

GOP analysis centre – 2012/2013

J. Douša, P. Václavovic

jan.dousa@pecny.cz

*Geodetic observatory Pecný
Research Institute of Geodesy, Topography and Cartography
Czech Republic*

November 28-29, 2013, Copenhagen, Denmark

GOP (near) real-time ZTD solutions

- **Regional GPS solution (official solution)**

4-h data batch of basic processing

12-hour NEQ stacking for troposphere estimation

28-day NEQ stacking for precise coordinate solution

- **Global hourly solution (official solution)**

Derived from regional solution, need for a high solution robustness

Station-specific quality, additional product filtering based on formal errors

- **Regional GPS+GLONASS solution (testing)**

Operational GPS+GLONASS solution in parallel

Evaluation vs. GPS (the official solution)

Additional stations in Greece (19) & Latvia (23)

- **Real-time solution (demonstration campaign)**

G-Nut/Tefnut – in-house software for PPP strategy and IGS products

Basic characteristics

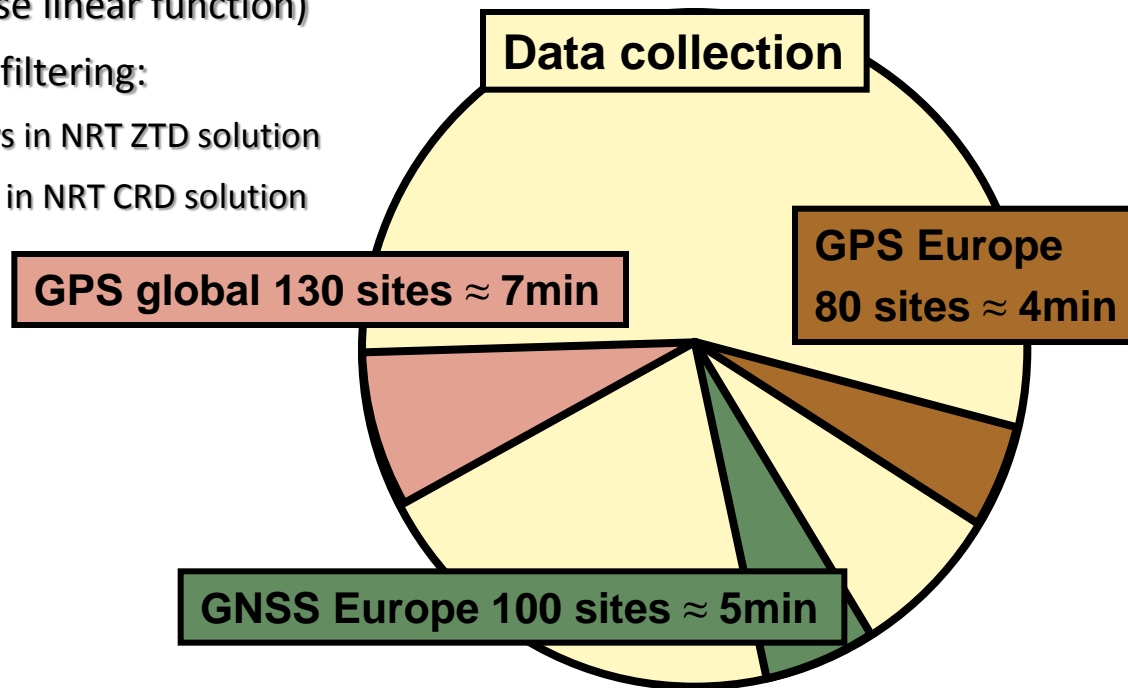
no change

GOP NRT processing features:

- ❑ Bernese GPS software v.5.0
- ❑ Inputs: hourly GNSS data and precise IGU/IGV orbits (precise clocks not necessary)
- ❑ Processing starts at single server every hour at HH:20, HH:28, HH:40
- ❑ 4 hourly data batches and normal equations (NEQ)

GOP ZTD characteristics:

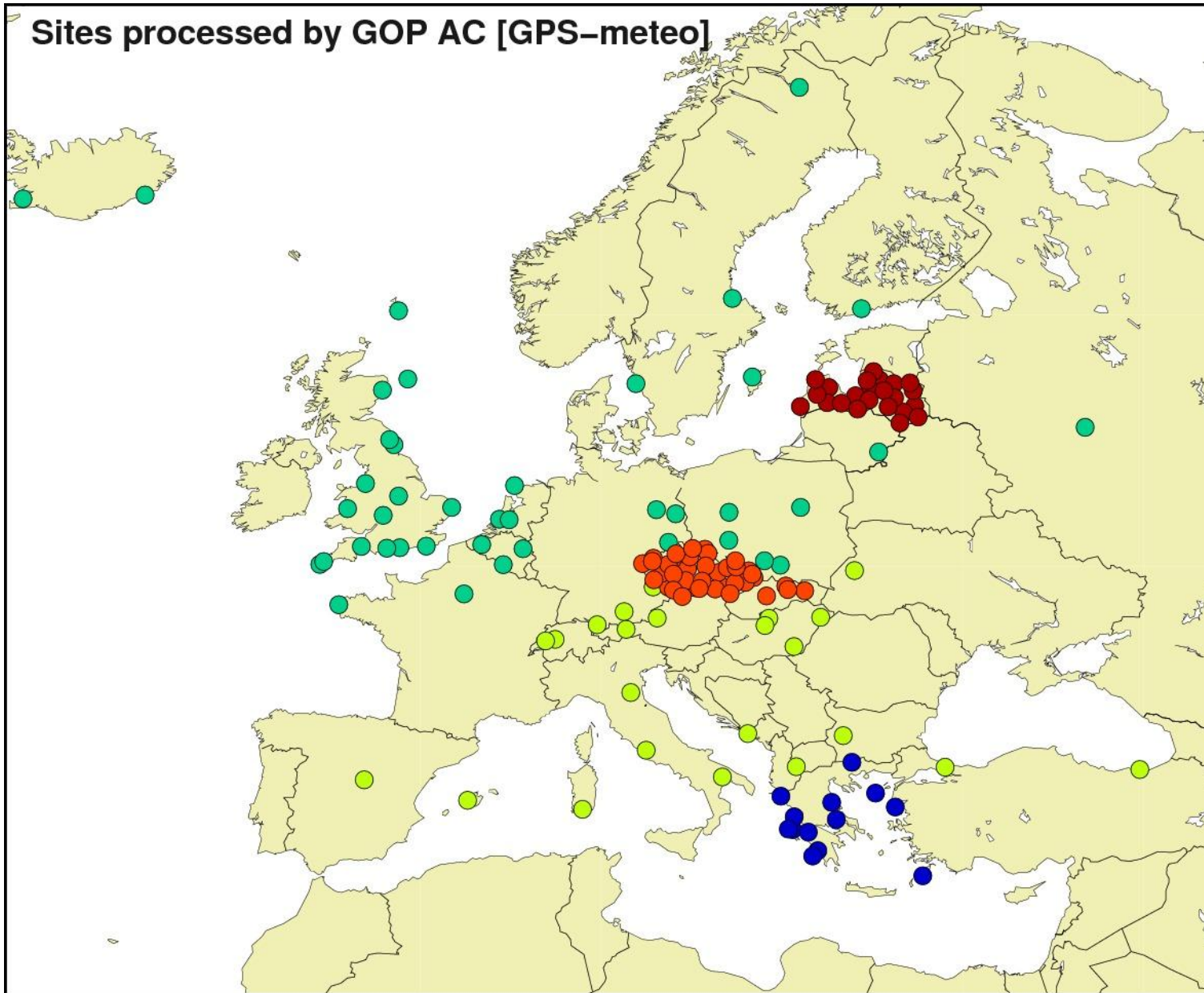
- ❑ ZTD product (HH:00 – HH:59) - linear trend model
(piece-wise linear function)
- ❑ ZTD product filtering:
 - ❑ min 4 hours in NRT ZTD solution
 - ❑ min 2 days in NRT CRD solution



GNSS regional network processed in GOP

no change

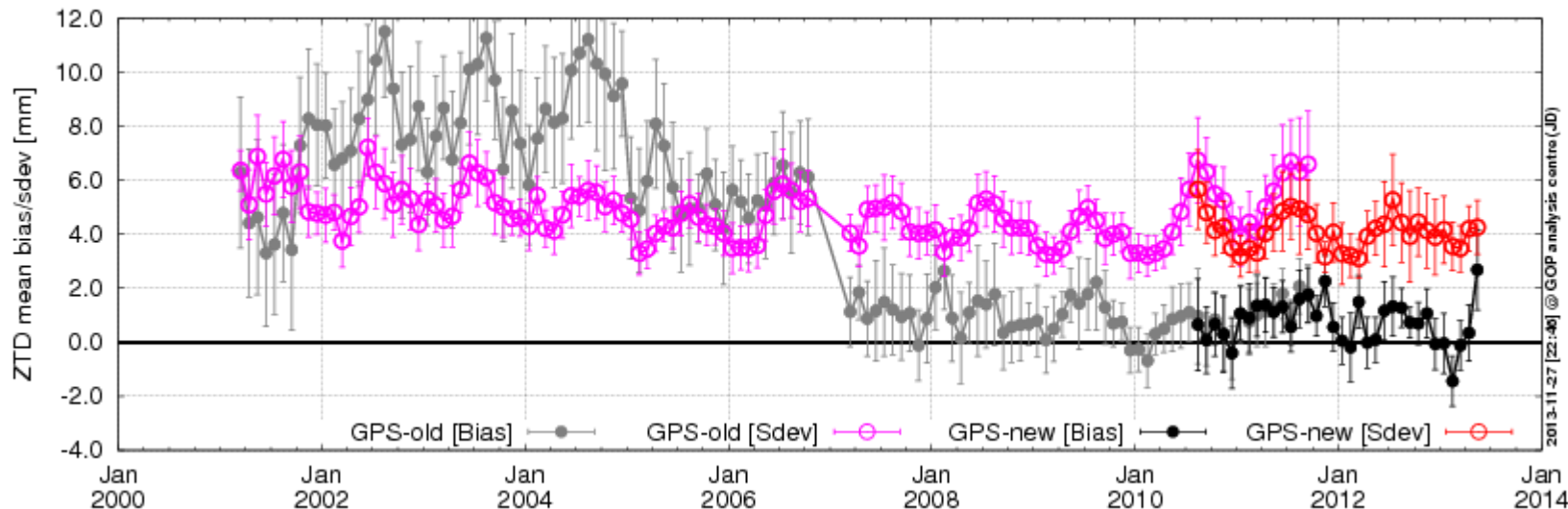
Sites processed by GOP AC [GPS-meteo]



Updated

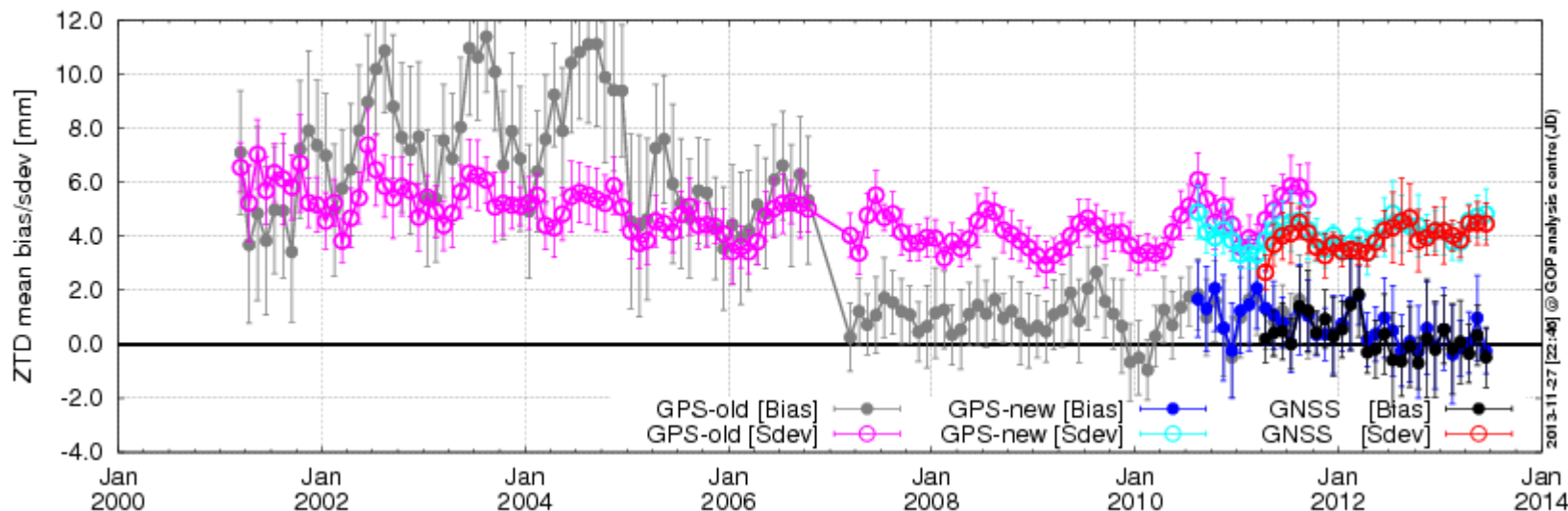
GOP near real-time ZTD comparison (monthly)

Time-series of monthly ZTD comparisons [GOP-NRT GPS regional - EUR-repro1]



w.r.t. EUREF

Time-series of monthly ZTD comparisons [GOP-NRT GPS/GNSS regional - IGS-repro1]



w.r.t. IGS

NO CHANGE

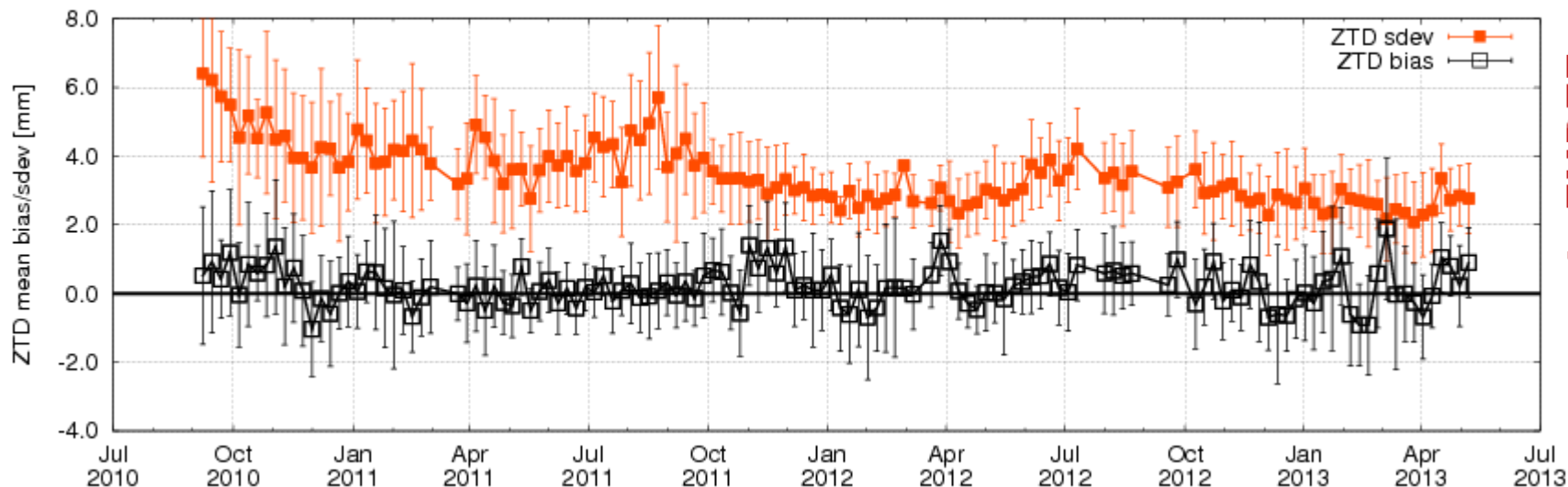
**Research Institute of Geodesy, Topography and Cartography
Geodetic Observatory Pecny (GOP)**



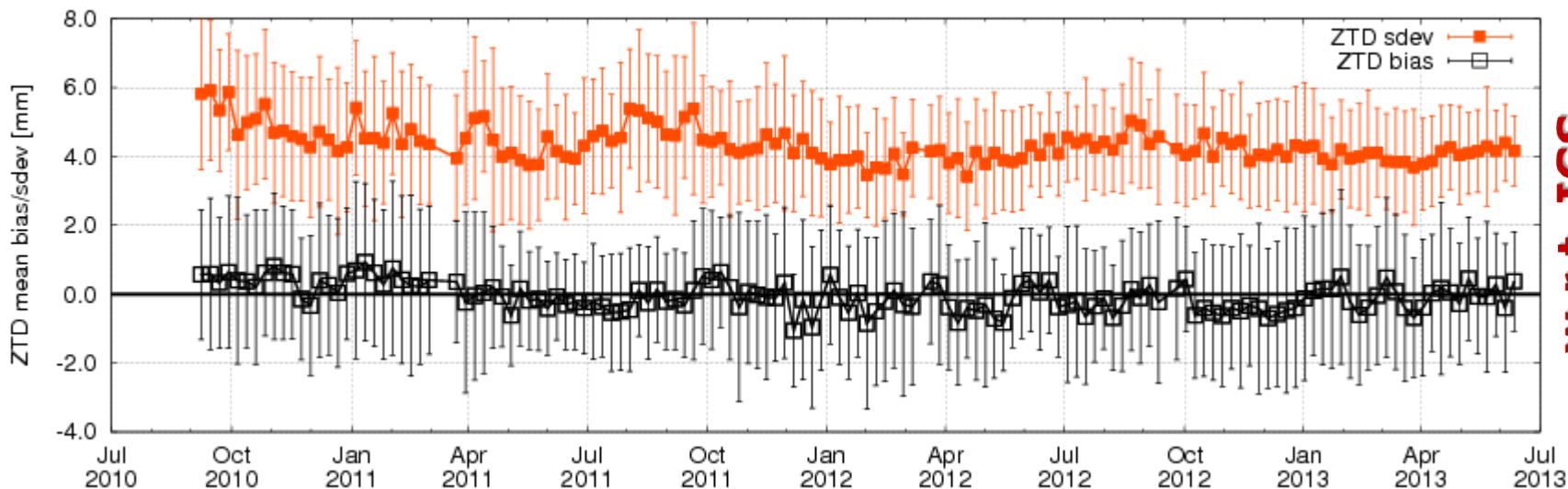
Updated

GOPG – NRT global solution (weekly)

Time-series of weekly ZTD comparisons [GOP NRT global - EUR-repro1]



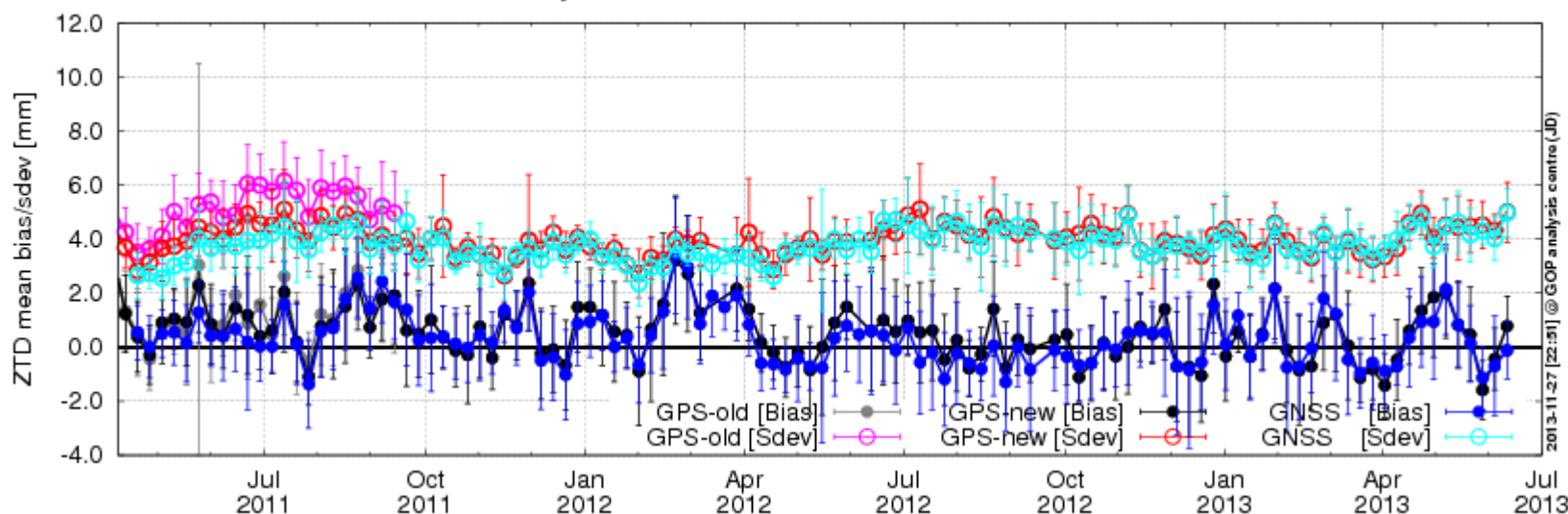
Time-series of weekly ZTD comparisons [GOP NRT global - IGS-repro1]



Operational NRT multi-GNSS GOP ZTD

- Multi-GNSS ZTD started after GPS week 1632 (IGS08 PCV+PCO models)
- Using the same strategy as GPS official contribution to E-GVAP, but more frequently exploit robustness of GOP NRT solution than stand-alone GPS
- Testing unofficial IGV (GPS+GLONASS) ultra-rapid orbits
- With exception of June/July (leap second), running continuously
- Compared with GPS (official) shows slightly better Sdev and Bias

Time-series of weekly ZTD comparisons [GOP-NRT GPS/GNSS - PP_IGSREP1]



G-Nut software library, user applications

Goals & Status:

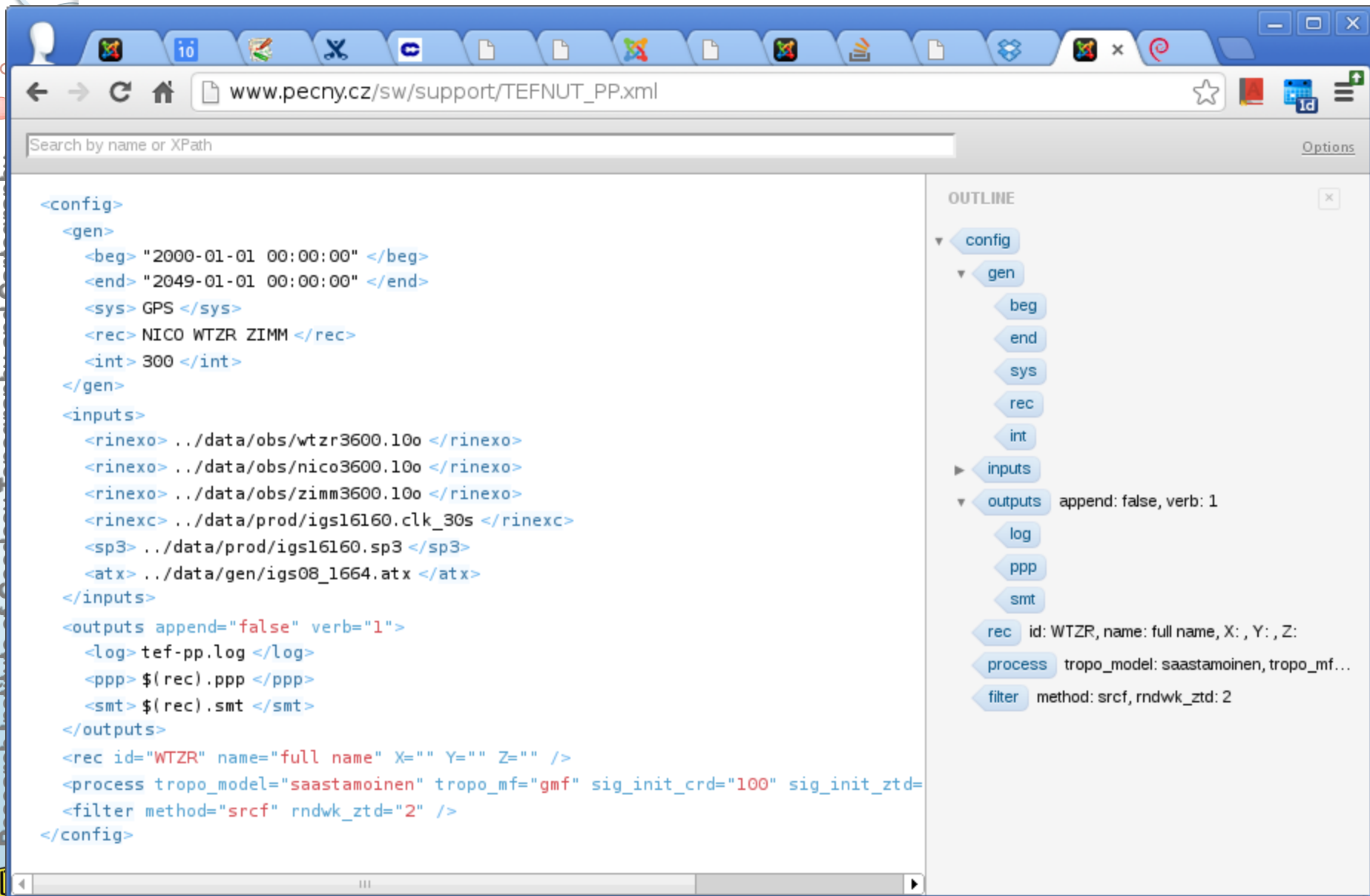
- *G-Nut generic library for developments of GNSS applications*
- *Open-source tools for user applications (available under GNU GPLv3)*
 - **G-Nut/Geb** – precise positioning (static/kinematic)
 - **G-Nut/Tefnut** – troposphere monitoring (real-time/post-processing)
 - **G-Nut/Anubis** – data editing, cutting/splicing, QC monitoring tool
 - **G-Nut/Shu** – tropospheric models based on NWM data

Main characteristics

- written in C++, object oriented design, supporting multi-thread applications
- command-line application design for Linux (future support for Windows/OS-X)
- multi-GNSS (RINEX-3.2 compliant – GPS, GLONASS, Galileo, BeiDou, SBAS, QZSS)
- various adjustment methods (LSQ, Kalman/srcf, back-smoothing, NEQ stacking)
- (near) real-time and offline processing in PPP mode
- configuration via XML inputs (file, standard input)

new

Example configuration for Tefnut (PP)



Search by name or XPath

Options

```
<config>
  <gen>
    <beg> "2000-01-01 00:00:00" </beg>
    <end> "2049-01-01 00:00:00" </end>
    <sys> GPS </sys>
    <rec> NICO WTZR ZIMM </rec>
    <int> 300 </int>
  </gen>
  <inputs>
    <rinexo> ../data/obs/wtZR3600.10o </rinexo>
    <rinexo> ../data/obs/nico3600.10o </rinexo>
    <rinexo> ../data/obs/zimm3600.10o </rinexo>
    <rinexc> ../data/prod/igs16160.clk_30s </rinexc>
    <sp3> ../data/prod/igs16160.sp3 </sp3>
    <atx> ../data/gen/igs08_1664.atx </atx>
  </inputs>
  <outputs append="false" verb="1">
    <log> tef-pp.log </log>
    <ppp> $(rec).ppp </ppp>
    <smt> $(rec).smt </smt>
  </outputs>
  <rec id="WTZR" name="full name" X="" Y="" Z="" />
  <process tropo_model="saastamoinen" tropo_mf="gmf" sig_init_crd="100" sig_init_ztd=
  <filter method="srcf" rndwk_ztd="2" />
</config>
```

OUTLINE

- config
 - gen
 - beg
 - end
 - sys
 - rec
 - int
 - inputs
 - outputs append: false, verb: 1
 - log
 - ppp
 - smt
 - rec id: WTZR, name: full name, X: , Y: , Z:
 - process tropo_model: saastamoinen, tropo_mf...
 - filter method: srcf, rndwk_ztd: 2

Web for Tefnut and other applications



Geodetic observatory Pecný



Main Menu

☐ Home

☒ GNSS

☐ software

☐ G-Nut sw library

☐ Geb (app)

☐ Tefnut (app)

☐ Anubis (app)

☐ observations

☐ data center

☐ troposphere

☐ precise orbits

☐ reference frame

☐ reprocessing

☐ EUREF-Czech-2009

☐ projects

☐ DORIS

☐ Gravimetry

☐ Database

☐ Links

☐ Search

☐ positions

TEFNUT APPLICATION

Page 1 of 2

"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 Observatory 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**.

- **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**.



Tefnut application
News
All Pages

Prev Next >>

Initial evaluation benchmark (various modes)

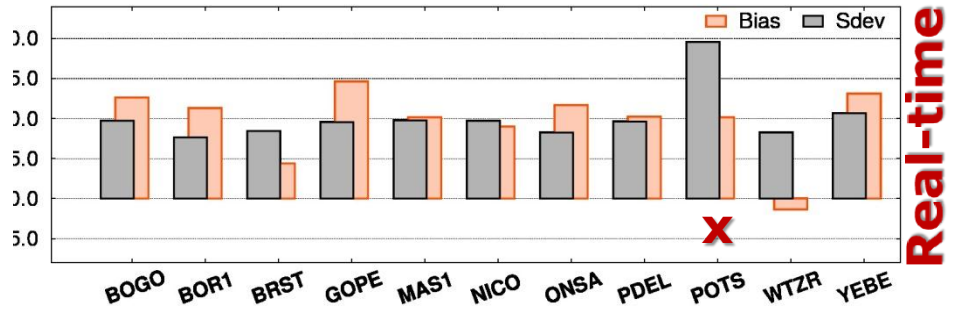
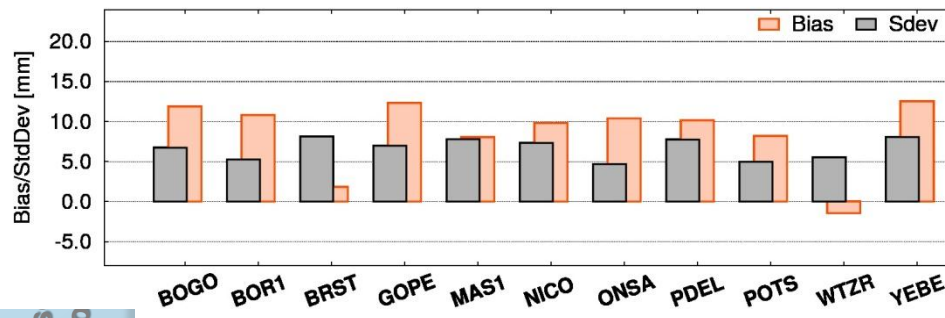
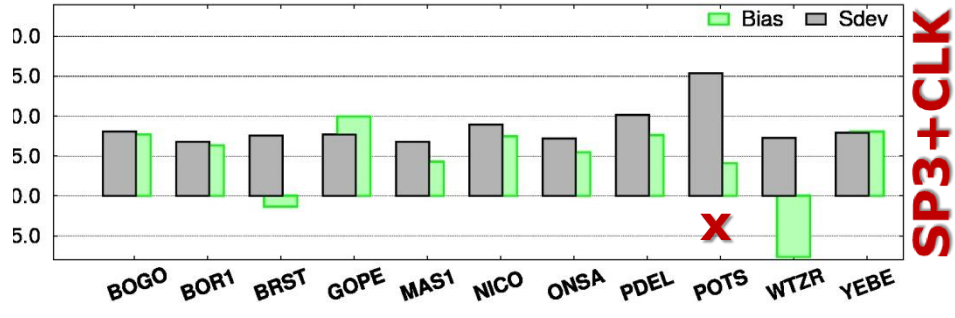
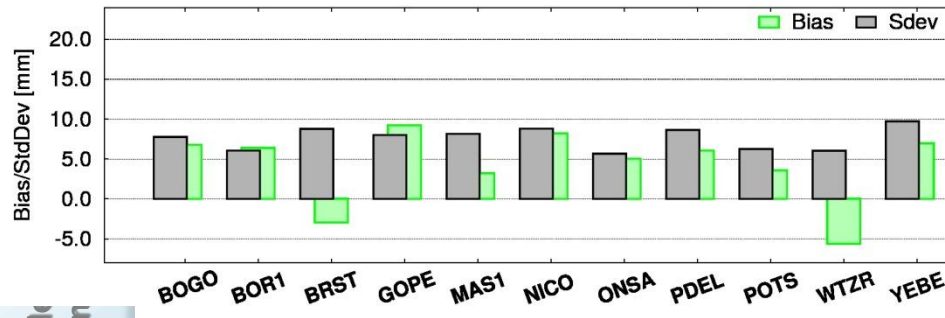
44-day statistics (2 April – 14 May 2012) with respect to IGS/EUREF repro1

Various modes of gNut-Tef settings:

a) CRD static or kinematic

b) real-time (RTCM) or offline (SP3+CLK)

Cartography



static mode

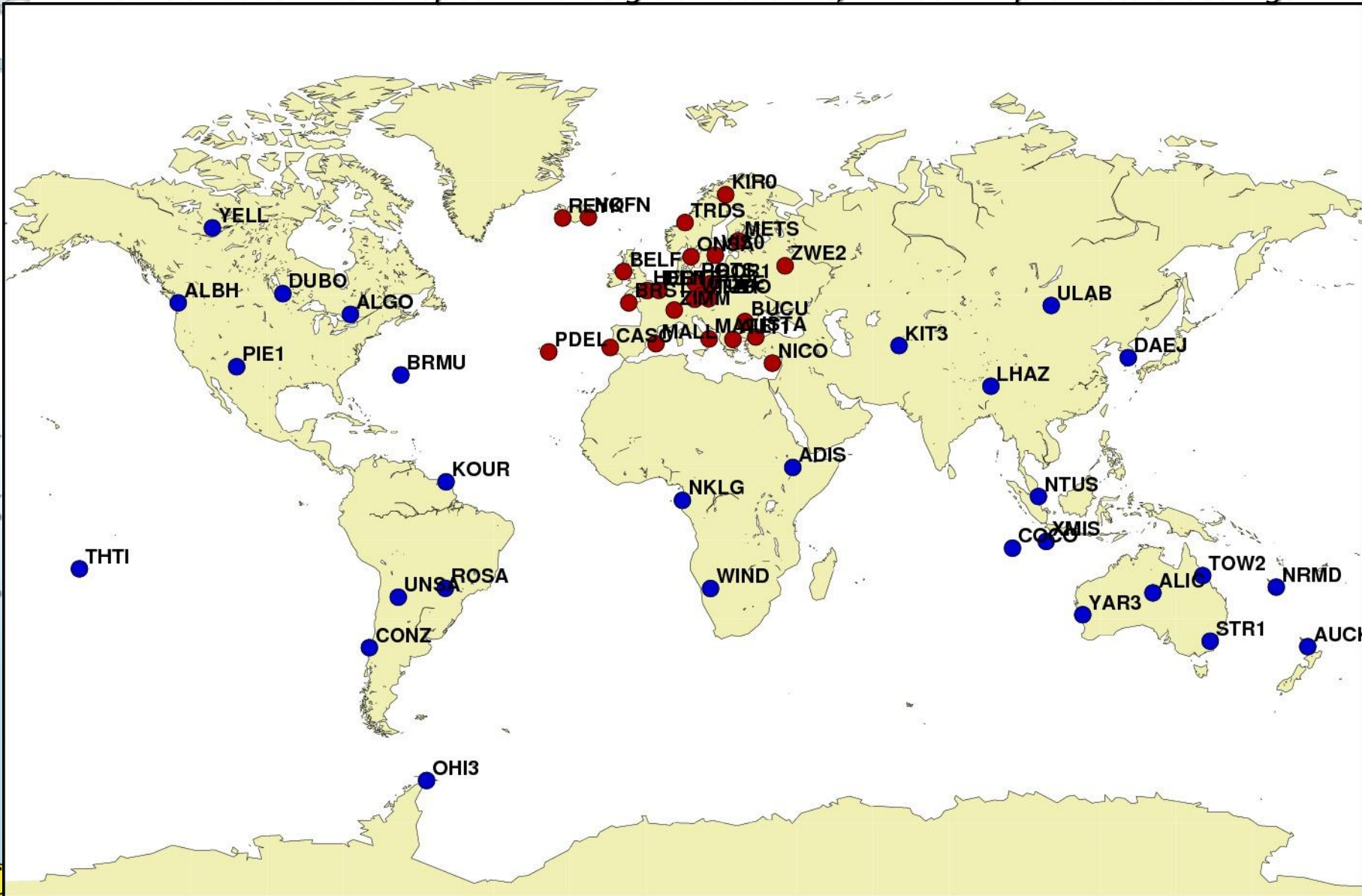
std dev 5-9 mm !

kinematic mode

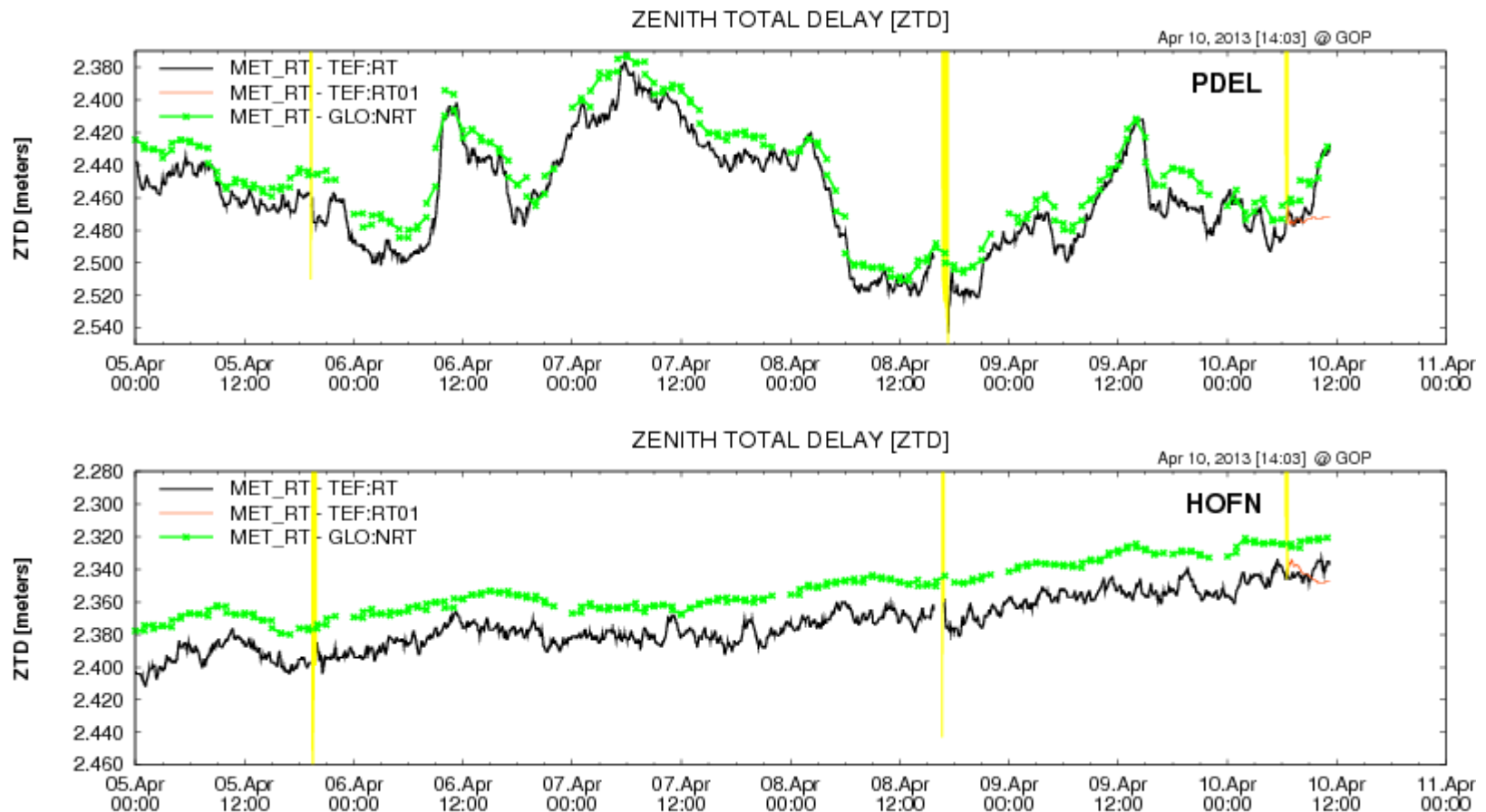
Not dramatically worse !

Real-time demonstration campaign

Feb-Oct 2013 – 18 European and 18 global stations, various RT products & settings



Real-time benchmark – initial results

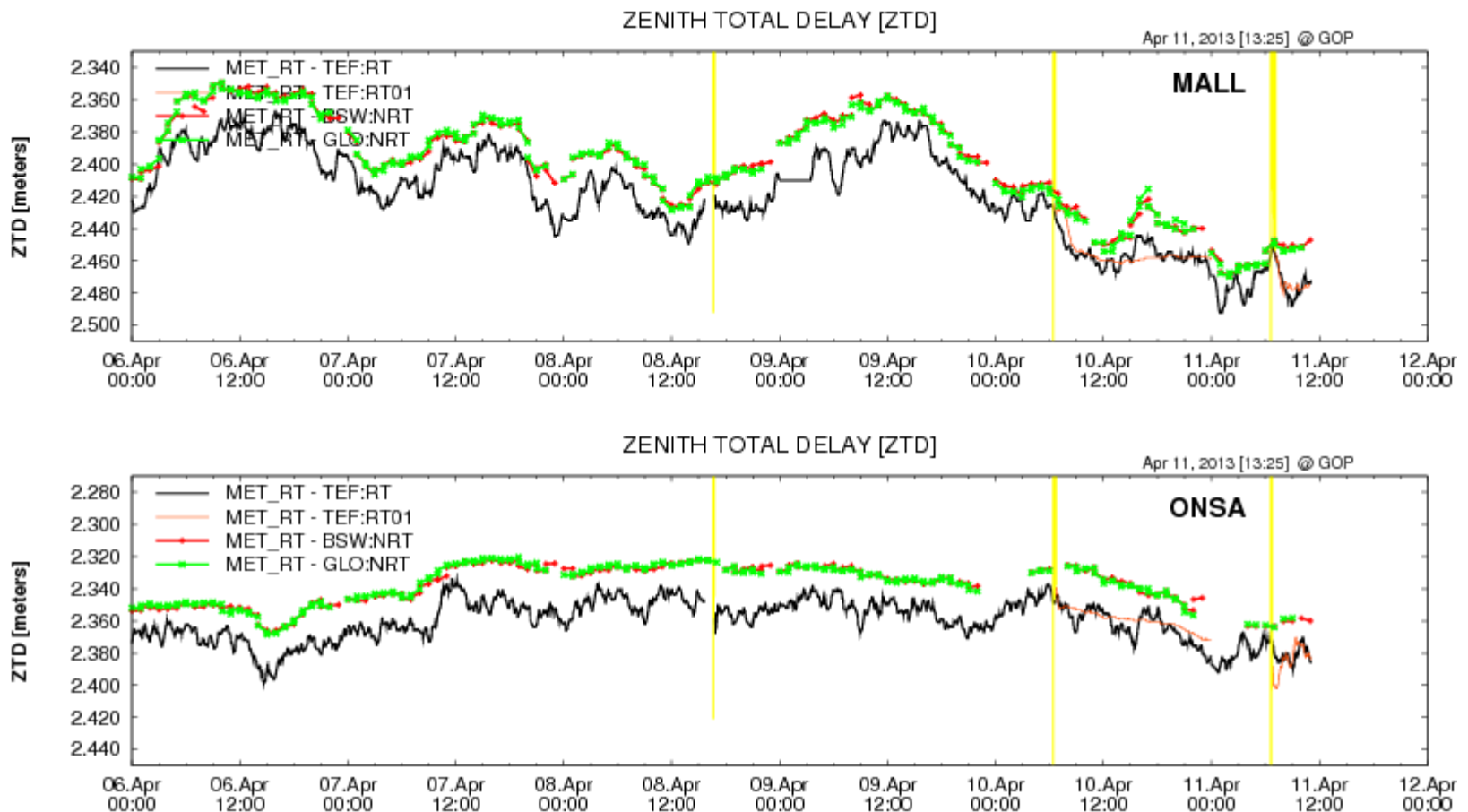


EUROPEAN STATIONS

GLO:NRT - GOP (Bernese) near real-time global solution

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

Real-time benchmark – initial results



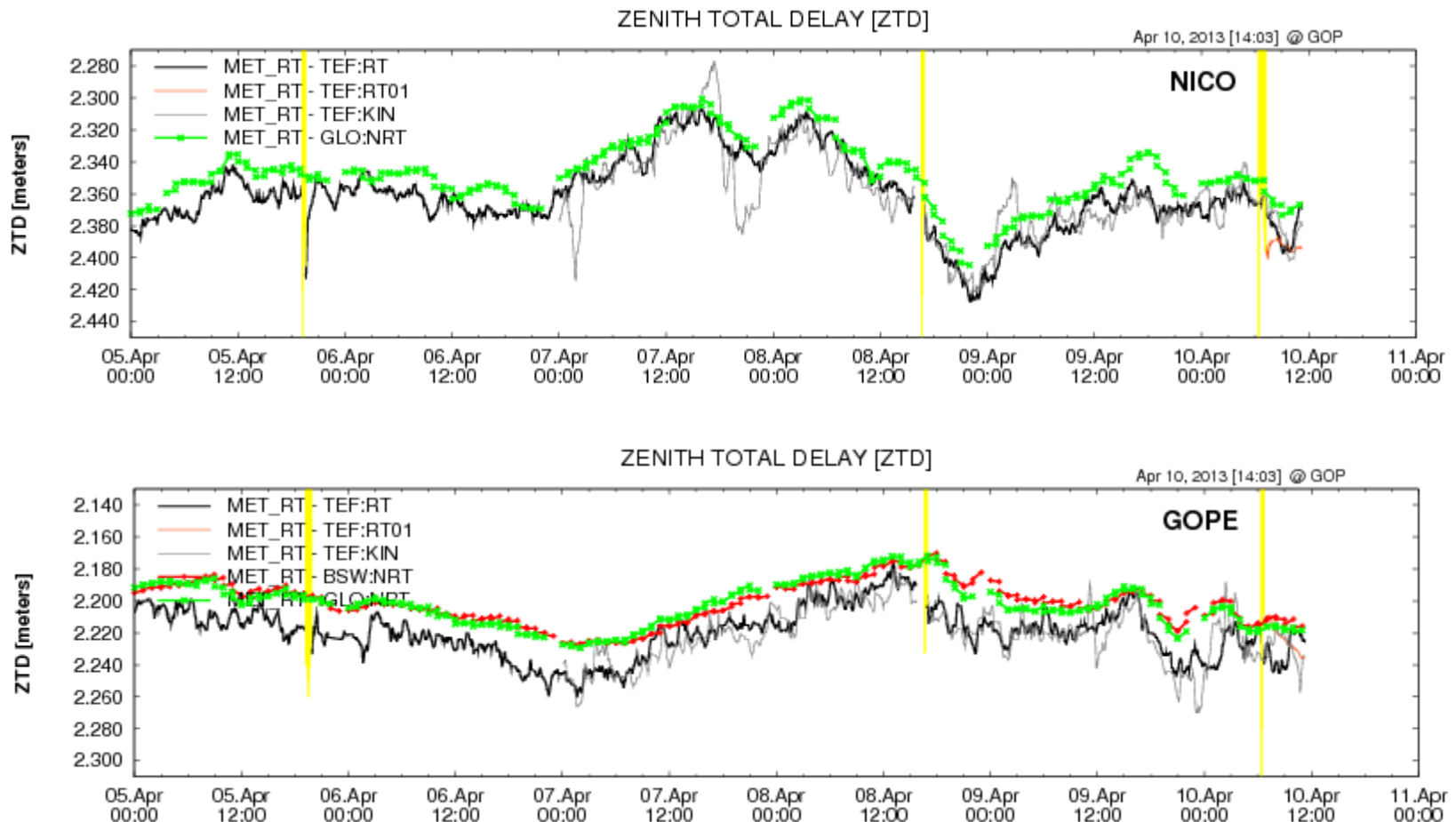
EUROPEAN STATIONS

BSW:NRT – GOP (Bernese) near real-time regional solution

GLO:NRT - GOP (Bernese) near real-time global solution

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

Real-time benchmark – initial results



EUROPEAN STATIONS

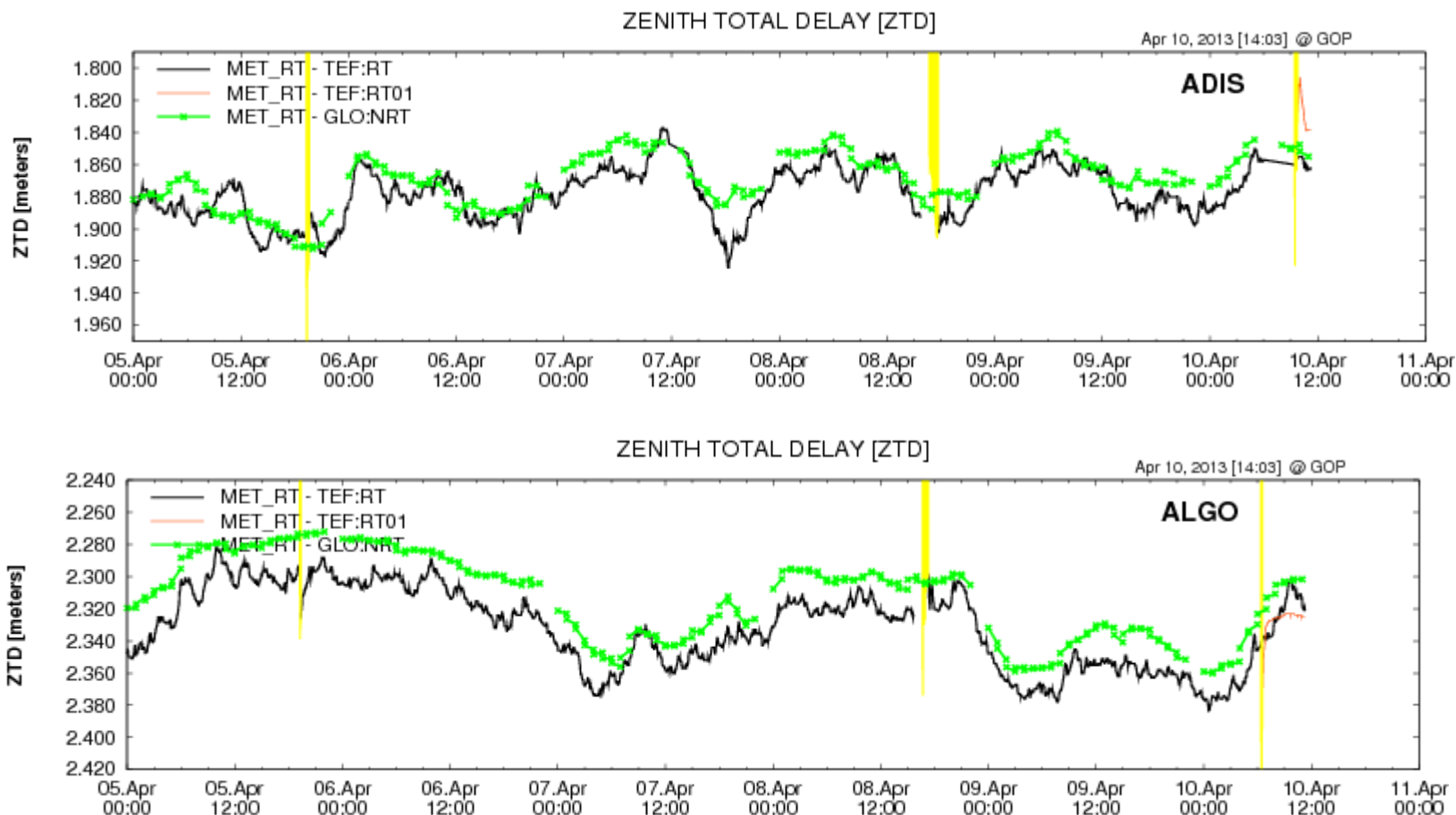
BSW:NRT – GOP (Bernese) near real-time regional solution

GLO:NRT - GOP (Bernese) near real-time global solution

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

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

Real-time benchmark – initial results



GLOBAL STATIONS !

GLO:NRT - GOP (Bernese) near real-time global solution

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

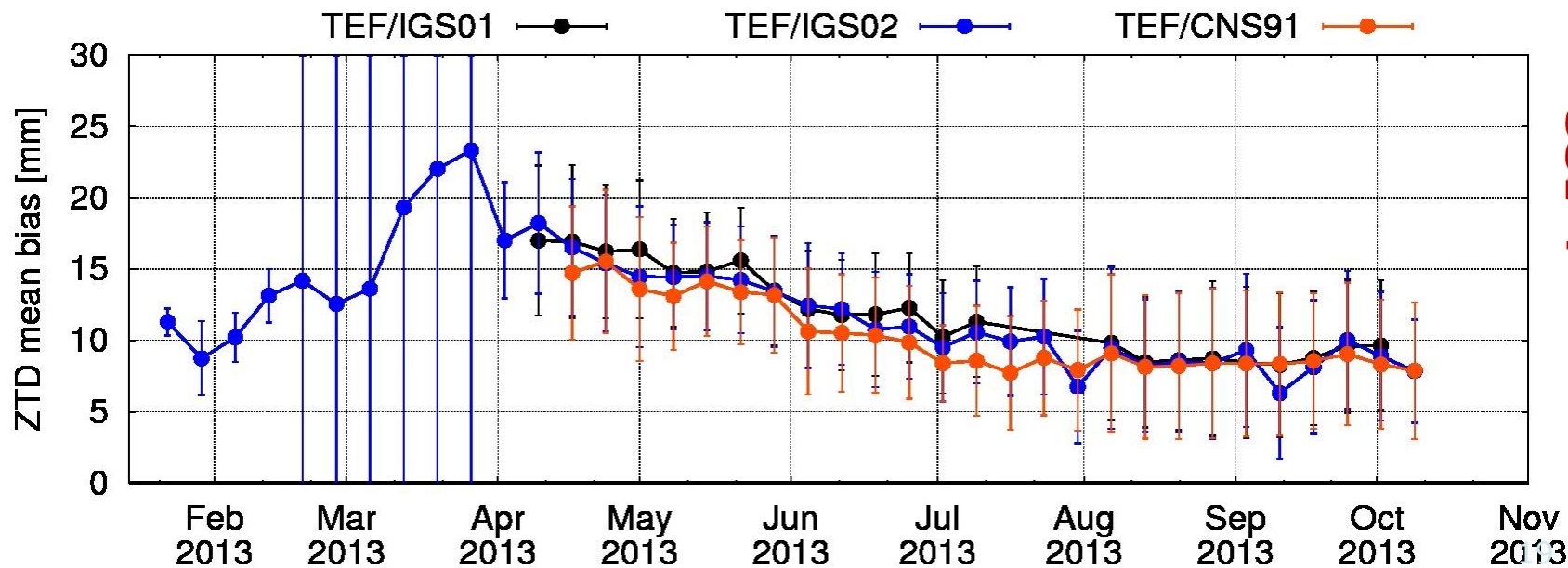
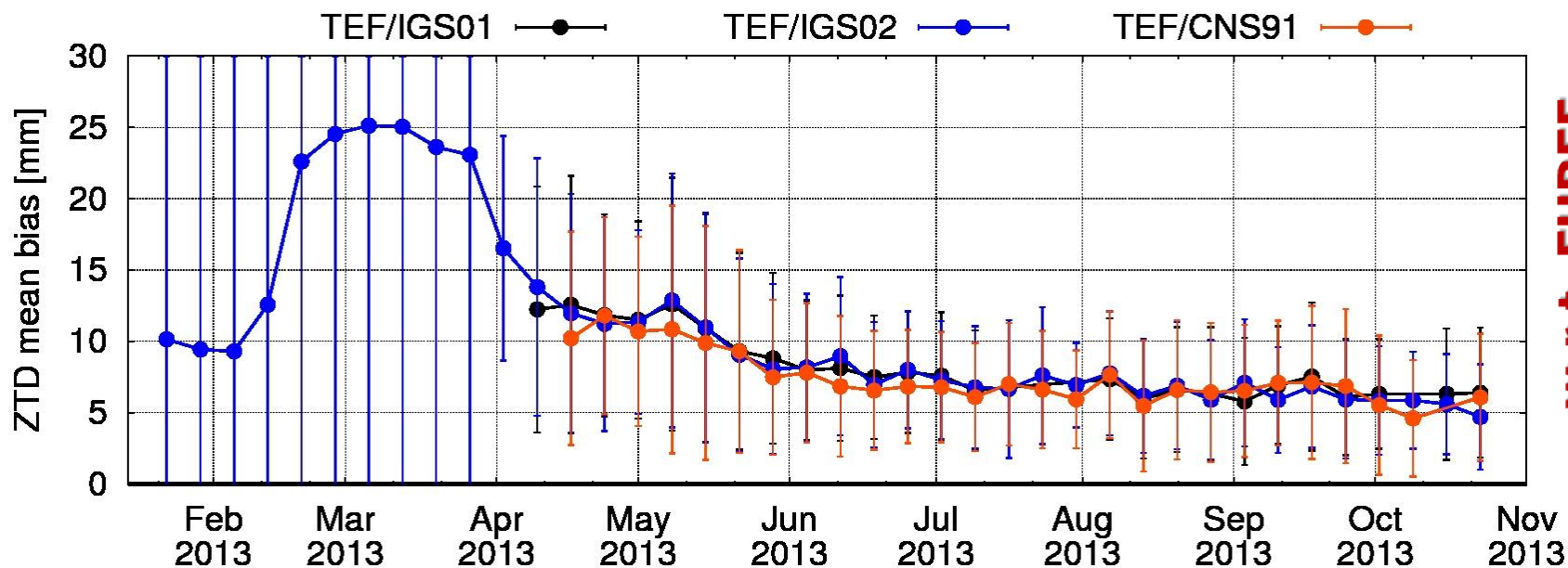
Global real-time orbit and clock products

- Real-time PPP requires orbit and clock products
- IGS Real-Time Service (RTS) has started to provide since the end of 2012
- Latency: 40-50s ; Accuracy: ~3-10 cm (orbits), ~0.05-0.20 ns (clocks)
- Three products were selected for the demonstration campaign:
IGS01, IGS02 and CNS91

Mount point	Update rate	Provider	Remarks
IGS01	Orbits – 5 s Clocks – 5 s	IGS/ESOC	Single-epoch combination
IGS02	Orbits - 60 s Clocks – 10 s	IGS/BKG	Kalman filter combination
CNS91	Orbits – 5 s Clocks – 5 s	CNES	Individual product

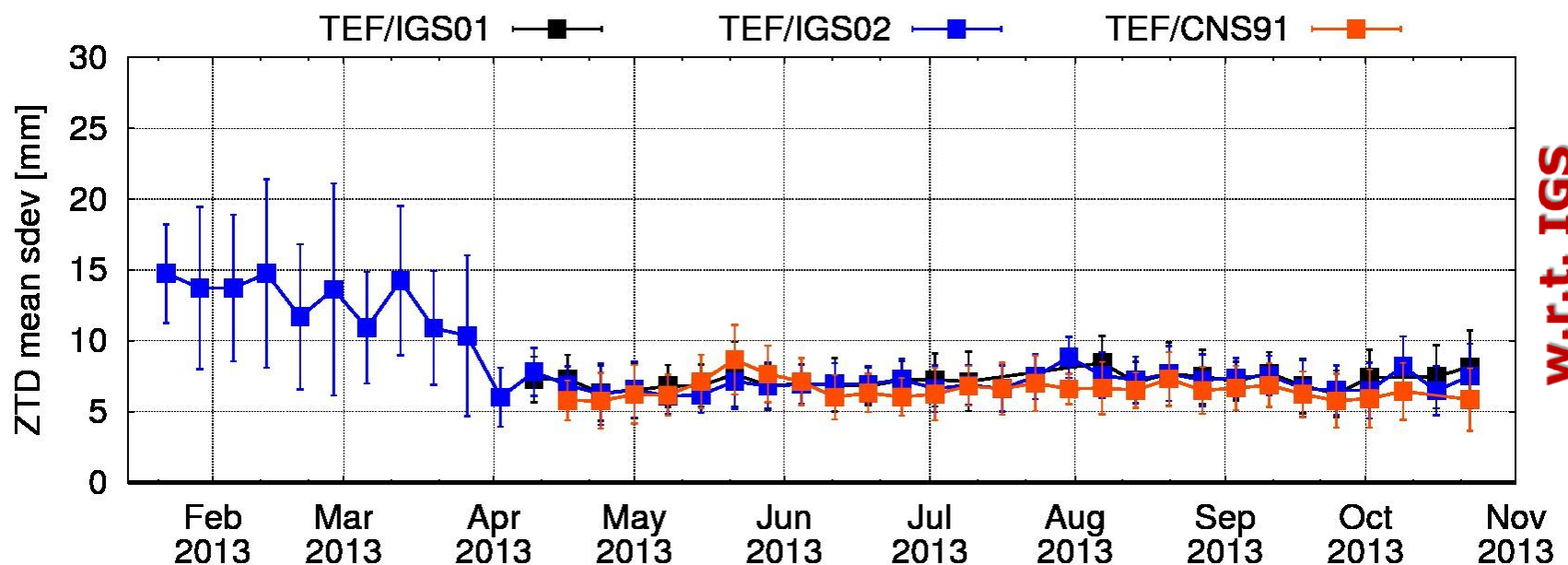
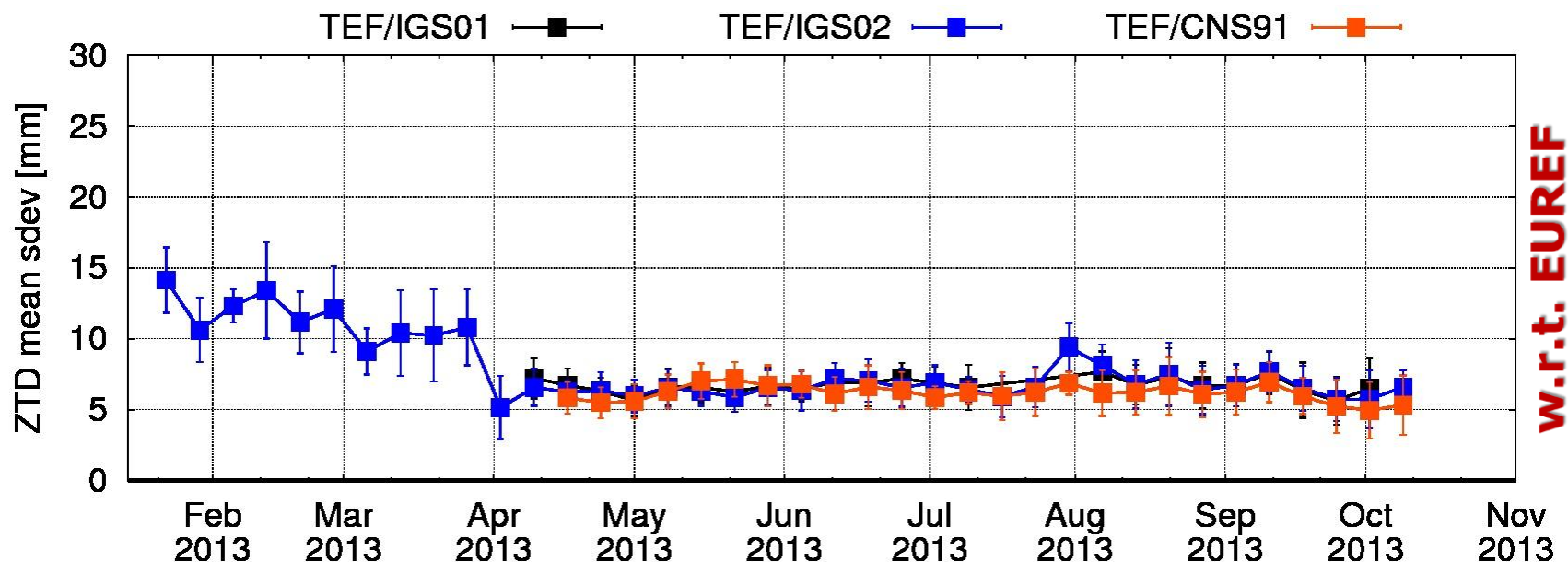


Real-time demonstration – weekly biases



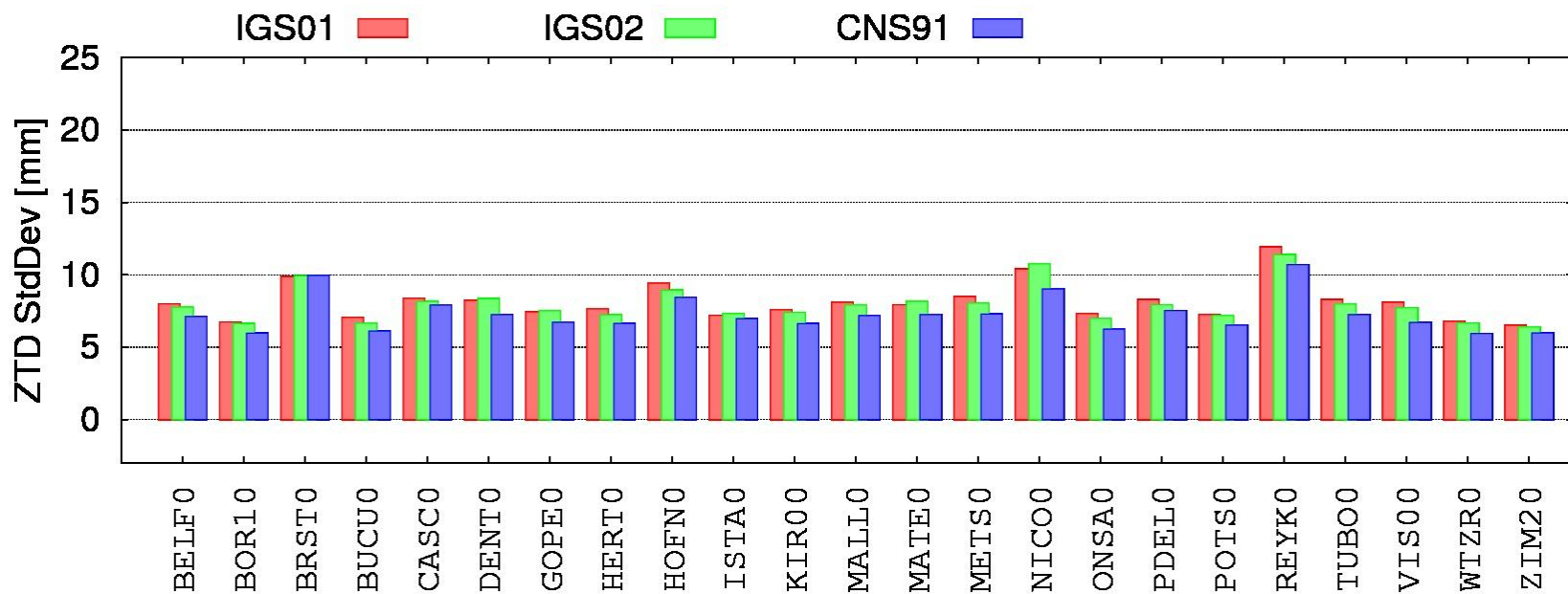


Real-time demonstration – weekly precision

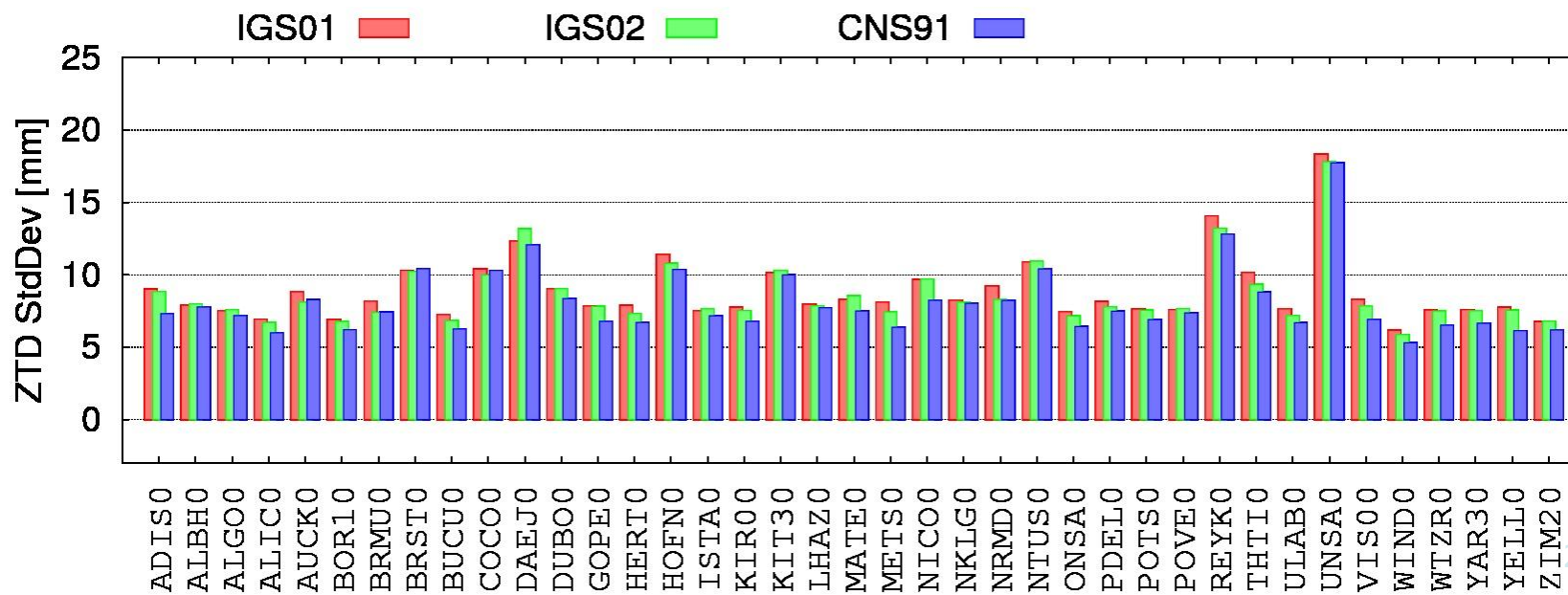




Real-time demonstration – precision



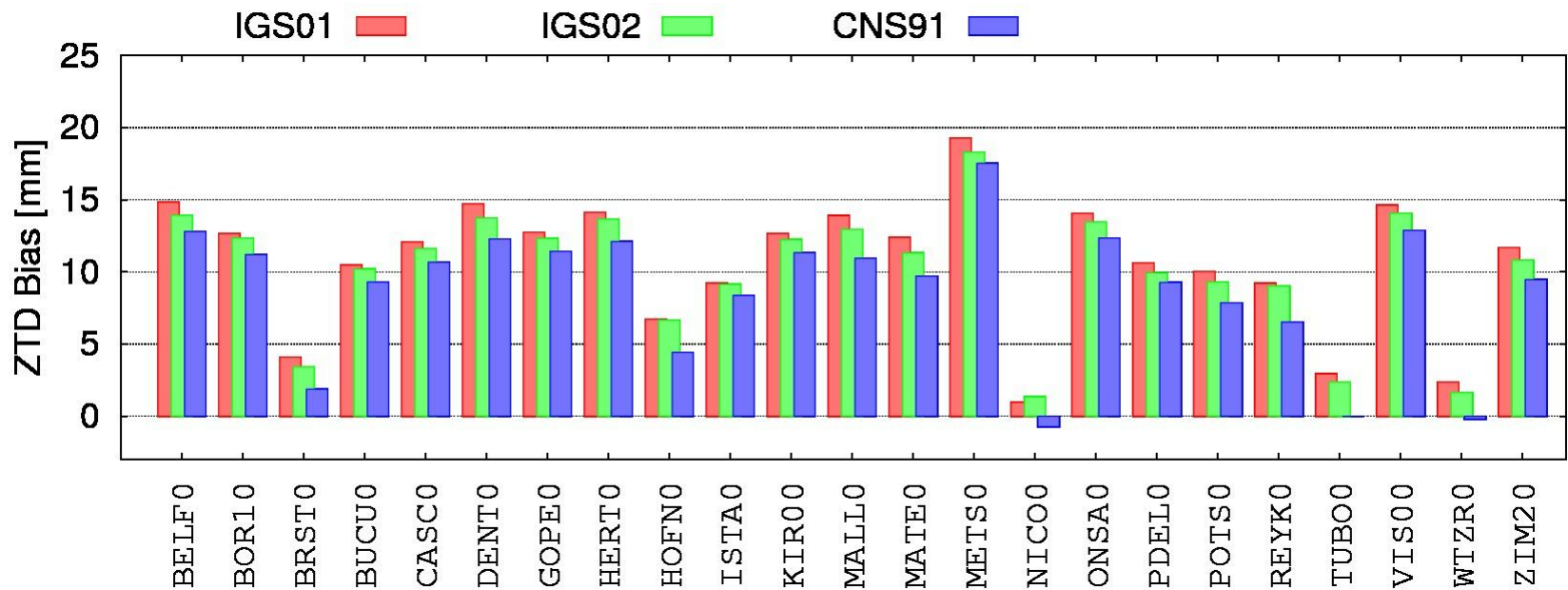
w.r.t. EUREF



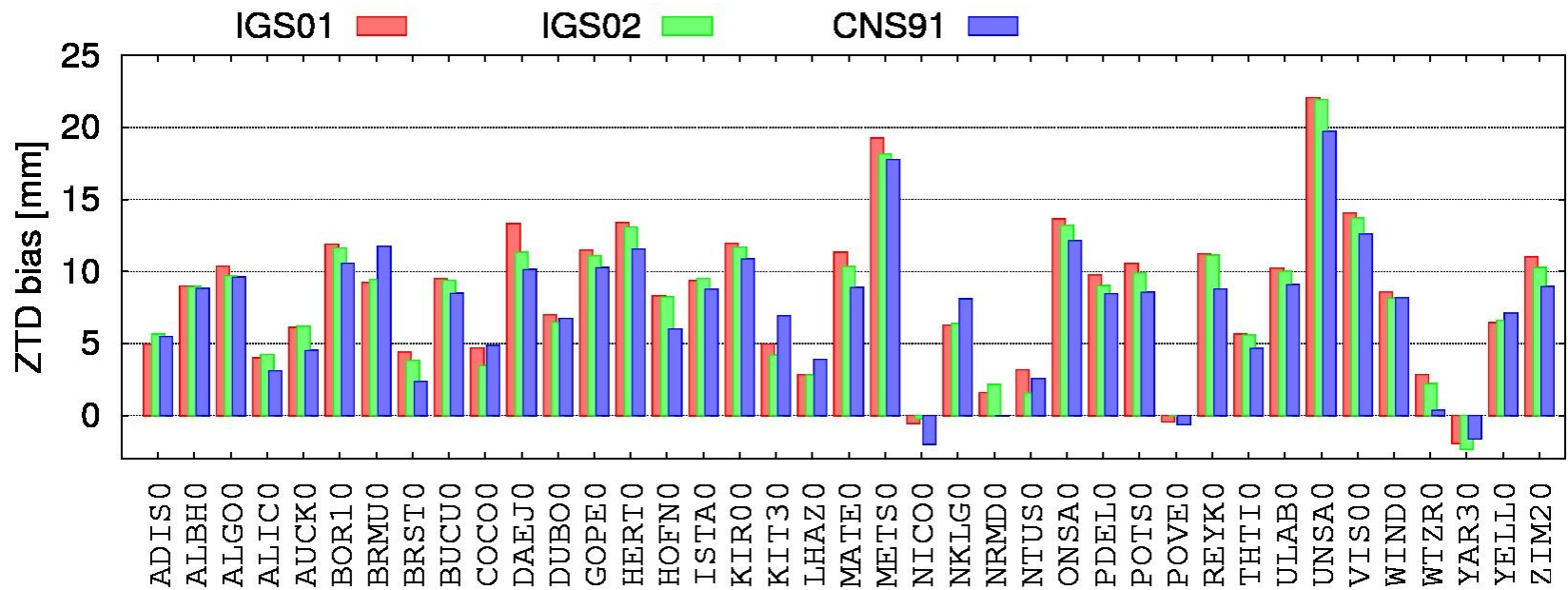
w.r.t. IGS



Real-time demonstration – biases



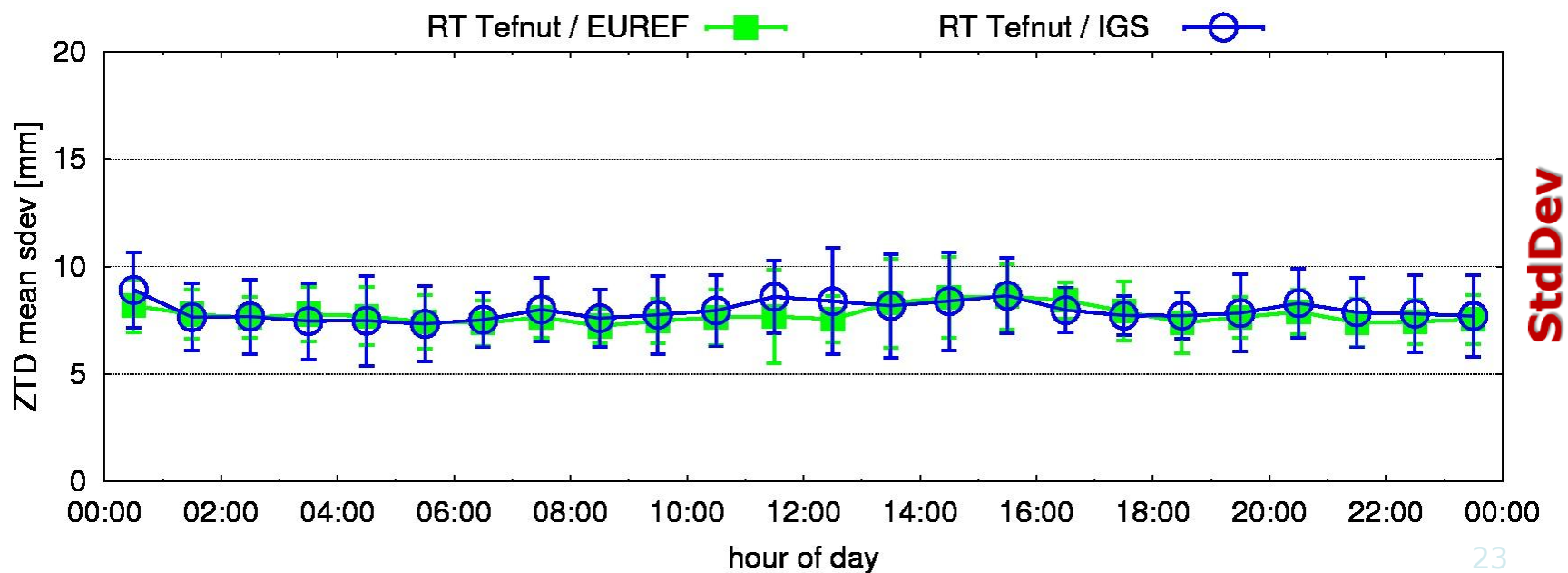
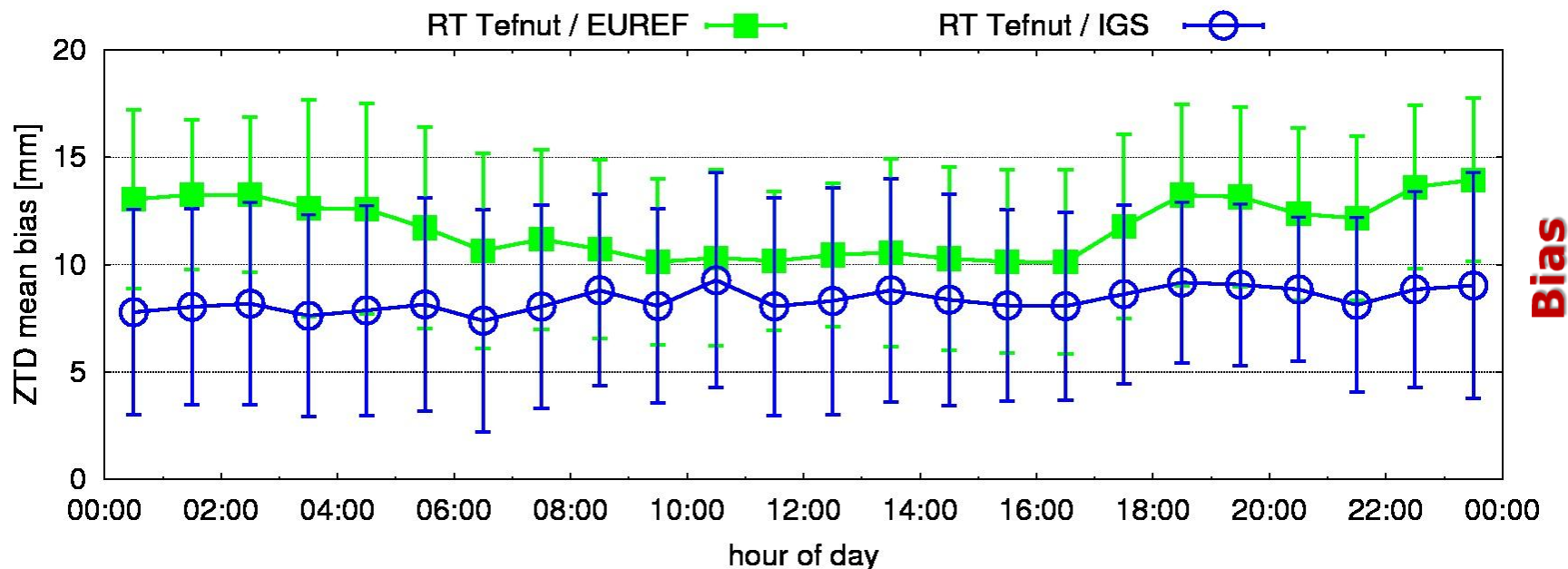
w.r.t. EUREF



w.r.t. IGS

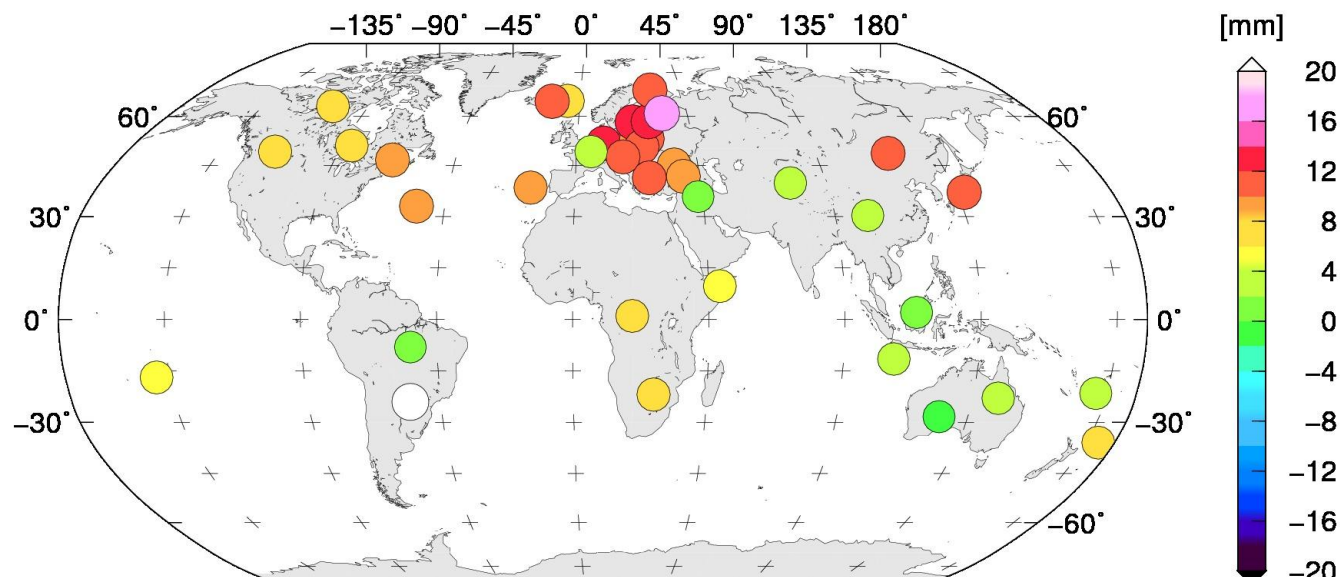


Real-time demonstration – hourly comparison

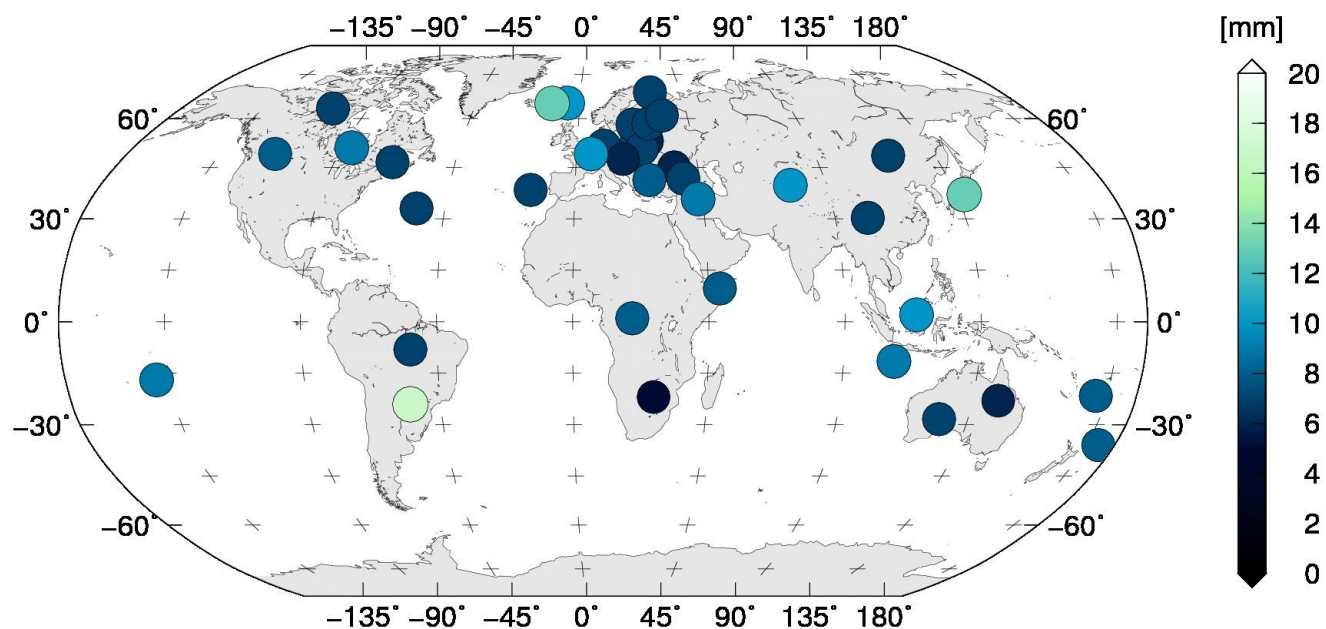


Real-time demonstration – geographical plots

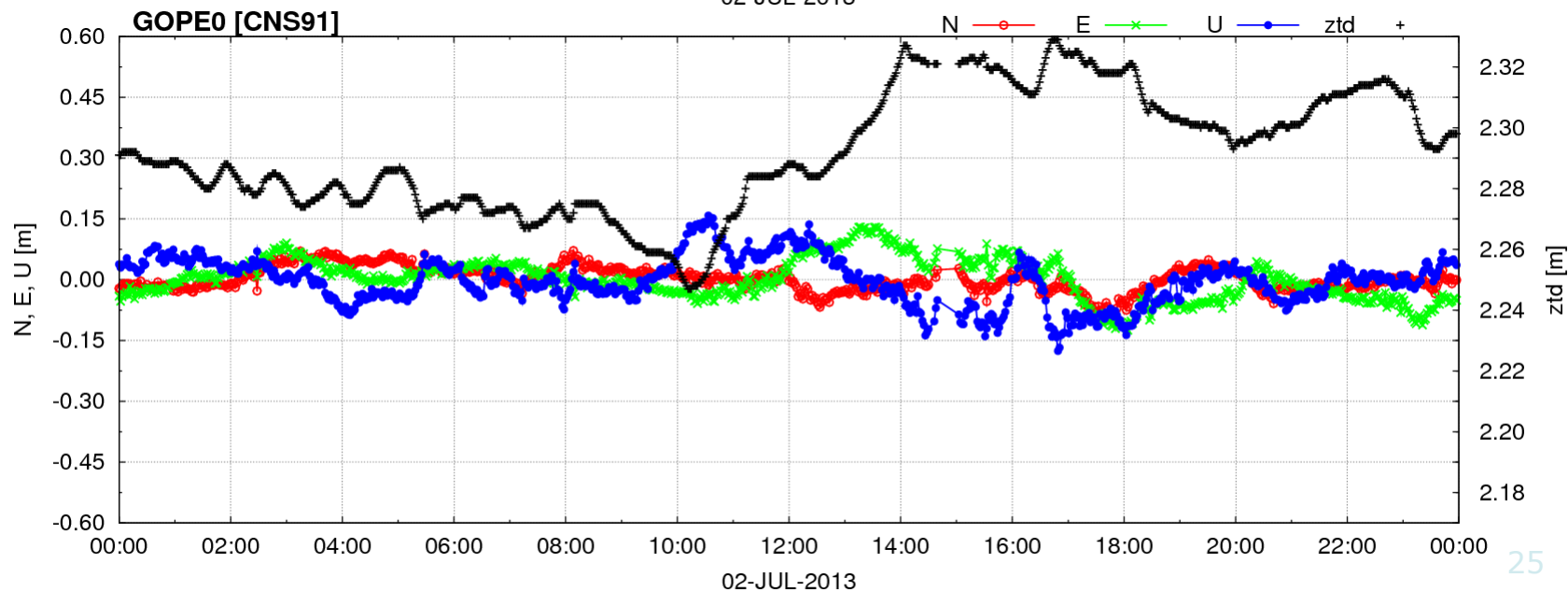
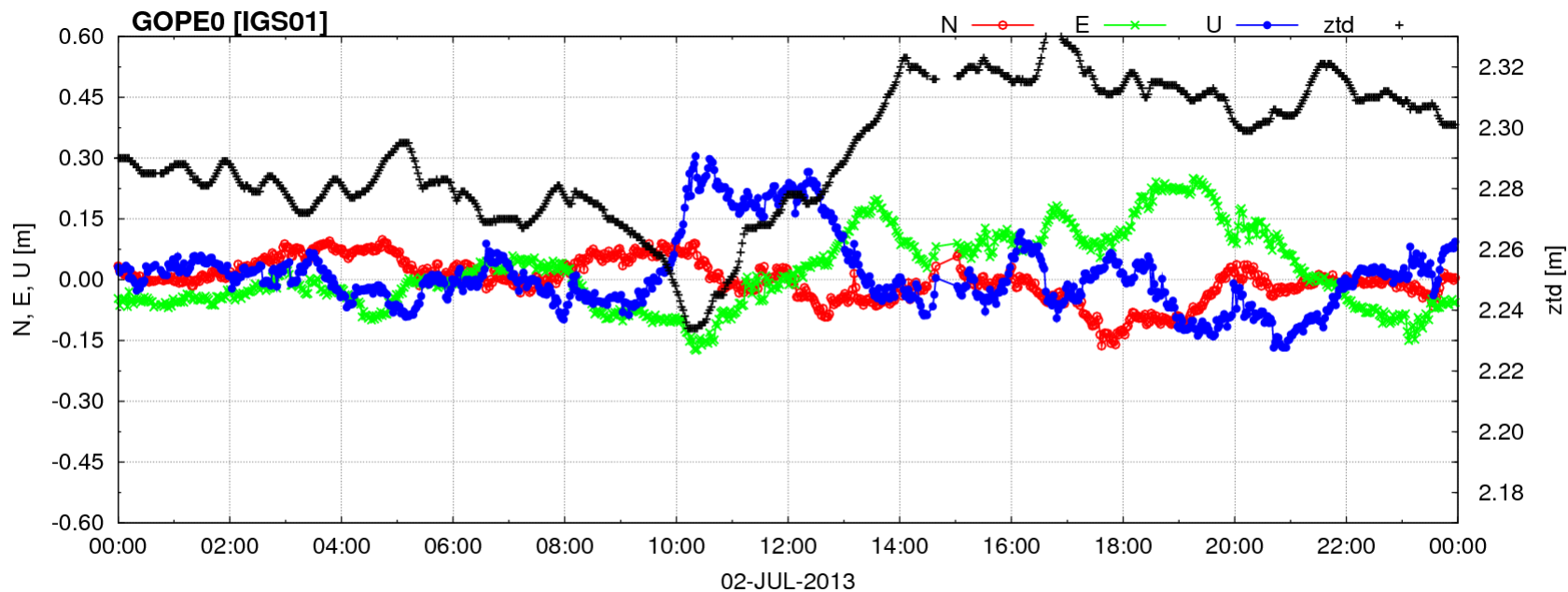
Bias



StdDev

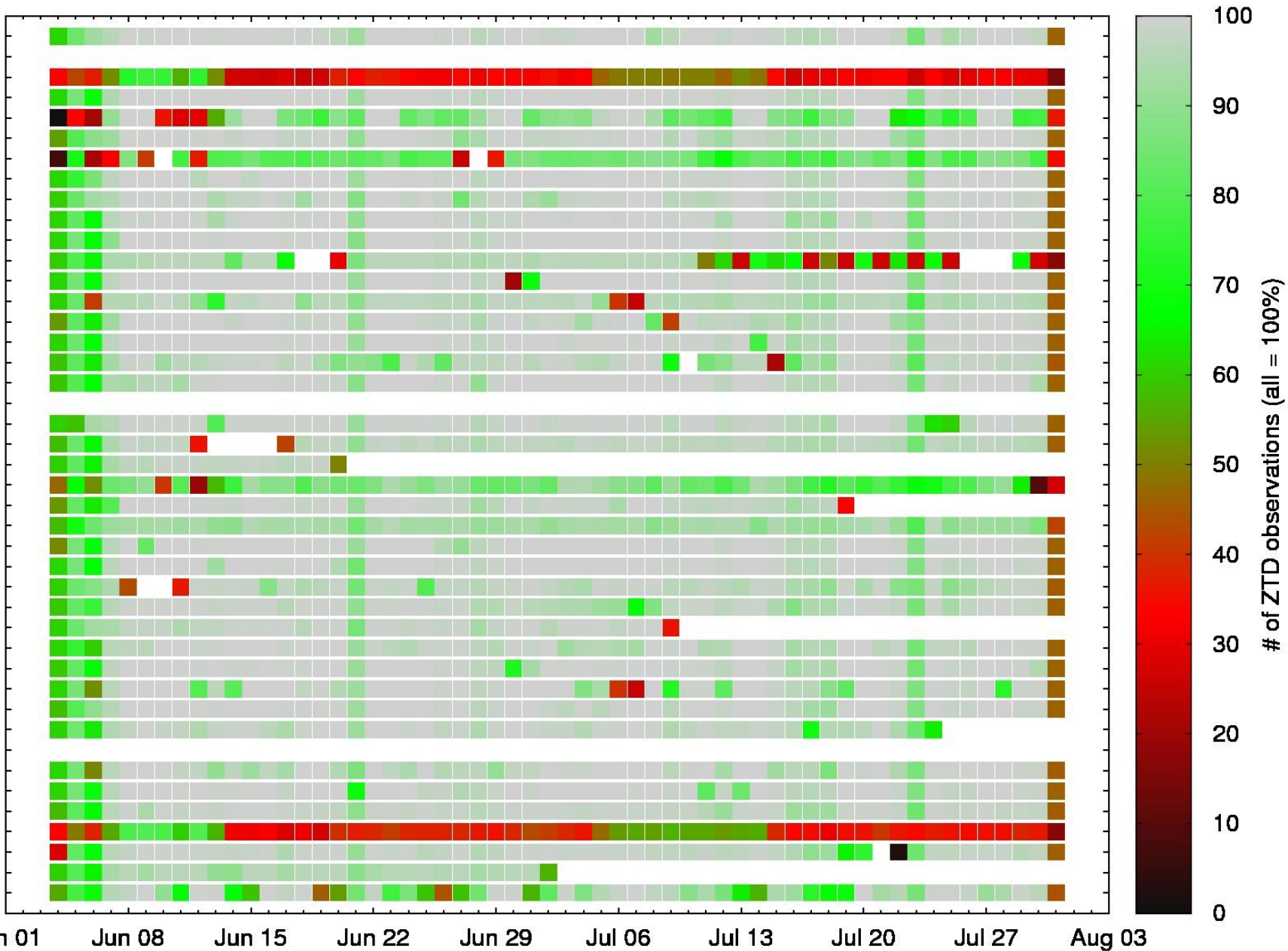


Real-time pseudo-kinematic coordinates



new

Availability of real-time ZTD (CNES product)

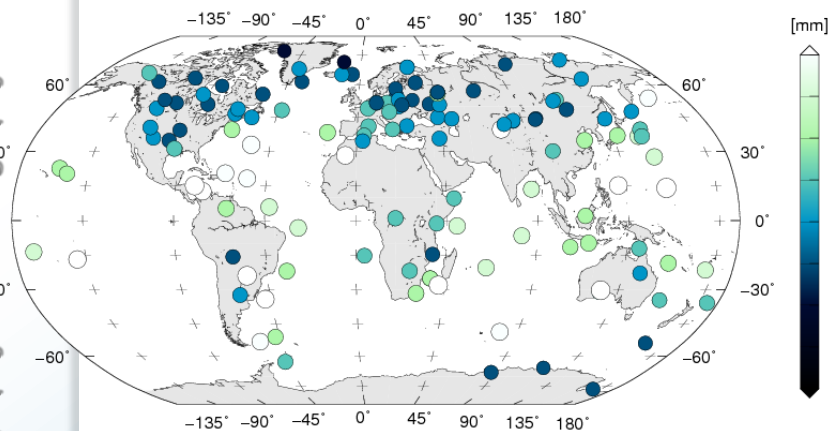


new

GOP tropo database: routine comparisons

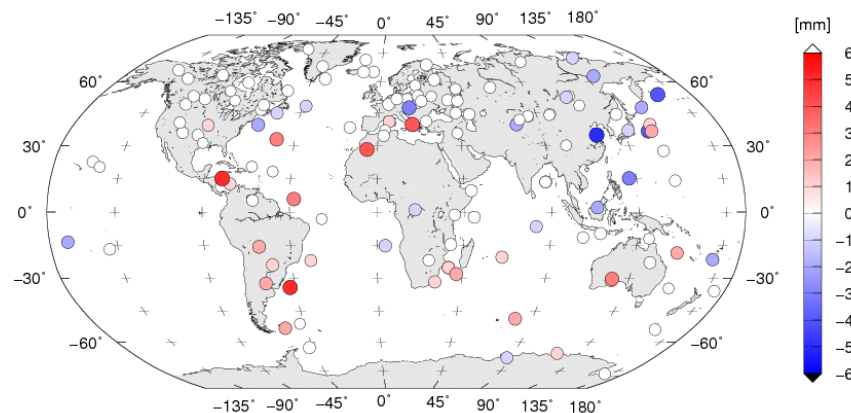
vs. final ZTD	AbsBias	StdDev
ZTD regional	0-1 mm	3-6 mm
ZTD global	0-3 mm	3-8 mm
ZTD real-time	0-20 mm	5-10 mm

ZTD/Sdev: NRT_GOPG (GPS/Global) – IGS (final)



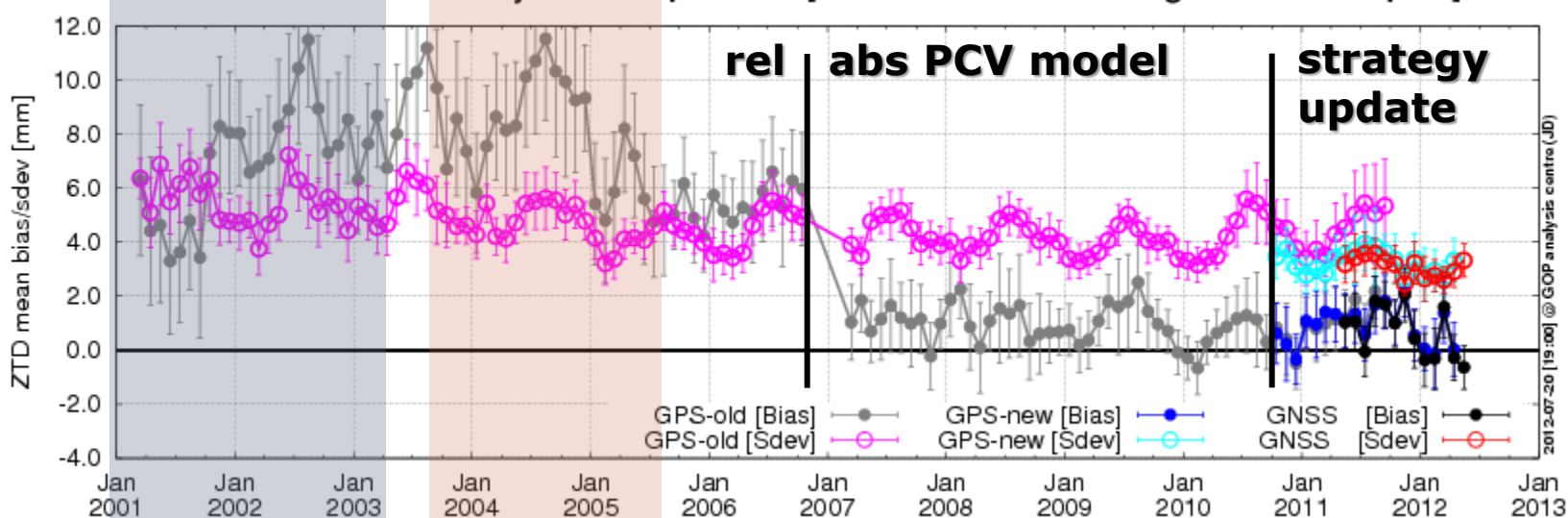
GLIM 2013 Jul 31 07:51:06 (c) RIGTCGOP jan.dusek@upce.cz

ZTD/Bias: NRT_GOPH (GPS/Global) – IGS (final)



GLIM 2013 Jul 31 07:51:06 (c) RIGTCGOP jan.dusek@upce.cz

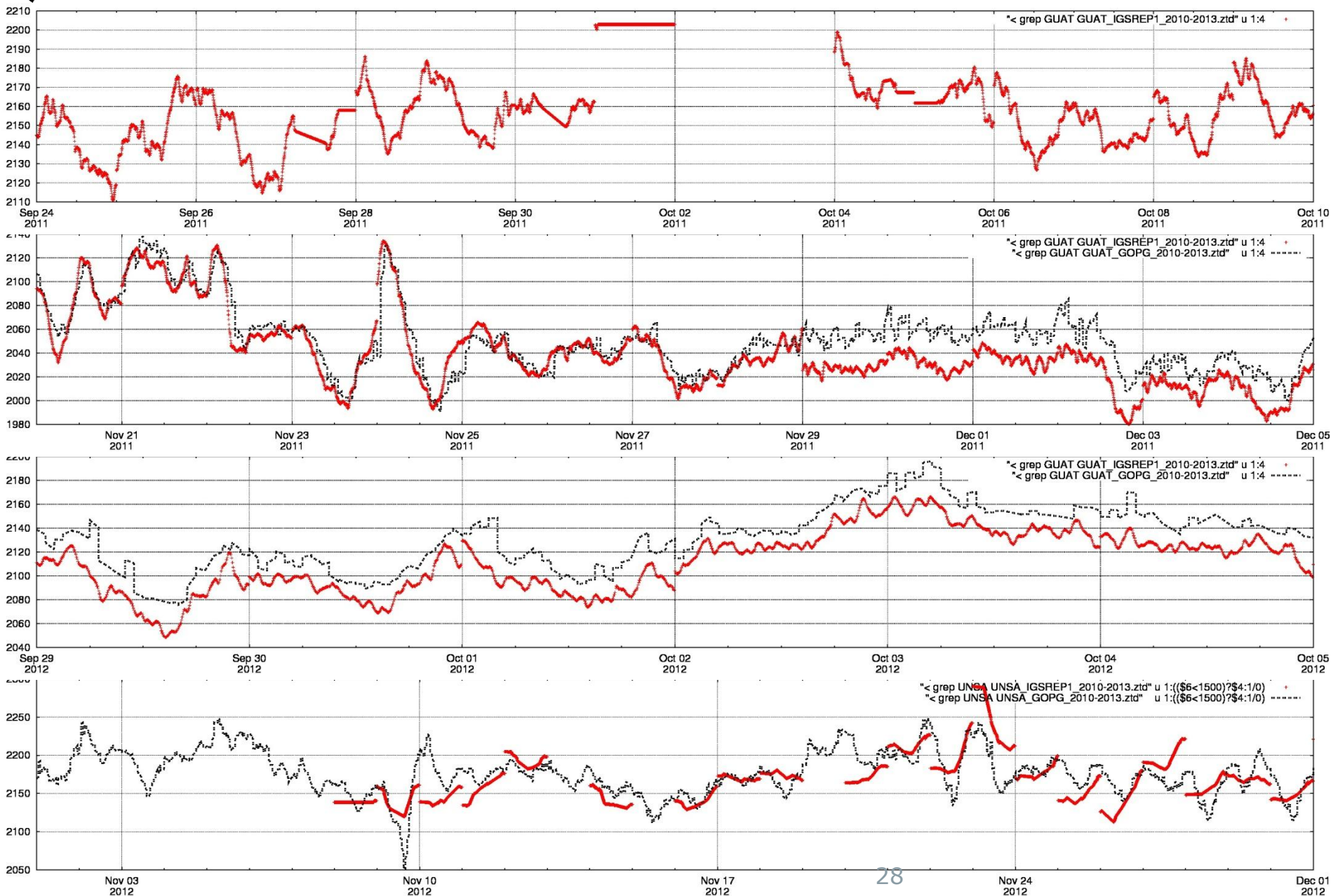
Time-series of monthly ZTD comparisons [GOP-NRT GPS/GNSS regional - EUR-repro1]



2012.07.20 [19:00] @ GOP analysis centre (JD)



IGS final product monitoring (examples)



References

G-Nut library

Václavovic P, Douša J, Györi G (2013), G-Nut software library - state of development and first results, Acta Geodynamica at Geomaterialia, pp 431-436, Vol. 10, No. 4 (172), doi:10.13168/AGG.2013.0042.

GOP near real-time solution - long-term evaluations

Douša J, Václavovic P (2013), Long-term evaluation of new ground-based GNSS tropospheric products, submitted to IAG Symposia Series - Proceedings of the IAG 2013 held in Potsdam, September 1-6, 2013

G-Nut/Tefnut - real-time ZTD product

Douša J, Václavovic P (2013), Real-time zenith tropospheric delay estimates in support of nowcasting, submitted to Advanced Space Research, 2013.

Global near real-time ZTD product

Douša J, Bennitt GV (2013), Estimation and evaluation of hourly updated global GPS Zenith Total Delays over ten months, GPS Solution, Springer, 17:453-464, doi:10.1007/s10291-012-0291-7, (ISSN online:1521-1886 printed: 1080-5370)

GLONASS near real-time ZTD product

Douša J (2012), Developments of the GLONASS ultra-rapid orbit determination at Geodetic Observatory Pecný, In: Geodesy of Planet Earth, S. Kenyon, M.C. Pacino, U. Marti (eds.), International Association of Geodesy Symposia, Vol 136, pp.1029-1036. (<http://www.springer.com/978-3-642-20337-4>)

GOP Tropospheric database

Györi G, Douša J (2013), GOP-TropDB developments for tropospheric product evaluation and monitoring -- design, functionality and initial results submitted to IAG Symposia Series - Proceedings of the IAG 2013 held in Potsdam, September 1-6, 2013

Thank you 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



EUROPEAN UNION

EUROPEAN REGIONAL
DEVELOPMENT FUND
INVESTING IN YOUR FUTURE



OP Research and
Development for Innovation