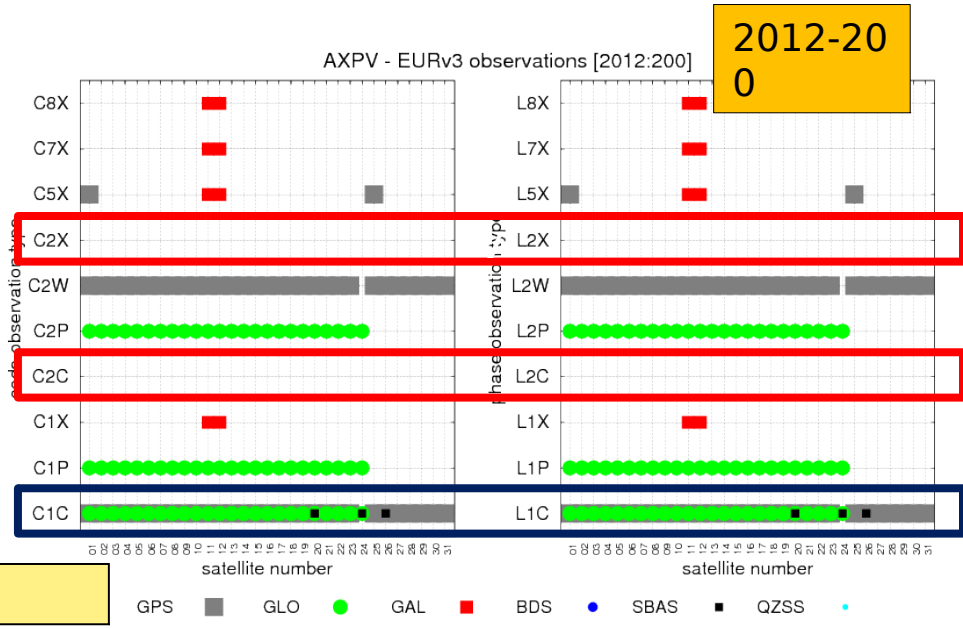
Geb: Tohoku-Oki (offline EQ monitoring results)



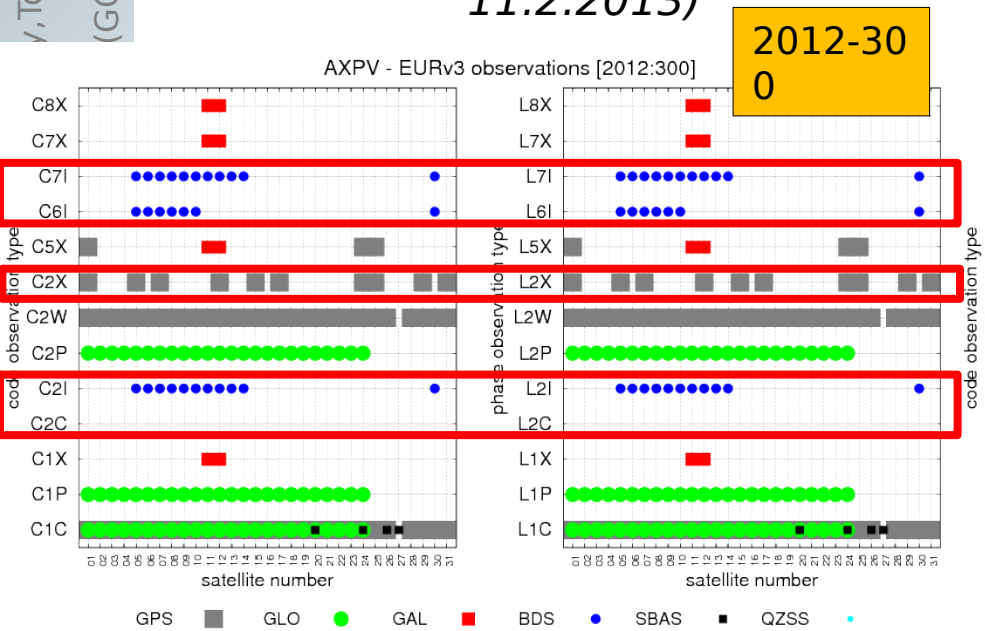


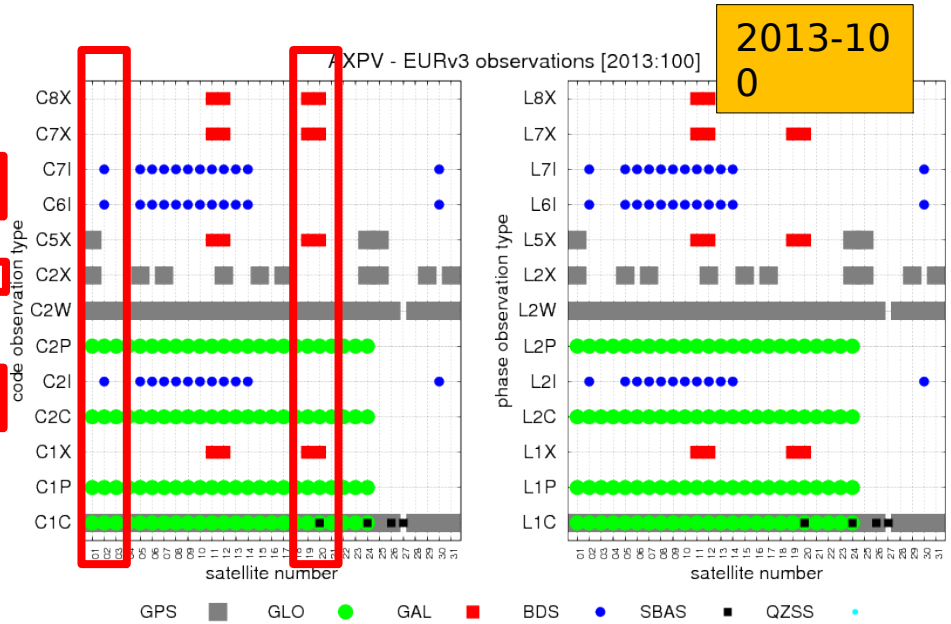
Anubis: EURv3 – multi-GNSS obs-types (AXPV)



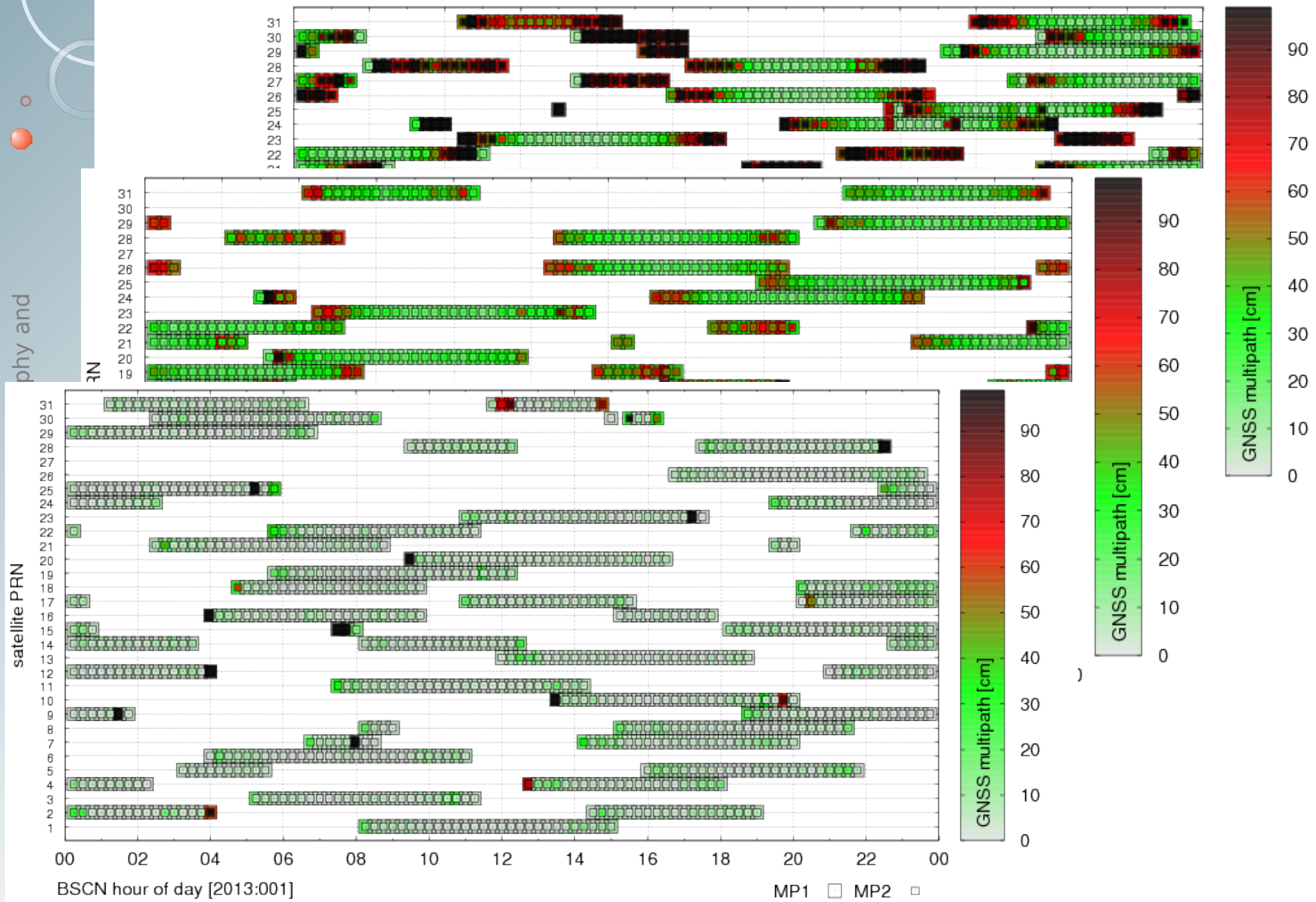


Two firmware upgrade (31.5.2012, 11.2.2013)

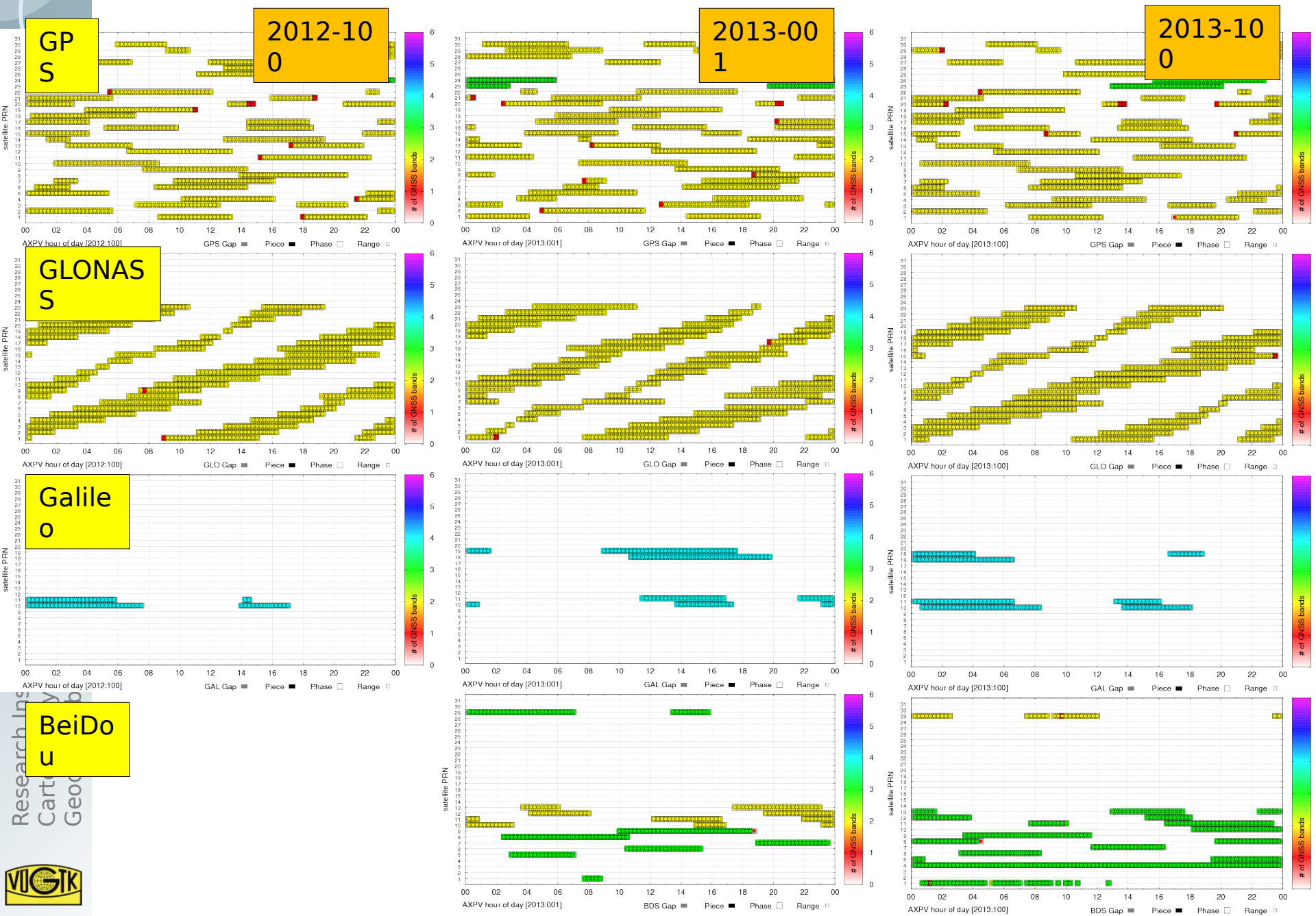




Anubis: EURv3 - multi-GNSS: # multipath (GPS)



Anubis - EURv3 - multi-GNSS # bands (AXPV)



Web for Tefnut and other applications

www.pecny.cz/joomla25/index.php/gnss-mainmenu-200/software-mainmenu-265/tefnut-main

Main Menu

- Home
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    - Tefnut (app)
    - Anubis (app)
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TEFNUT APPLICATION

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Tefnut application
News
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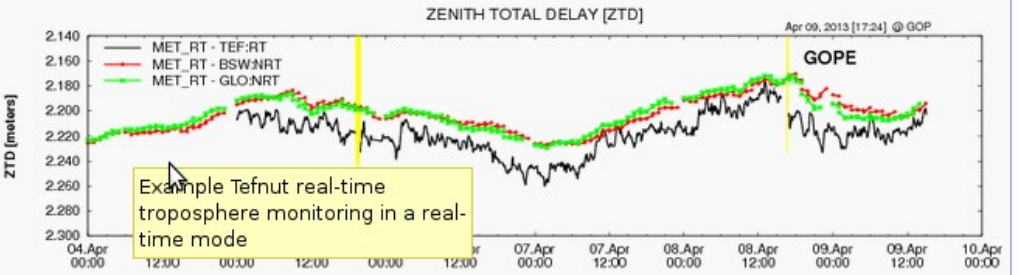
"Tefnut" are called end-user applications designed to estimate tropospheric path delays in various processing modes. Below applications are implemented using the **G-Nut core library** developed at the Geodetic Obsevatory Pecny. A comparison of supported capabilities is available in the **feature matrix**. All applications are released under the **GNU General Public Licence**.
Figure shows an example of Tefnut's real-time troposphere monitoring in real-time mode using IGS RTCM clock and orbit corrections.

- **Tefnut-PP** is free open source lite application aimed for the post-processing mode.
- **Tefnut-RT** is free open source lite application aimed for the real-time processing mode.

The source code of lite applications are available **here** and example configurations at the **support center**.



Example Tefnut real-time troposphere monitoring in a real-time mode

- **Tefnut** is non-free application providing enhanced capabilities while including all processing modes (RT, NRT and PP), improved models and more flexible use. **The release is under preparation and planned for the second half of 2013.**

Support - the current lite version is provided as a beta release and still undergoes final consolidations of the core library. The software is provided "as is" and without warranty of any kind. The support is given on a best-effort basis only. However, if you find G-Nut/Tefnut application(s) useful for your work, consider supporting its further development by ordering the enhanced version and we will try to give you a priority in the support.
Other related questions could be sent to **gnss@pecny.cz** (J.Dousa/P.Vaclavovic).

News - in order to keep informed about news you can join the **G-Nut mailing list**.

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Conclusion and outlook

GOP has contributed to EUREF since 1997 as a local analysis centre. However, GOP contribution would be foreseen more beneficial in various other domains that could support EUREF WGs or regular products:

- Full EPN reprocessing with Bernese
- Ultra-fast and near real-time coordinate monitoring
- Real-time PPP processing development
- Troposphere estimation, evaluation and modelling
- Multi-GNSS processing and data QC monitoring
- Software development
- …

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Thank you for your attention

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