EPN-Related Activities and Research at ROB: Status and Perspectives

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Presentation of the ROB team (http://www.gnss.be/who.php)

Carine Bruyninx
???

Pascale Defraigne
PPP and Time Transfer

Quentin Baire
Quality Check & Antenna Calibration

Wim Aerts
Error Sources in Positioning and Timing Instrumentation, Engineering

Juliette Legrand
Reference Frame and Velocity Field

Nicolas Bergeot and Jean-Marie Chevalier
Modelling and Monitoring of the Ionosphere

Eric Pottiaux and Julie Berckmans
Modelling and Monitoring of the Troposphere

Dominique Mesmaker and Ann Moyaert
IT Technical support

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Main EPN-related Activities and Research

EPN Central Bureau
(Bruyninx et al., "EPN CB Support to EPN Data Analysis and Future Strategy")

IAG WG "Integration of Dense Velocity Fields in the ITRF"
(Legrand et al., "Future EUREF contribution to the IAG WG 'Integration of Dense Velocity Fields in the ITRF' ")

EPN Data Centres & Broadcaster

(EPN-style) Data Analysis

PPP for Time Transfer

Antenna Calibrations

Monitoring of the Ionosphere

Monitoring of the Troposphere

EPN Data Centers

- ROB EPN Data Center:
  - URL: ftp://gnss.oma.be/gnss/data/rinex/
  - hourly and daily RINEX files of ROB's EPN stations (BRUS/BRUX, DOUR, DENT, WARE)

- EPN Historical Data Center:
  - URL: ftp://ftp.epncb.oma.be/pub/obs/
  - Daily EPN RINEX data (also "pre-EPN" data – but uncomplete)
  - Corrected RINEX headers according to site log – 3 month delay

```
     2               OBSERVATION DATA     G (GPS)            RINEX VERSION / TYPE
HEADER CHANGED BY EPN CB ON 2009-05-18                      COMMENT
TO BE CONFORM WITH THE INFORMATION IN                      COMMENT
ftp://epncb.oma.be/pub/station/log/ankr_20080509.log       COMMENT
                                                           COMMENT
RGRINEXO V2.4.2 VM  IFAG-WETTZELL        04-JAN-96 10:12   PGM / RUN BY / DATE
BIT 2 OF LLI (+4) FLAGS DATA COLLECTED UNDER "AS" CONDITION COMMENT
     0.000000000000           HARDWARE CALIBRATION (S)     COMMENT
     0.000000084672           CLOCK OFFSET (S)             COMMENT
ANKR                                                       MARKER NAME
20805M002                                                  MARKER NUMBER
```

ROB EPN Broadcaster

- Caster URL : http://www.euref-ip.be
- User registration form:
  http://gnss.be/data.php#NTRIPaccess

- 65 registered users (160 active listeners on average)
- 181 configured stations (135 unique streams, some redundant from 2 casters)
- Plan: secure connection (https) will become available in 2013

Welcome to the ROB EUREF RELAY GNSS Server

This server, available at *www.euref-ip.be*, is run by Royal Observatory of Belgium, GNSS Team.

It aims at being a thematical server for all EUREF NTRIP streams.
The Belgian ROB stations BRUX0, BRUX1, DENT0, WARE0 are directly streaming to the caster.
The other EUREF stations are mirrored from 17 casters such as:

- the caster in CHE run by SWISSTOPO (for stations ZIM2_RTCM)
- the caster in CZE run by GOP (for stations GOPE0, GOPE1, TUBO0)
- the caster in ESP run by IGN (for stations ACOR0, ACOR1, ALAC0, ALBA0, ALME0, ARDU0, ARDU1, BCLN0, BORR0, CACE0, CANT0, CANT1, CEU10, COBA0, COBA1, FRAG0, GIRO0, HUEL0, IGNE0, IGNE1, IZAN0, IZAN1, JACA0, JORD0, LEON0, LEON1, LPAL0, LUGO0, MALA0, MALA1, MALL0, MALL1, MELI0, MER20, MER21, RIO10, SALA0, SALA1, SONS0, SONS1, TARI0, TERU0, TN010, TN020, TN030, VALE0, VIGO0, YEB10, YEB11, YEBE0, ZARA0, ZFRA0)
- the caster in FRA run by IGN (for stations AJAC1, BRST1, BSCN1, GRAS1, MARS1, SCOA1, TLSE1, VFCH1)
- the caster in GBR run by OS (for stations DARE_RTCM, INVR_RTCM, SHOE_RTCM)
- the caster in GER run by BKG (for stations AJAC0, AUT10, BELF0, BELL0, BOGI0, BOR10, BORJ1, BRST0, BSCN0, BUCU0, BUTE0, BZRG0, CAGZ0, CFRM0, CLIB0, CPAR0, CRAK0, CREU0, CTAB0, DARE0, DRES1, DUBR0, EBRE0, GANP0, GRAZ3, HERT0, HOE21, HOFN0, IENG0, IGEO0, INVR0, ISTA0, JOEN0, JOZ20, KARL1, KIR00, KURE0, LAMA0, M0SE0, MAR60, MARS0, METS0, MOP20, NICO0, OBE40, ONSA0, ORID0, OSJE0, OSLS0, PADO0, PENC0, REYK0, ROVE0, SASS1, SKE00, SODA0, SOFI0, SPT00, STAS0, SULP0, SUR4, TOIL0, TOR20, TORI0, TRDS0, UNPG0, UNTR0, VAAS0, VALA0, VARS0, VFCH0, VIS00, WARN1, WROC0, WSRT0, WTZR0, ZIM20, ZOUF0)
- the caster in GER run by BKG (for stations POTS0)
- the caster in GER run by BKG (for stations BRUX7)
- the caster in HUN run by FÖMI (for stations PENC_RAW-RTCM3.0)
- the caster in ITA run by UNIPD (for stations Bolzano, Padova, Rovereto)
- the caster in ITA run by E-GEOS (for stations MATE0, USAL0, VEN10)
- the caster in ITA run by SAPIENZA (for stations M0SE0)
- the caster in NOR run by SK (for stations Oslo, Stavanger, Trondheim, Vardo)
- the caster in POL run by AGH (for stations KRA10, KRAW0, KRAW1)
- the caster in PRT run by IGEO (for stations CASC0, FLRS0, FUNC0, GAIA0, LAGO0, PDEL0, TERC0)
- the caster in SVK run by STUBA (for stations MOP2)
- the caster in SWE run by LM (for stations kir0_euref, mar6_euref, onsa_euref, ske0_euref, spt0_euref, vis0_euref)

This server supports the *NTRIP 2.0* protocol. See http://igs.bkg.bund.de/ntrip/about for more information on NTRIP.

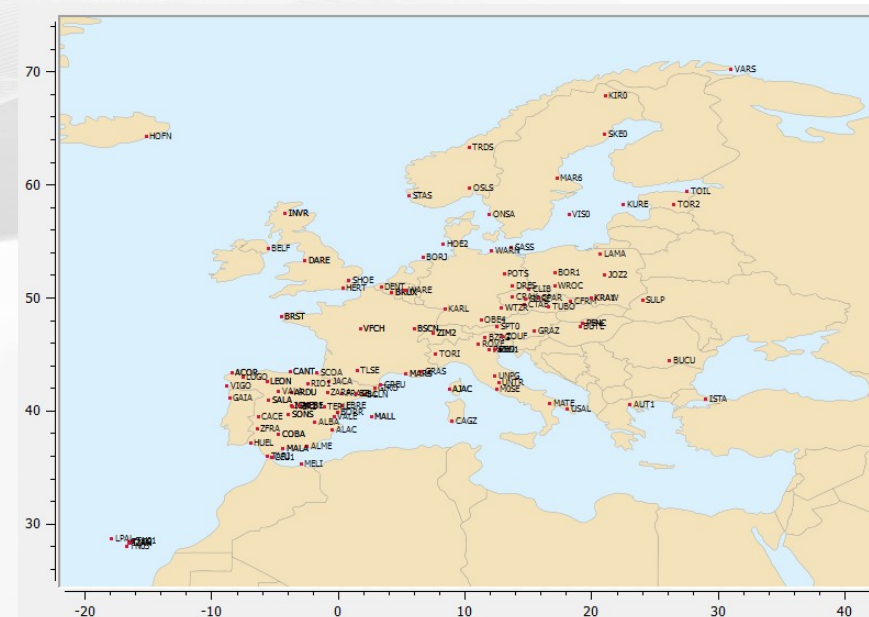Uptime is 74 days, 14 hours, 17 minutes and 13 seconds, since 21/Feb/2013:23:17:15.
169 streams available (see sourcetable), 178 listeners connected.

To apply for an account, use this form.

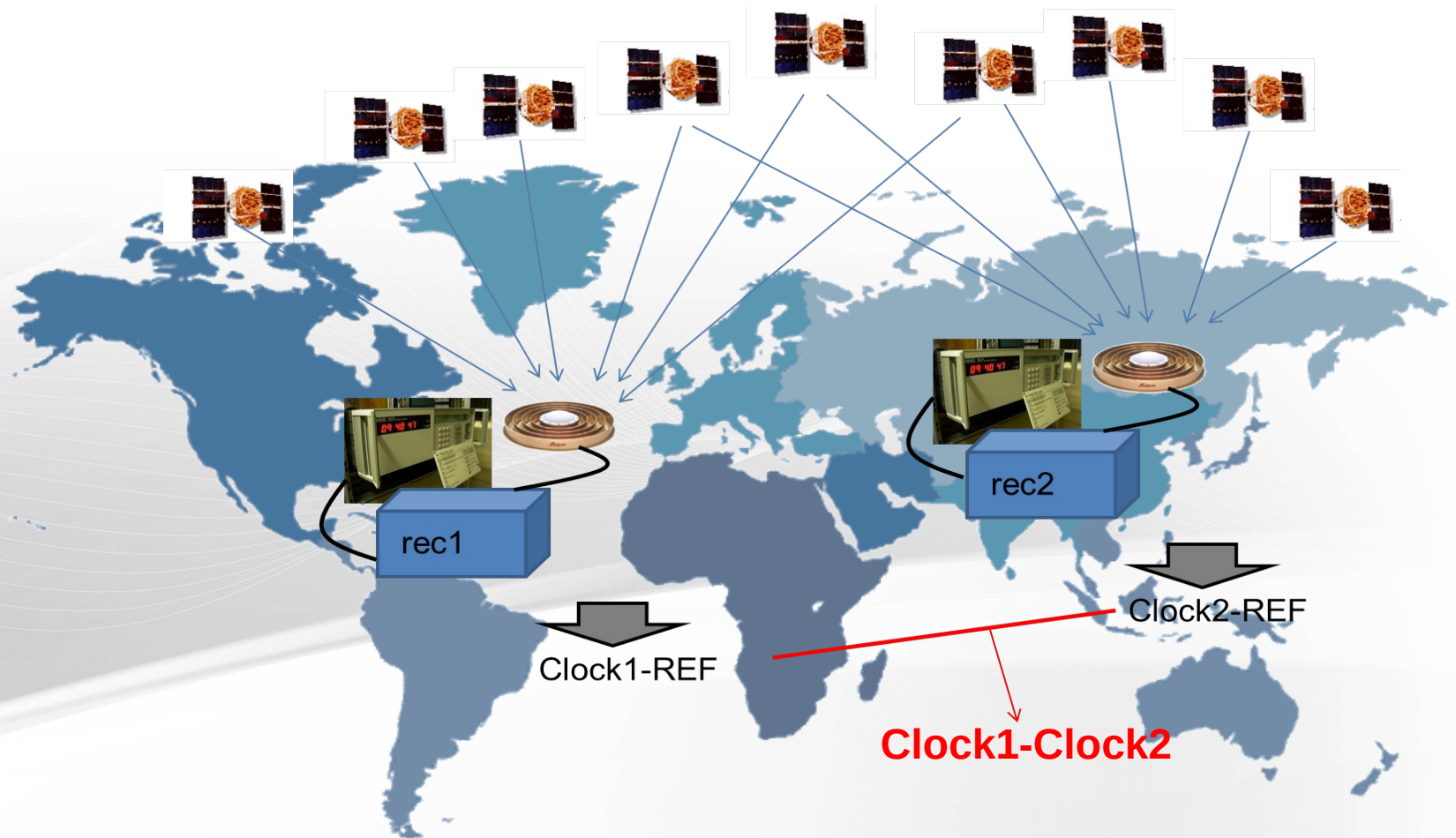Below you find a selection of some of our 66 users and their application for our NTRIP streams:

- Olha (from AUT): testing
- Bram (from BEL): low cost RTK
- Bart (from BEL): Test and generation of 1sec files

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(EPN-style) Data Analysis

- Bernese V5.0, GPS+GLONASS

- EPN analysis: submitted rapid daily + final weekly

- Other analysis:
  - Stations in EPN analysis complemented with all Belgian GNSS stations + additional EPN reference stations "repro-mode"

- Plans:
  - Bernese 5.2 (of course)
  - Global (in any case)
  - More emphasis on PPP? To be tested with Bernese 5.2.
  - Stop as official EPN LAC and start as EPN "coordinate monitoring" facility (link EPN CB) ?? (Under discussion internally!)

PPP for Time Transfer

Objective : near real-time clock monitoring

rec1

rec2

Clock1-REF

Clock2-REF

Clock1-Clock2

Compare two remote clocks to a same reference:
REF

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DATA ANALYSIS

Using IGS real-time satellite clocks and orbits +
NRCAN ultra-rapid (EMU) satellite clocks and orbits
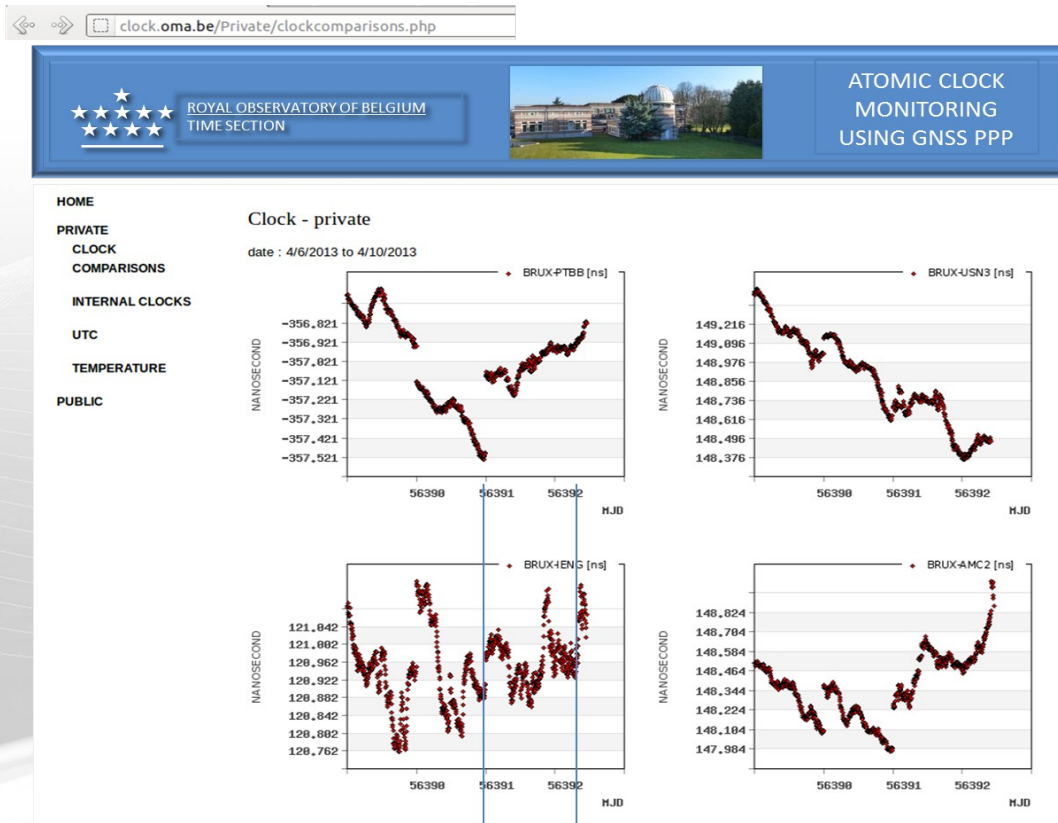
Detection of clock problems

Phase jump :

> 1.5 ns after some minutes

frequency jump :
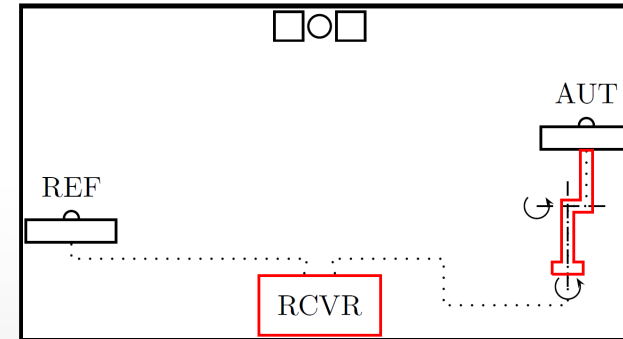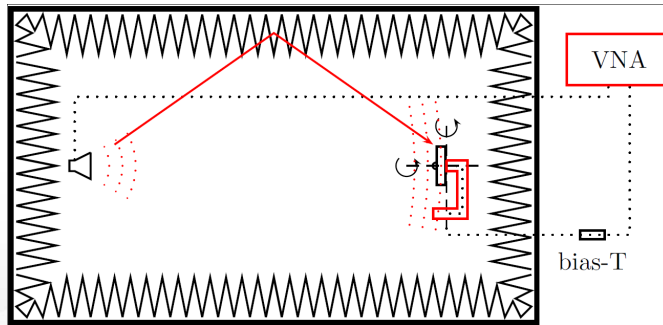   > 2E-13 after 2h
       > 2E-14 after 24h

Antenna Calibrations
Error Sources in Absolute Individual Antenna Calibrations

- The repeatability of a given calibration method (1 to 1.5mm) is better than differences between the chamber and robot calibrations (up to 4 mm)

- Robot calibrations using different antenna mounts (used typically in stations) can differ up to 5 mm

- The dominant error for chamber and robot calibration is **near field multipath**

- Conclusion: (sub-)millimeter <u>absolute</u> positioning with GNSS will only be possible after solving this near field multipath issue (that are in the calibration and in the station setup).

Antenna Calibrations
Influence of GPS receiver antenna calibration model on geodetic positioning

- Six antennas, five TRM59800.00 and one LEIAR25.R3, all individually calibrated at both Geo++ and UniBonn have been installed at ROB

- Position offsets resulting from using the two different sets of individual calibrations have been computed

- Differences in absolute positioning impacted by using either robot or chamber calibration method:
  - Up to 1.5 mm in the horizontal components
  - Up to 8 mm in the vertical component

- Plan: Field experiment at NGS (Virginia, USA), to compare baseline GPS with individually calibrated antenna and local tie (ground thruth)
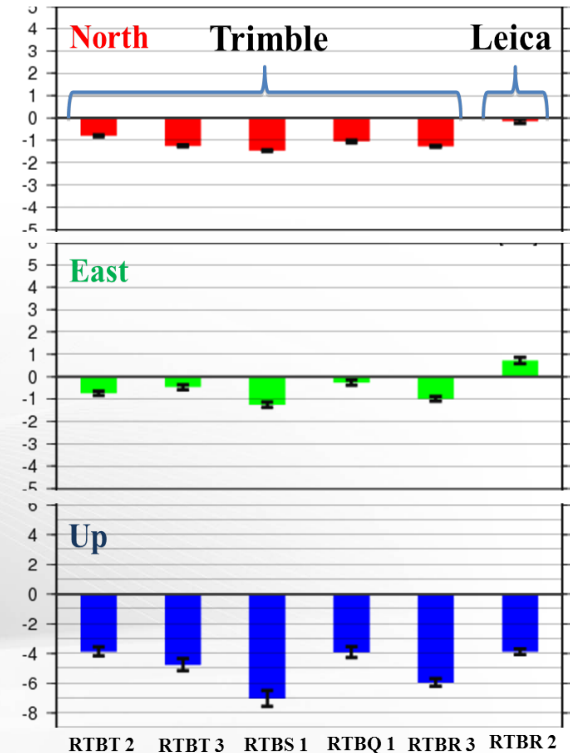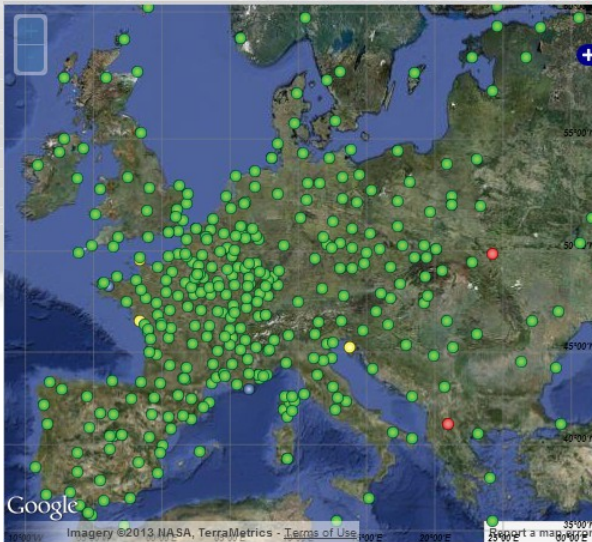
Modelling and Monitoring of the Ionosphere

- Thursday, May 16, 2013 - [09:45 - 10:00]

  Space Weather products and studies based on EPN GNSS data at ROB
  N. Bergeot, J.M. Chevalier, C. Bruyninx, E. Pottiaux, Q. Baire, J. Legrand, P. Defraigne, W. Aerts

Modelling and Monitoring of the Troposphere

- Related Projects:
  - E-GVAP III
  - COST Action ES1206
  - Nationally founded projects

- Data used (~390/850 stations):
  - EPN (&IGS) data centers and Broadcasters
  - National densification networks
  - Real-time, Hourly and Daily RINEX

- Current analysis: Bernese v5.0, GPS-only, ZTD-only, Hourly+Daily

Modelling and Monitoring of the Troposphere

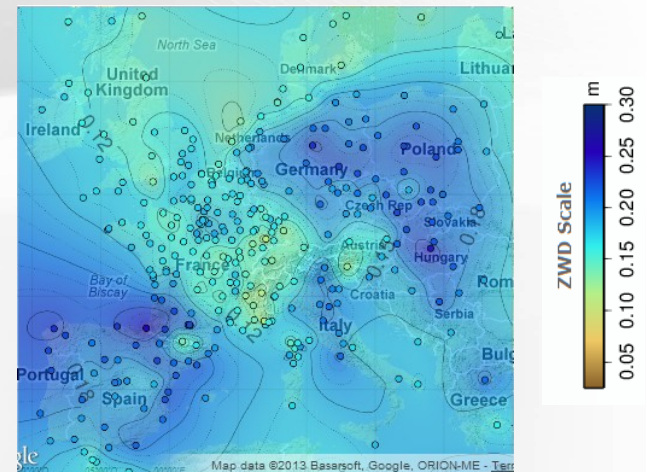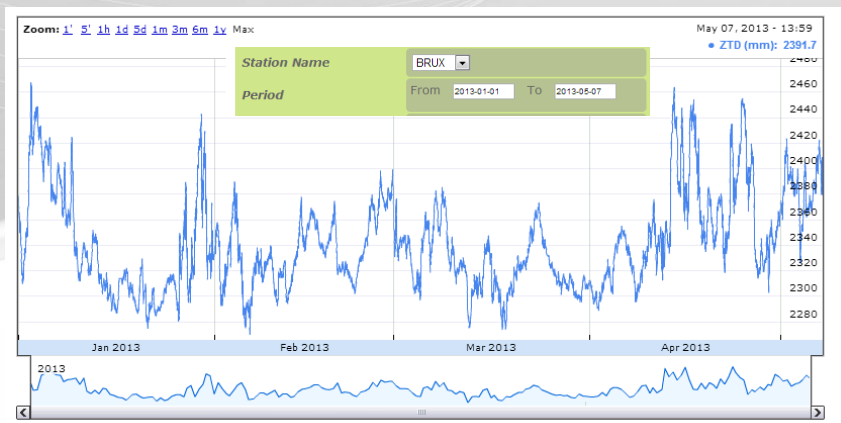- Domain of applications targeted:
  - Nowcasting of severe weather
  - Regional and global NWP
  - Regional climate modelling

- Products:
  - ZTD time series
  - Regional Tropospheric delay maps/models

- Plans:
  - Switch to Bernese GNSS software v5.2
  - GPS+GLO Analysis
  - Sub-hourly data processing (15 min)
  - Global analysis
  - Reprocessing
  - PPP
  - Gradient/Slant delay estimations

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Thank You For Your Attention