



Enhanced Assessment of EPN Station Performance

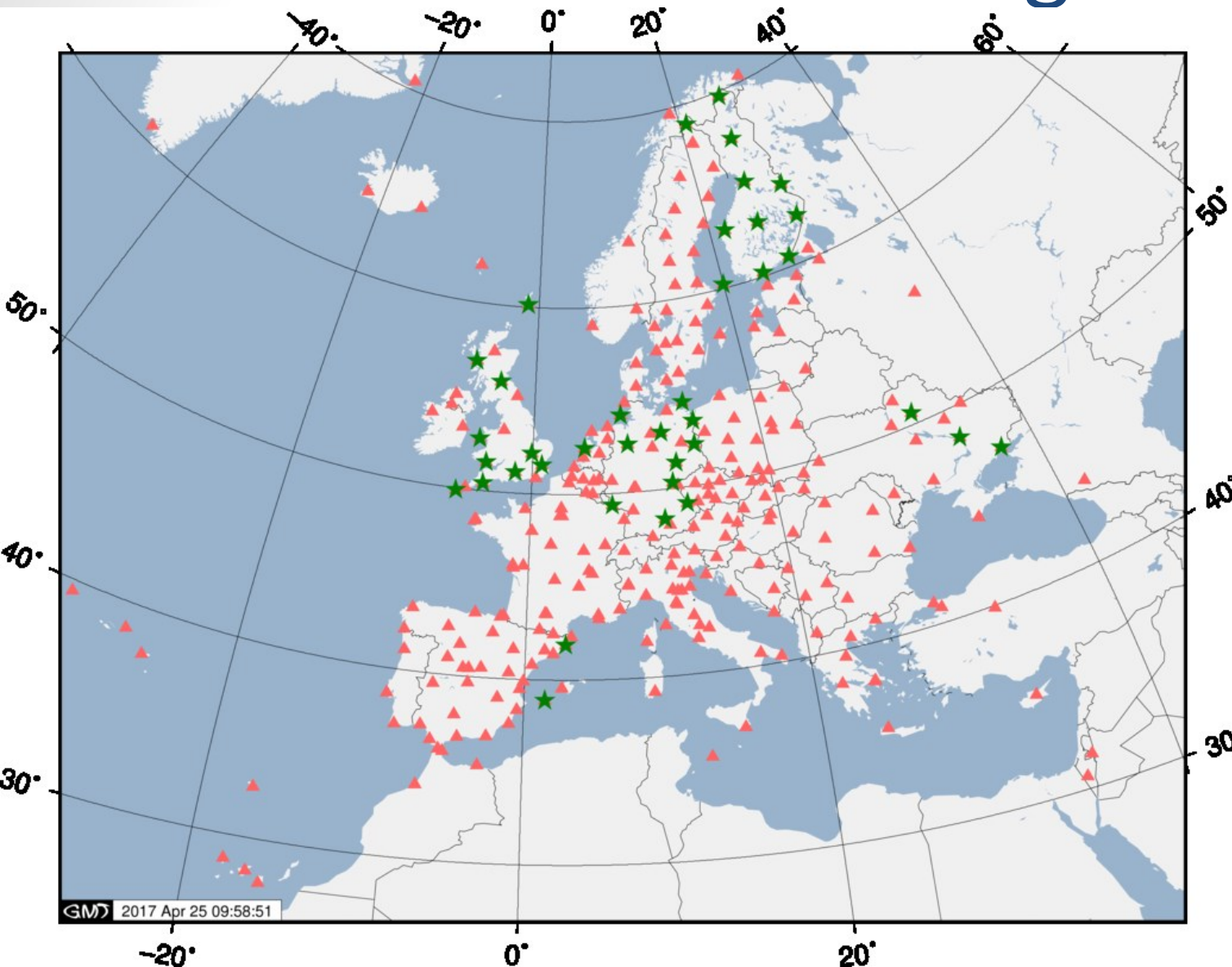
C. Bruyninx, J. Legrand, A. Fabian, E. Pottiaux, F. Roosbeek

EPN Central Bureau, Royal Observatory of Belgium

<http://www.epncb.eu/>

Special thanks to D. Mesmaker and A. Moyaert

Evolution of the Tracking Network



320 EPN stations

2 inactive (MOPS, RABT)

280+ tracking GLONASS

150+ tracking Galileo

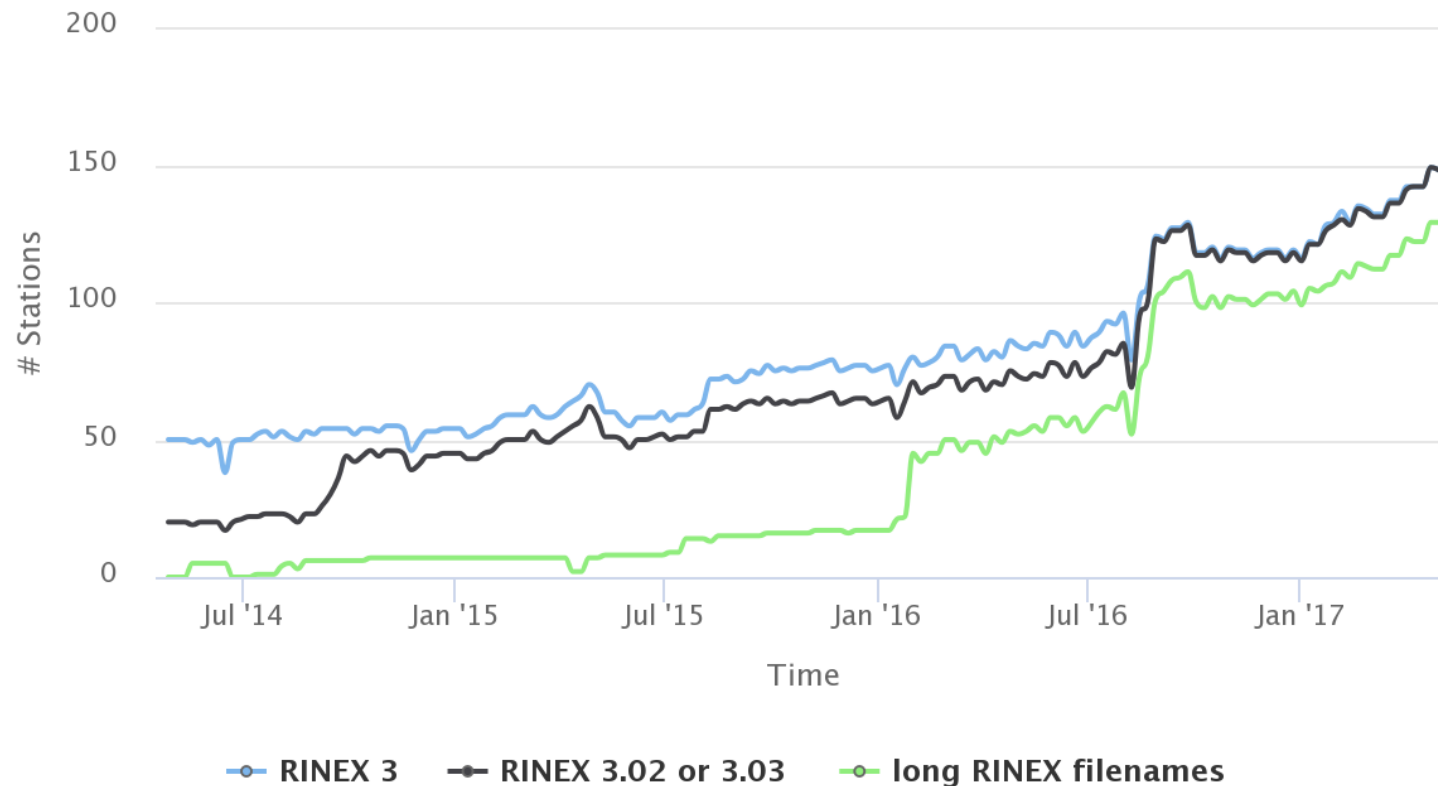
39 new EPN stations since last EUREF symposium :

- Antenna calibrations
 - Type mean 8 stations
 - Individual 31 stations
- Multi-GNSS
 - GPS+ GLO 15 stations
 - GPS+GLO+GAL+.. 24 stations
- Networks
 - 8 stations included in ITRF2014
 - 3 stations included in IGS network

RINEX 3

RINEX 3 observation files

Source: EPN Central Bureau



On May 12, 2017:

~150 stations providing RINEX 3
(all RINEX 3.02 or 3.03)

129 stations providing RINEX 3
with long filenames

Providing RINEX 3 with short
filenames:

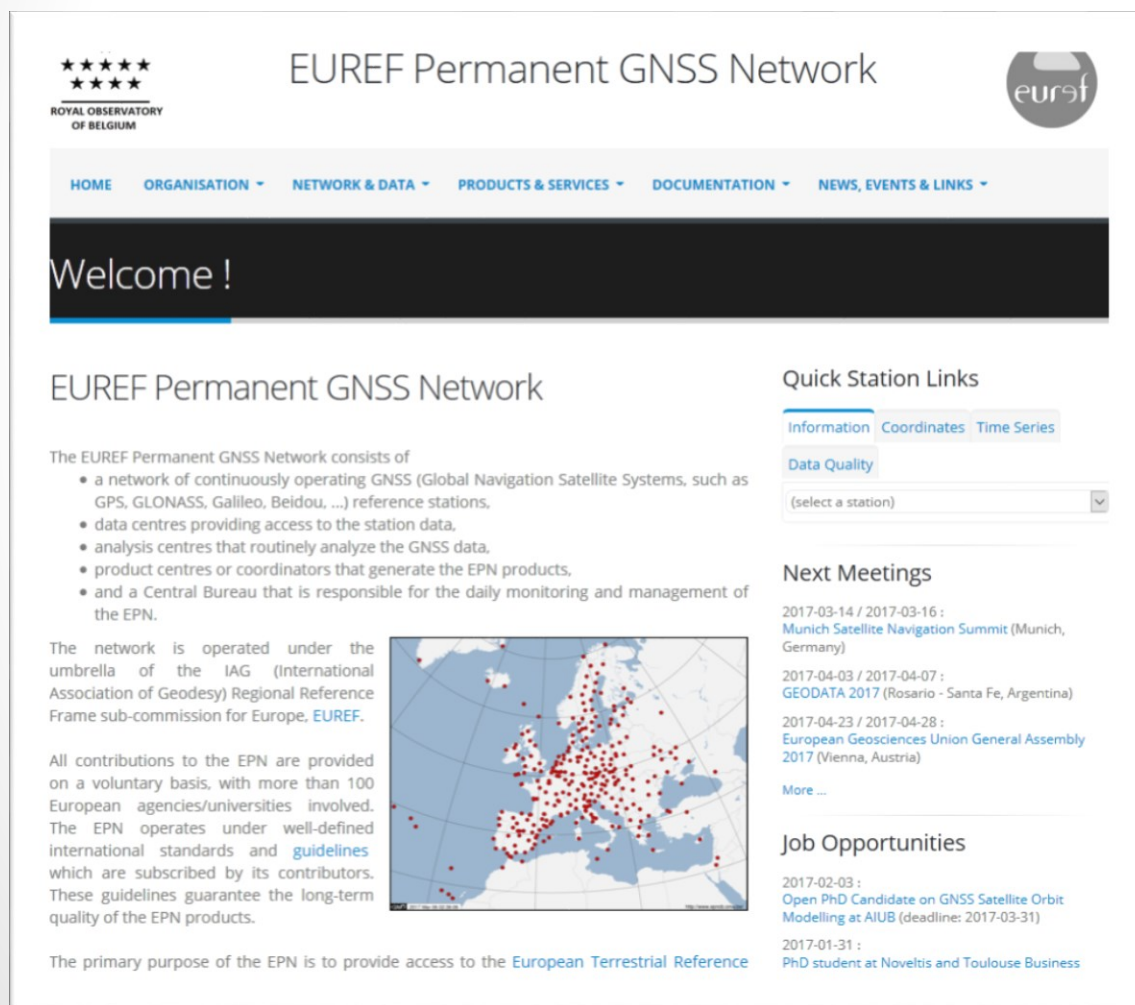
BPDL BUTE* BYDG CASC FLRS FUNC
GAIA GWWL KATO KLOP LAGO LINZ
LODZ MOSE* PDEL REDZ SWKI USDL
VAIN VLNS WROC ZYWI

*RINEX 3 in both short and long
format (short at BKG, long at
OLG/BEV)*

New EPN Central Bureau web site

Nov. 2016

<http://www.epncb.oma.be/> or <http://www.epncb.eu/>



The screenshot shows the homepage of the EUREF Permanent GNSS Network. At the top, there is a header with the EUREF logo (a circle with 'euref' inside) and the text 'EUREF Permanent GNSS Network'. Below the header is a navigation menu with links: HOME, ORGANISATION, NETWORK & DATA, PRODUCTS & SERVICES, DOCUMENTATION, and NEWS, EVENTS & LINKS. A large black banner with the text 'Welcome !' is positioned below the navigation menu. The main content area is divided into two columns. The left column contains a section titled 'EUREF Permanent GNSS Network' with a paragraph describing the network and a map of Europe showing the locations of the network stations. The right column contains a section titled 'Quick Station Links' with tabs for Information, Coordinates, Time Series, and Data Quality. Below these tabs is a dropdown menu labeled '(select a station)'. Further down, there is a section titled 'Next Meetings' with a list of upcoming events, including the Munich Satellite Navigation Summit, GEODATA 2017, and the European Geosciences Union General Assembly. At the bottom, there is a section titled 'Job Opportunities' with a list of open positions, including a PhD Candidate on GNSS Satellite Orbit Modelling and a PhD student at Noveltis and Toulouse Business.

Redesign of frontend

- ✓ More intuitive menu structure to navigate through the web site
- ✓ Dynamic plots (data latency, data quality, time series)

Backend

- ✓ GNSS data availability and data latency
- ✓ GNSS data quality checks
- ✓ Extended real-time data monitoring
- ✓ Administrator tools – still developing

Data Availability & Latency

OLG will stop operations end of 30/06/2017

Station managers are asked to switch data upload from OLG to BEV (Bundesamt für Eich- und Vermessungswesen, Vienna)

EUREF mail 8976 (10/04/2017), reminder EUREF mail 9001 (02/05/2017)

Scans of content of regional data centers BEV, OLG, BKG and historical data center ROB

New functionality to FLAG files:

- Invalid RINEX 3 (No GPS L1/L2), Isolated RINEX 3 (tests)
- RINEX 3 converted from RINEX 2 ⚠
- Cannot uncompress data
- RINEX 3 data found in RINEX 2 directory
- Incorrect filename
- ...

→ In preparation of EPN-REPRO2 input for additional flagging of data files in historical data center (moving to separate directory)

**INPUT FROM STATION MANAGERS
AND USERS IS IMPORTANT!**

Data Availability & Latency

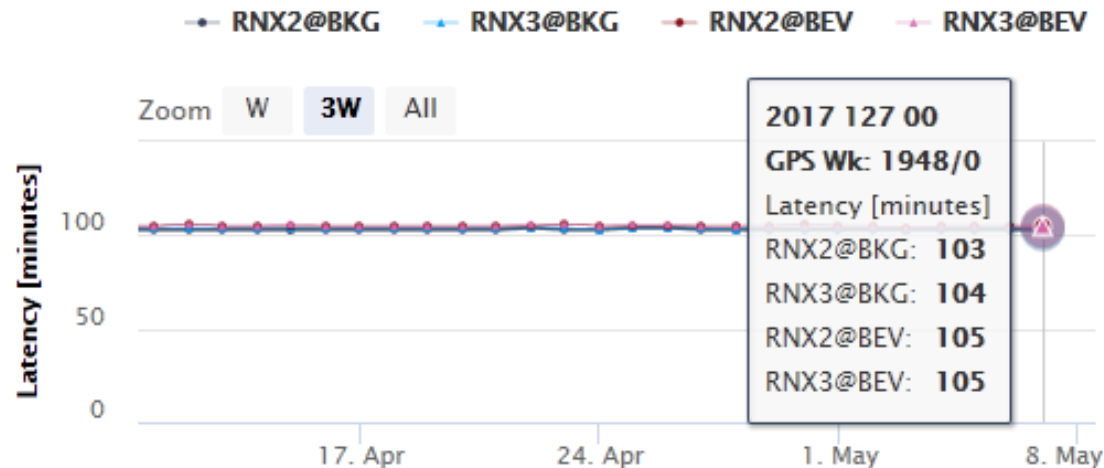
RESULTS

http://www.epncb.eu/networkdata/data_access/dailyandhourly/latency/

Dynamic plots available for each station

CACE00ESP: Daily Data Latency

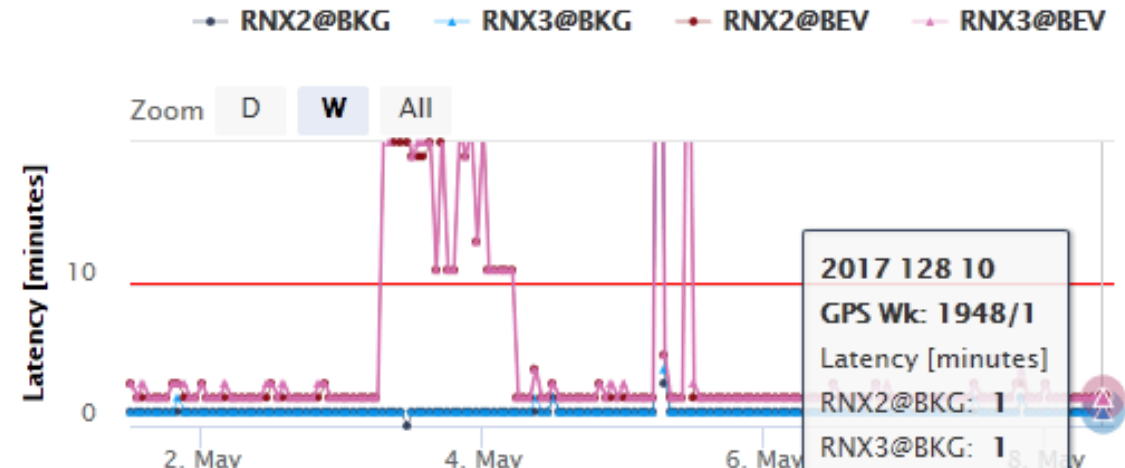
© EPN Central Bureau



Zoom Y axis: Show All Max = 480 minutes Max = 120 minutes

CACE00ESP: Hourly Data Latency

© EPN Central Bureau



Zoom Y axis: Show All Max = 90 minutes Max = 15 minutes

Data Quality

METHOD

- Focus on daily RINEX 2 & 3 data
- Daily: G-nut/Anubis*
 - Once with navigation messages
 - Rerun, when precise orbits become available
 - Dynamics plots → web site (1 year, full history can be viewed)
- Once a month: G-nut/Anubis* runs with higher verbosity
 - Monthly snapshots (skyplots)
- Store multiple key metrics in database

*Václavovic P, Dousa J (2016)

Satellite constellations

RESULTS

Satellite constellations vs. site log → Mails to station manager

From administrator tools:

Station Name	Station Log	RINEX 2 data file	RINEX 3 data file
ARGI00FRO	GPS+GLO	GPS+GLO+GAL (127/2017)	
BOGI00POL	GPS+GLO+GAL	GPS+GLO (127/2017)	
BRST00FRA	GPS+GLO+GAL+BDS+SBAS	GPS+GLO+GAL (128/2017)	GPS+GLO+GAL+BDS (128/2017)
DRAG00ISR	GPS+GLO+BDS	GPS+GLO (128/2017)	
HELG00DEU	GPS+GLO+GAL+SBAS	GPS+GLO+SBAS (128/2017)	GPS+GLO+GAL+BDS+SBAS (128/2017)
INVR00GBR	GPS+GLO	GPS (128/2017)	
MATG00ITA	GPS+GLO+GAL+BDS+SBAS	GPS (92/2017)	GPS+GLO+GAL+SBAS (92/2017)
NEWL00GBR	GPS+GLO+GAL	GPS+GLO (125/2017)	
SULP00UKR	GPS+GLO+SBAS	GPS+SBAS (126/2017)	

Status May 9, 2017

QZSS inconsistencies are neglected



ROYAL
OBSERVATORY
OF BELGIUM

Wroclaw, May 17-19, 2017

EUREF Symposium



Elevation cut off

RESULTS

Elevation cut off vs. site log \rightarrow Diff $> 3^\circ$ \rightarrow Mails to station managers

From administrator tools:

Obstruction/old:
includes older receivers with
8/10 channels
TRIMBLE 4000SSE/SSI

Status May 3, 2017

Station Name	Station Log	RINEX 2 data	RINEX 3 data
BOGI00POL	0	5 (2017-05-02)	
BOGO00POL	0	4 (2017-05-02)	
BRST00FRA	0	10 (2017-05-02)	4 (2017-05-02)
JOZE00POL	0	3 (2017-05-02)	
MOPI00SVK	0	3 (2017-05-02)	
MORP00GBR	0	3 (2017-05-02)	
ROVE00ITA	0	3 (2017-05-02)	
SASS00DEU	0	4 (2017-05-02)	
SULP00UKR	0	4 (2017-05-02)	
TRF200AUT	0	4 (2017-05-02)	
TUBI00TUR	0	6 (2017-05-02)	

inconsistency

inconsistency

inconsistency

obstruction/old

obstruction/old

obstruction

obstruction

inconsistency

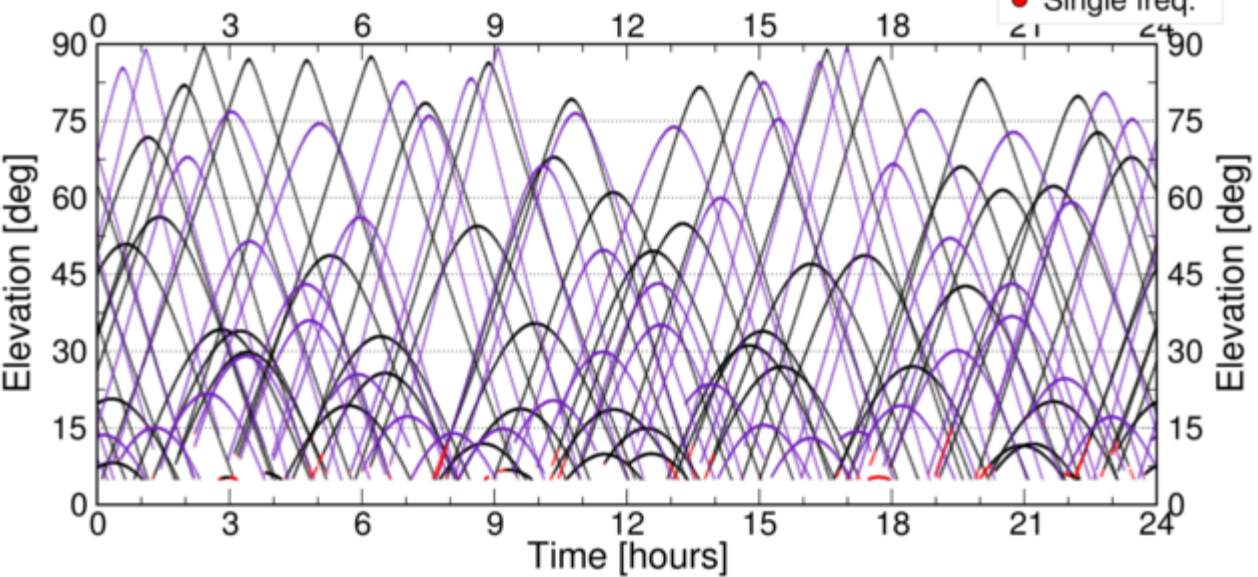
inconsistency

obstruction

obstruction

RESULTS

to station managers



Mon Apr 24 07:52:33 2017

EPN CB (www.epncb.eu)

	RINEX 2 data	RINEX 3 data
5 (2017-05-02)		
4 (2017-05-02)		
10 (2017-05-02)	4 (2017-05-02)	
3 (2017-05-02)		
3 (2017-05-02)		
3 (2017-05-02)		
3 (2017-05-02)		
4 (2017-05-02)		
4 (2017-05-02)		
4 (2017-05-02)		
6 (2017-05-02)		

inconsistency
inconsistency
inconsistency
obstruction/old
obstruction/old
obstruction
obstruction
inconsistency
inconsistency
obstruction
obstruction

Obstruction/old:
includes older receivers with
8/10 channels
TRIMBLE 4000SSE/SSI

Status May 3, 2017

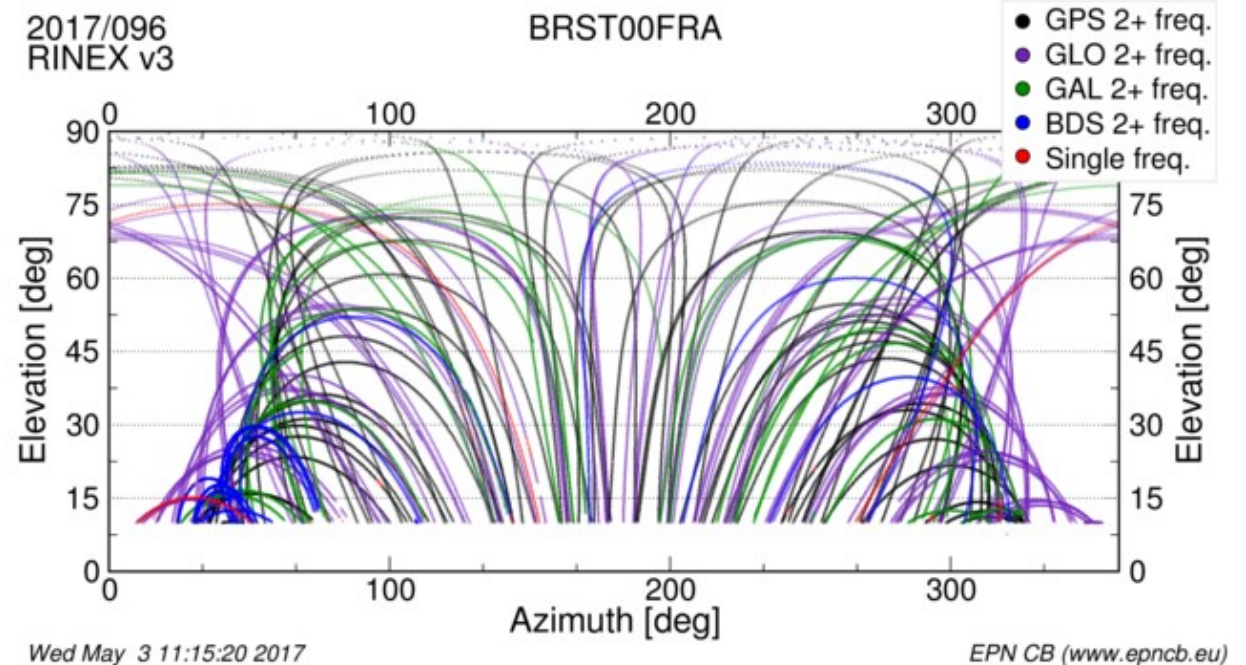
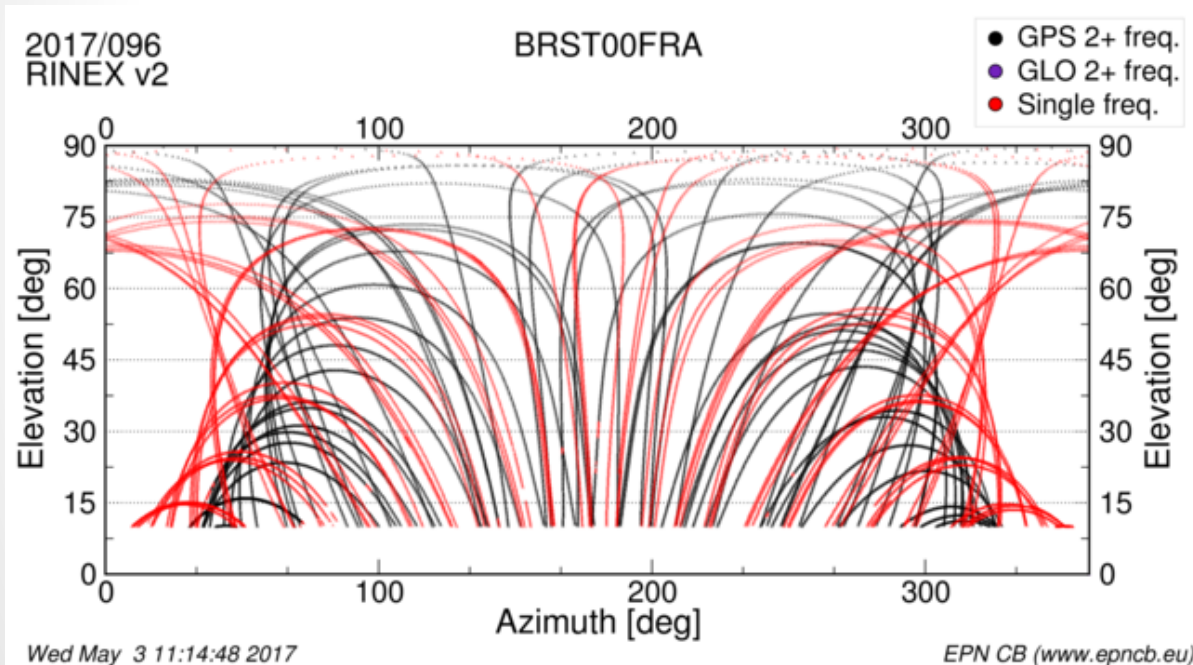
BRST00FRA	0
JOZE00POL	0
MOPI00SVK	0
MORP00GBR	0
ROVE00ITA	0
SASS00DEU	0
SULP00UKR	0
TRF200AUT	0
TUBI00TUR	0

Data Quality - Snapshots

RESULTS

http://www.epncb.eu/networkdata/data_quality/skylots/

Plots also available for all data in EPN historical data center at ROB



RINEX 2: GLONASS dual freq. tracking
RINEX 3: affected differently

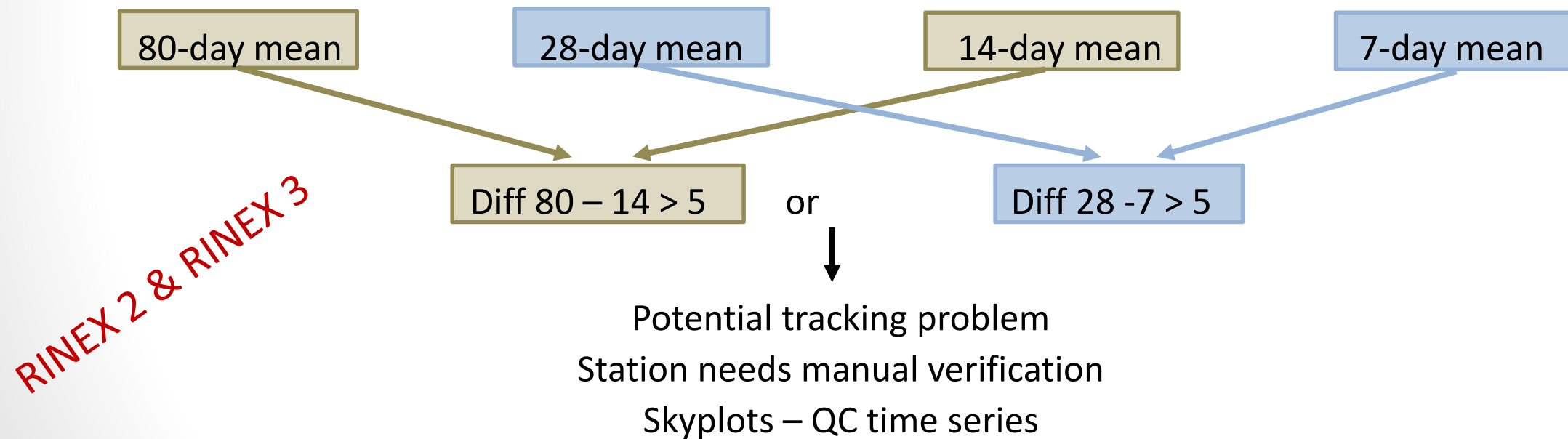
Data Quality

METHOD

To detect stations with RECENT tracking problems

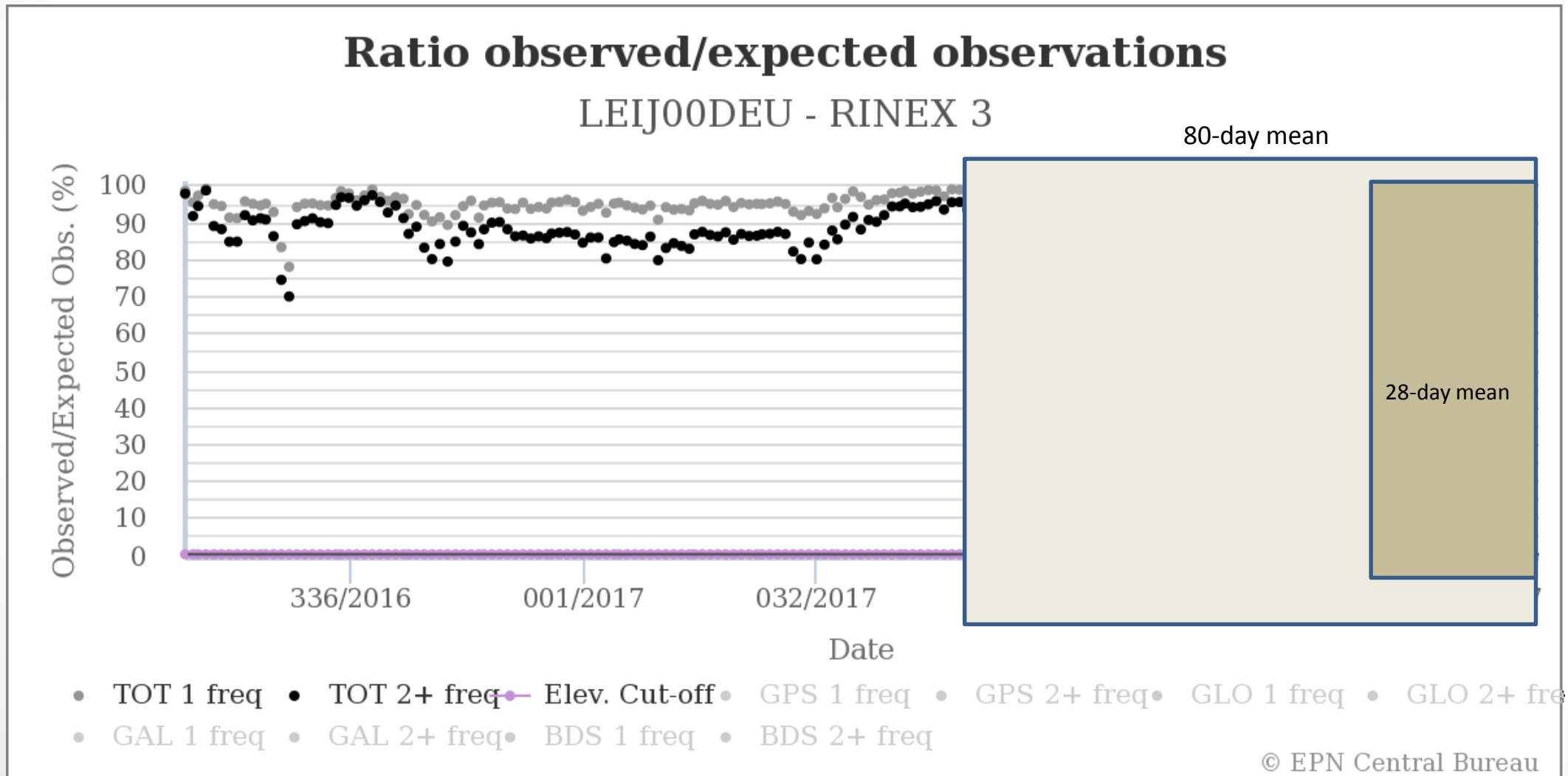
Administrator tools:

Evolution of daily computed % observed/expected **dual+ frequency** data (G-nut/Anubis)



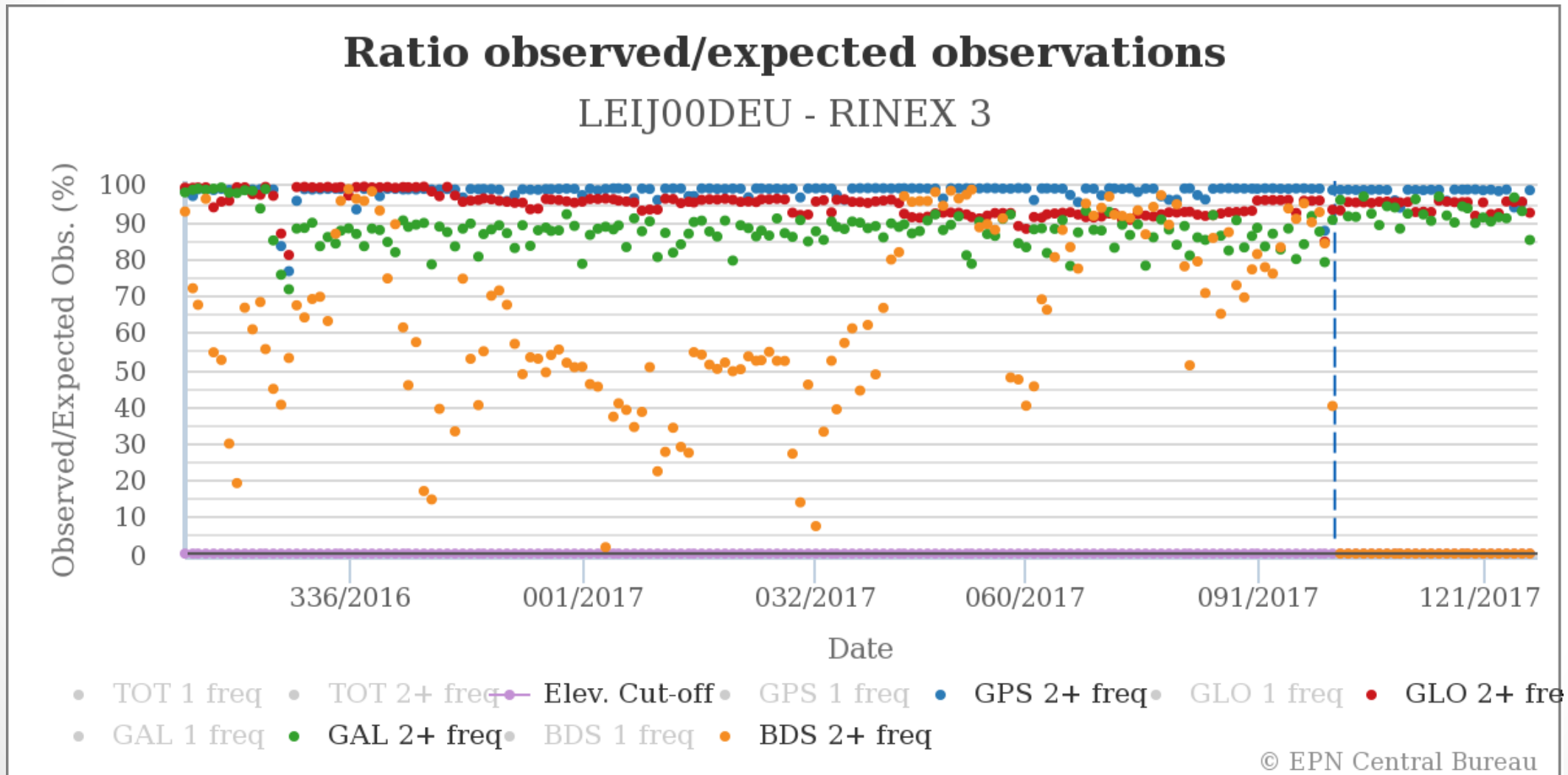
Data Quality – time series

RESULTS



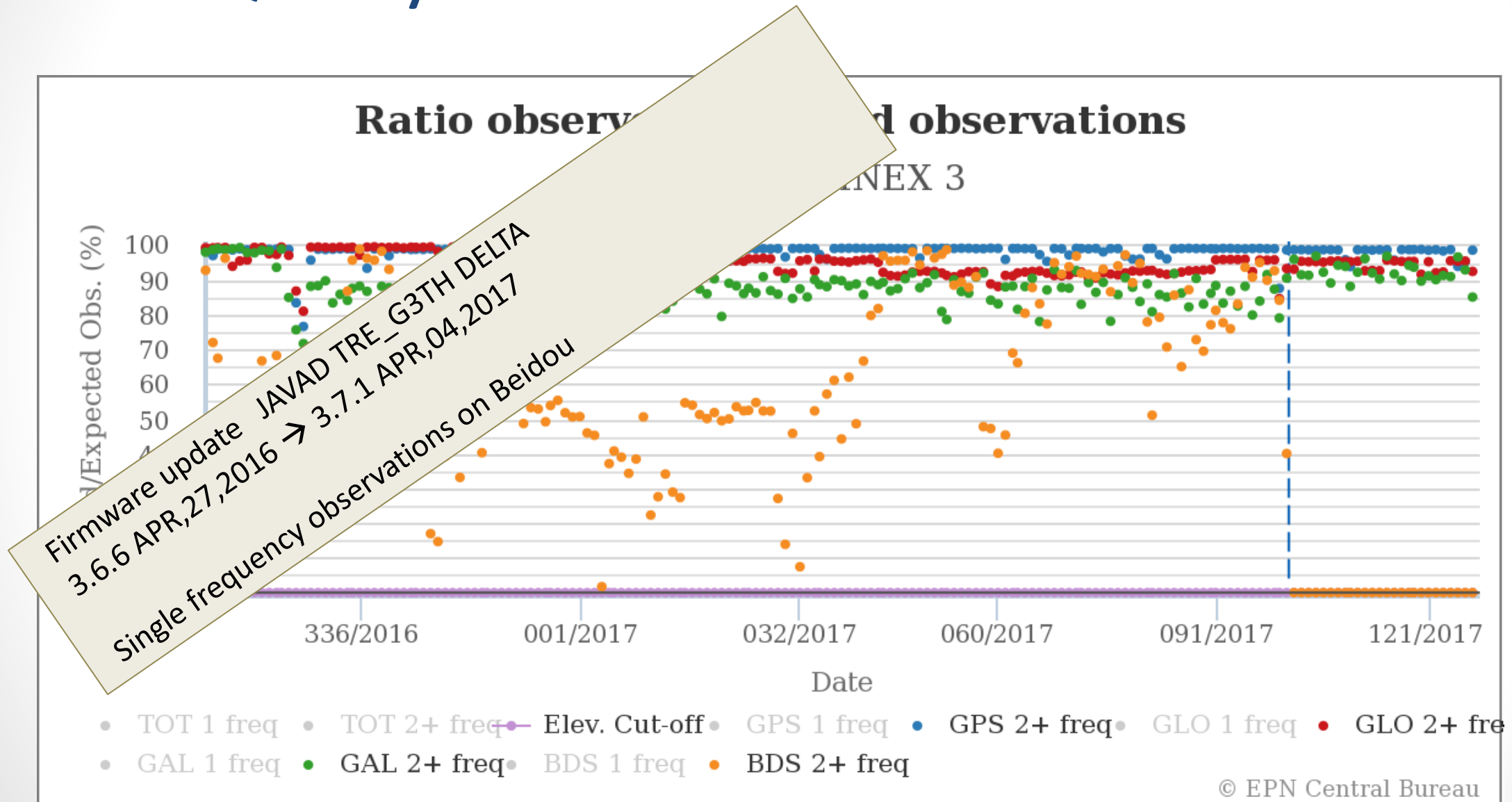
Data Quality – time series

RESULTS



Data Quality – time series

RESULTS





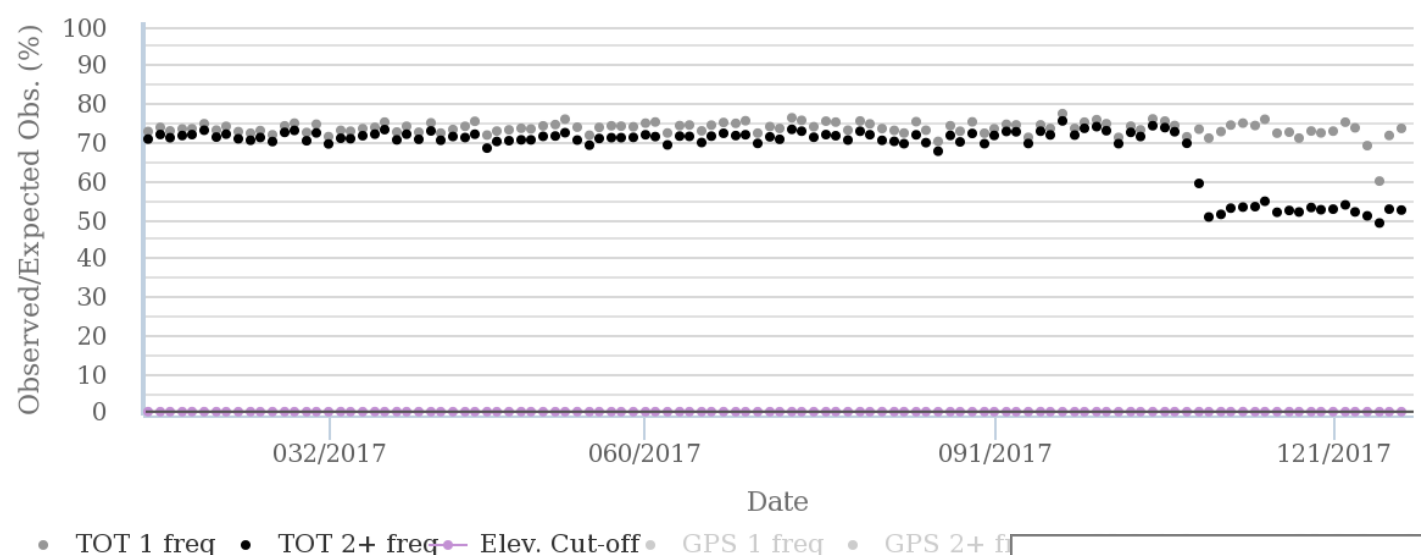
ROYAL
OBSERVATORY
OF BELGIUM

Proclaw, May 17-19, 2017

RESULTS

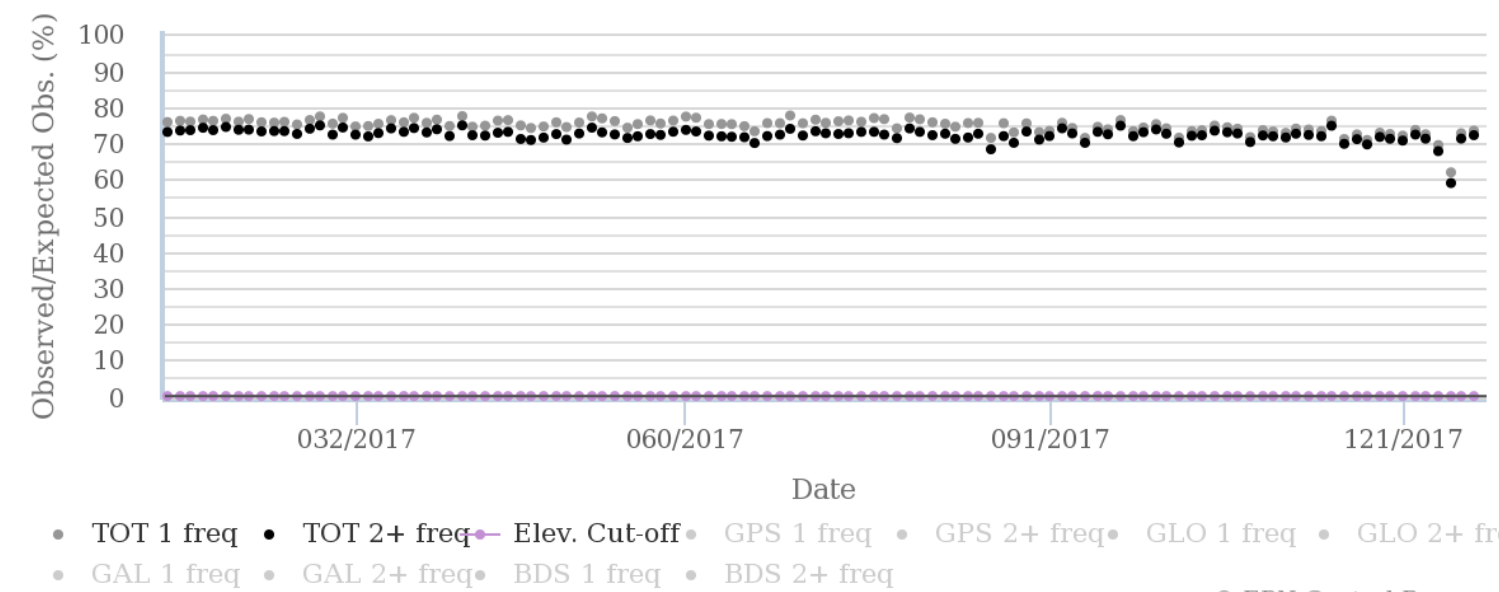
Ratio observed/expected observations

VIGO00ESP - RINEX 2



Ratio observed/expected observations

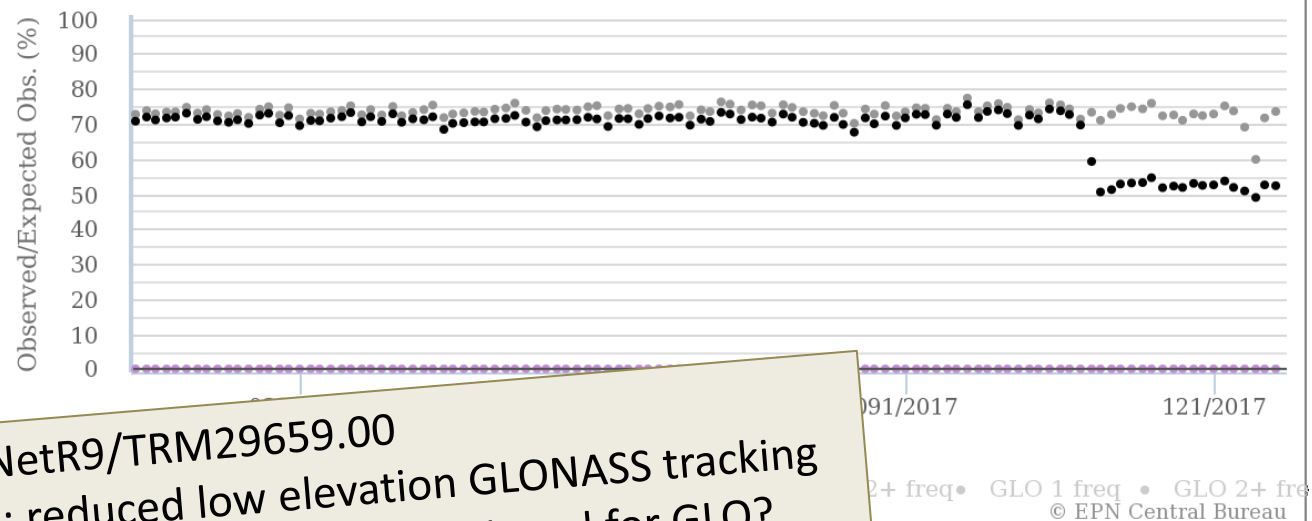
VIGO00ESP - RINEX 3



Da

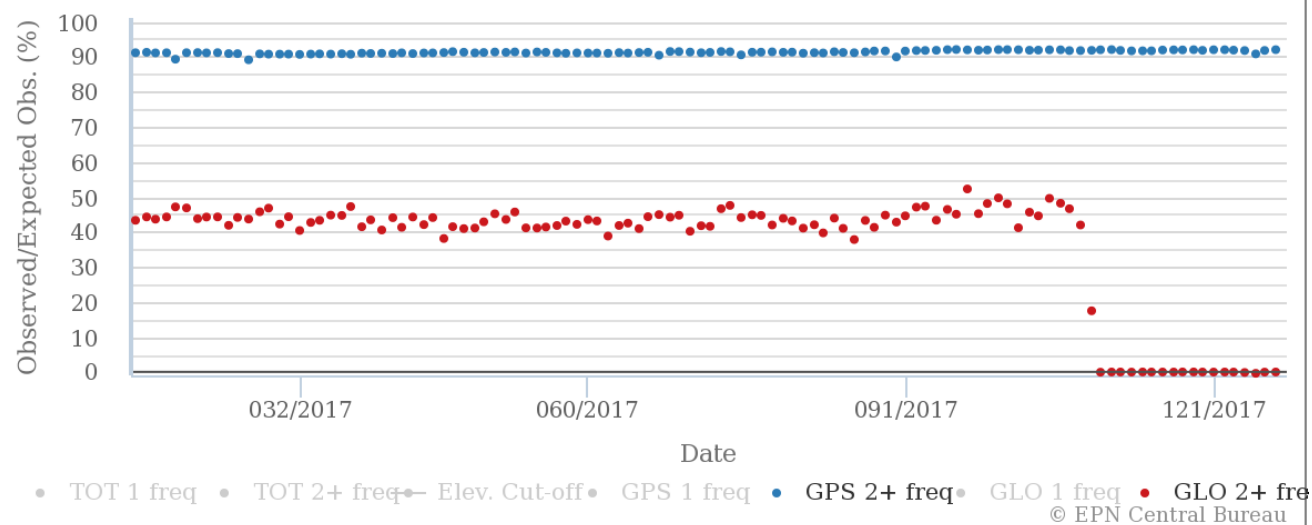
Ratio observed/expected observations

VIGO00ESP - RINEX 2



TRIMBLE NetR9/TRM29659.00
RINEX 2/3: reduced low elevation GLONASS tracking
Antenna pre-amplifier not designed for GLO?
But RINEX 3: not affected by last sudden jump

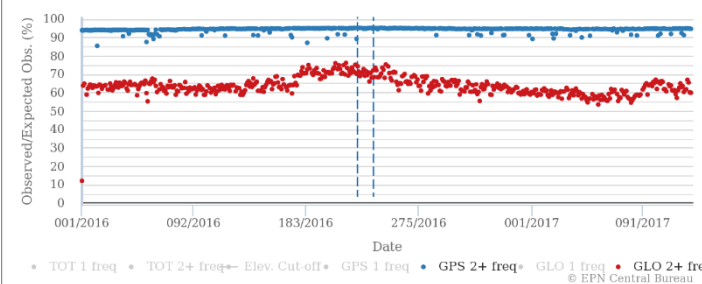
VIGO00ESP - RINEX 2



RESULTS

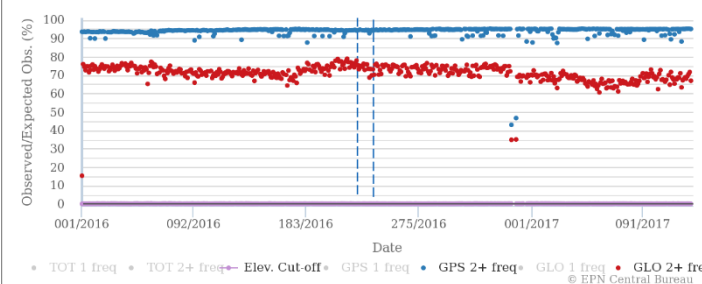
Ratio observed/expected observations

CACE00ESP - RINEX 2



Ratio observed/expected observations

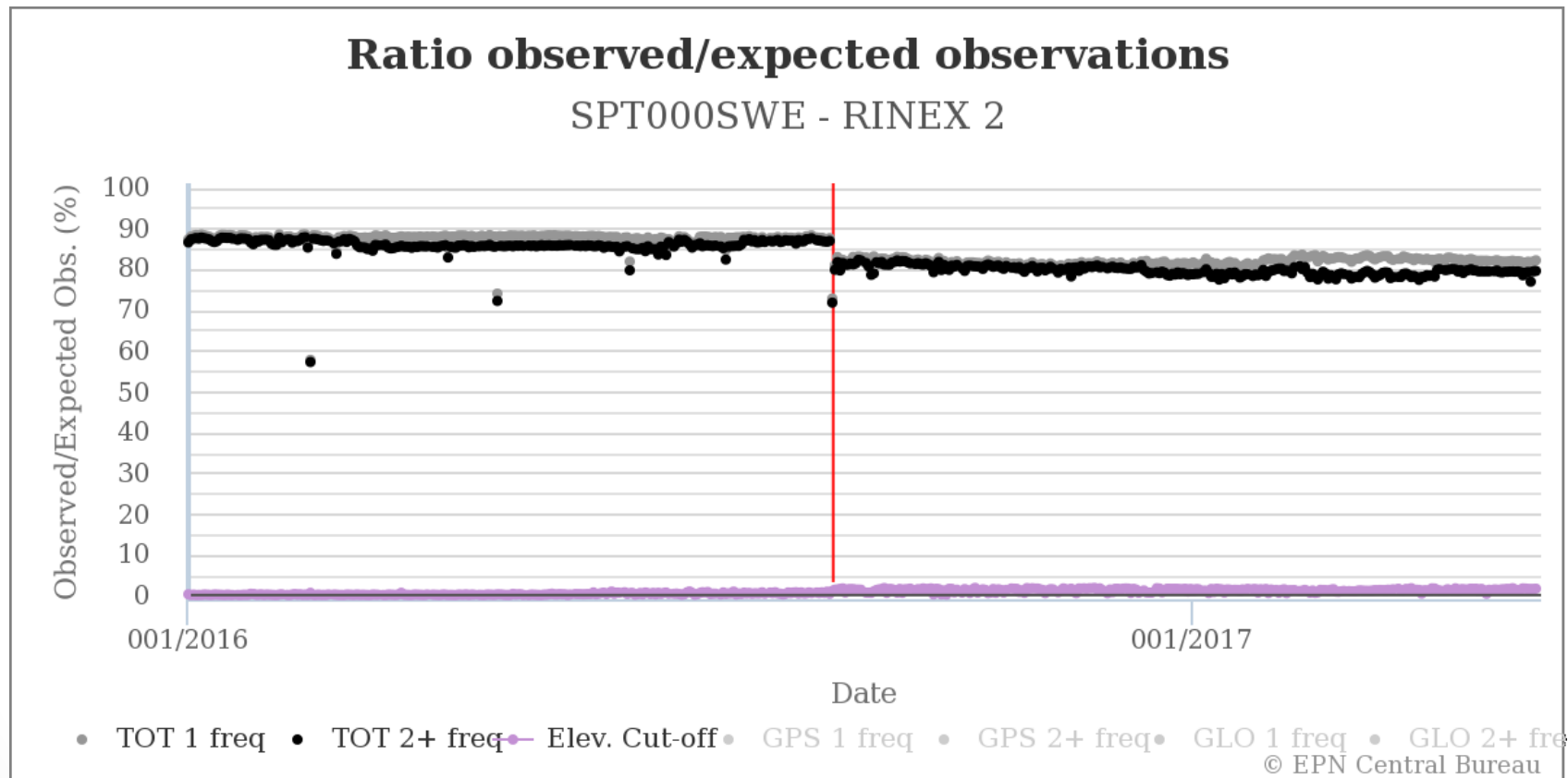
HUEL00ESP - RINEX 2



Data Quality

RESULTS

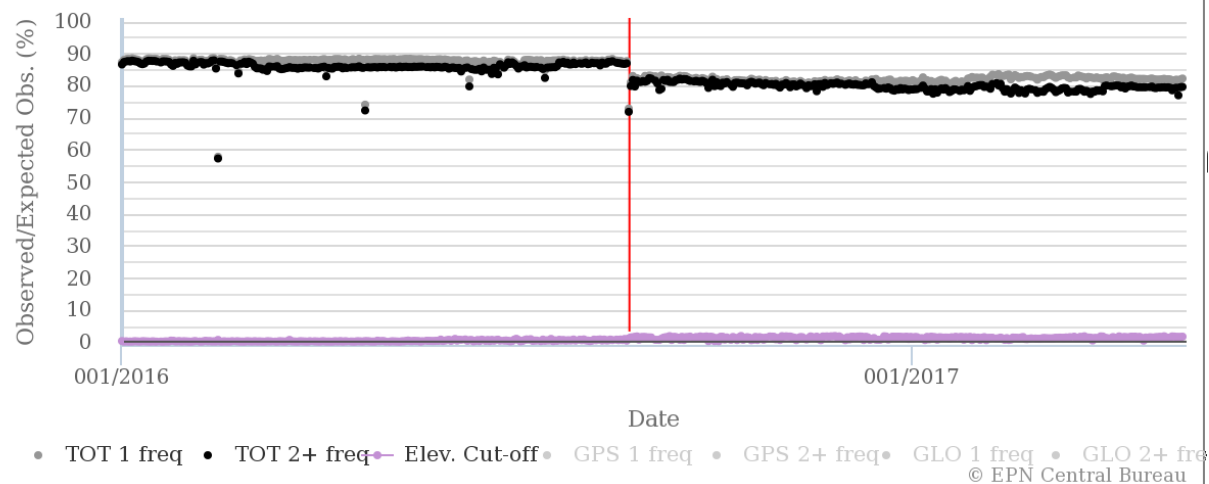
Too many interesting things to show. A last one....





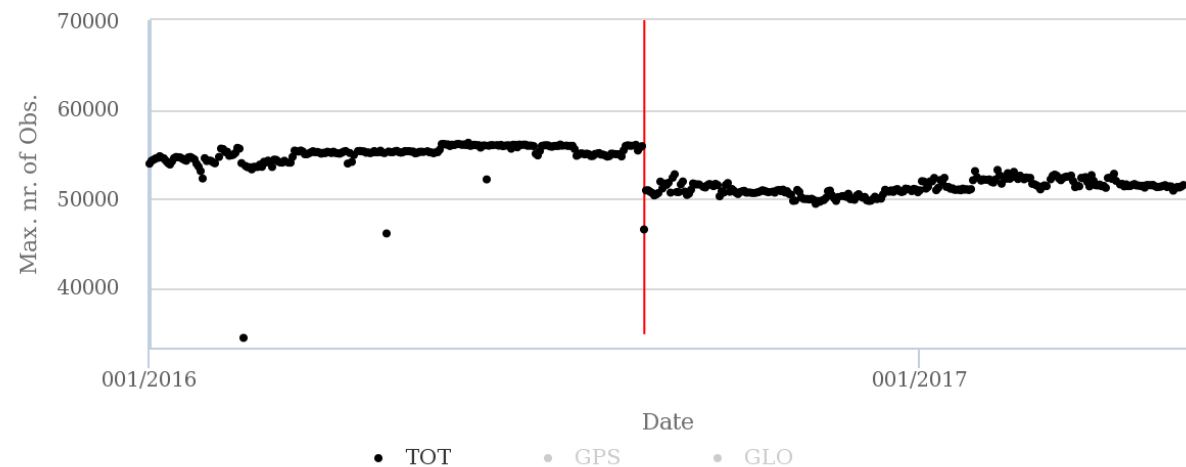
Ratio observed/expected observations

SPT000SWE - RINEX 2



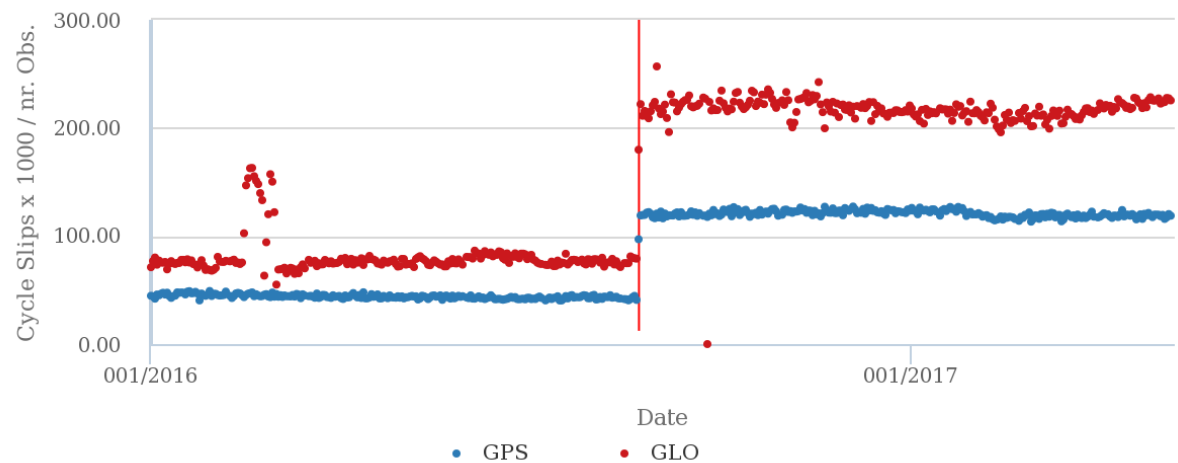
Maximum number of observations

SPT000SWE - RINEX 2



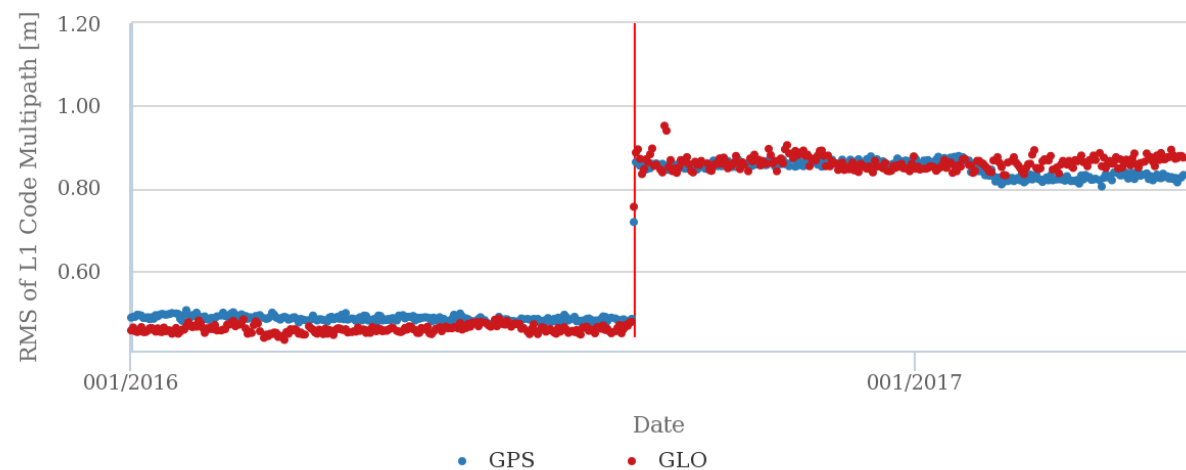
Number of cycle slips

SPT000SWE - RINEX 2



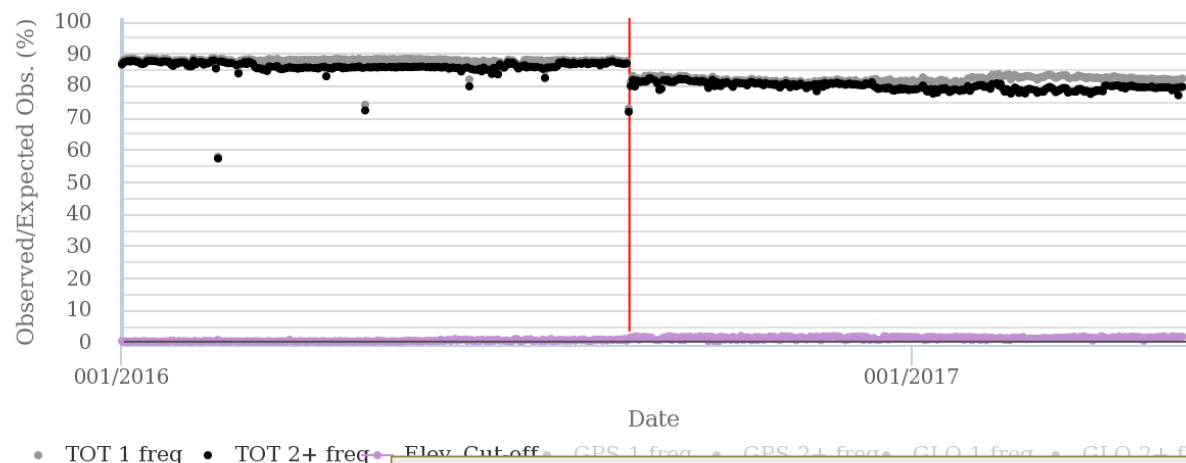
Daily RMS due to multipath on L1

SPT000SWE - RINEX 2



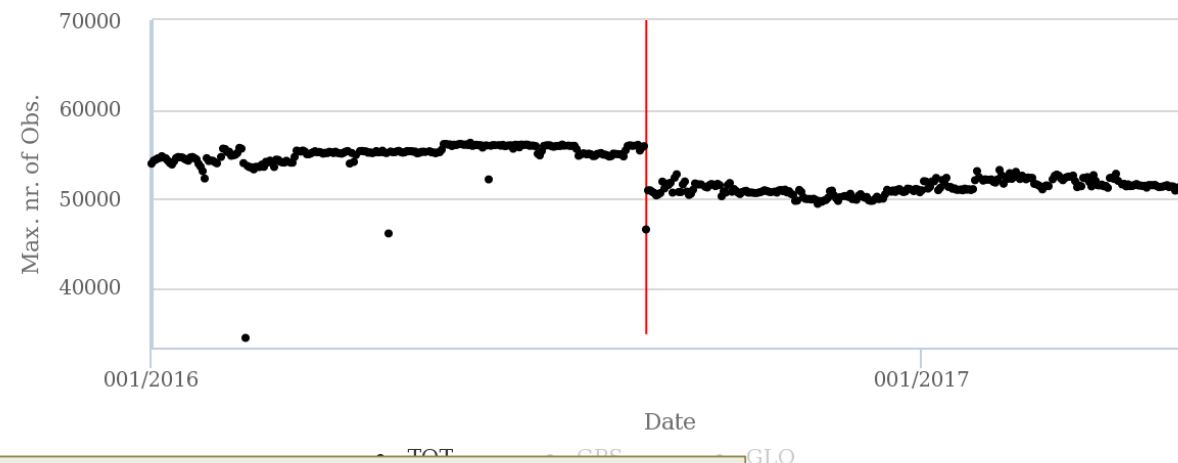
Ratio observed/expected observations

SPT000SWE - RINEX 2



Maximum number of observations

SPT000SWE - RINEX 2

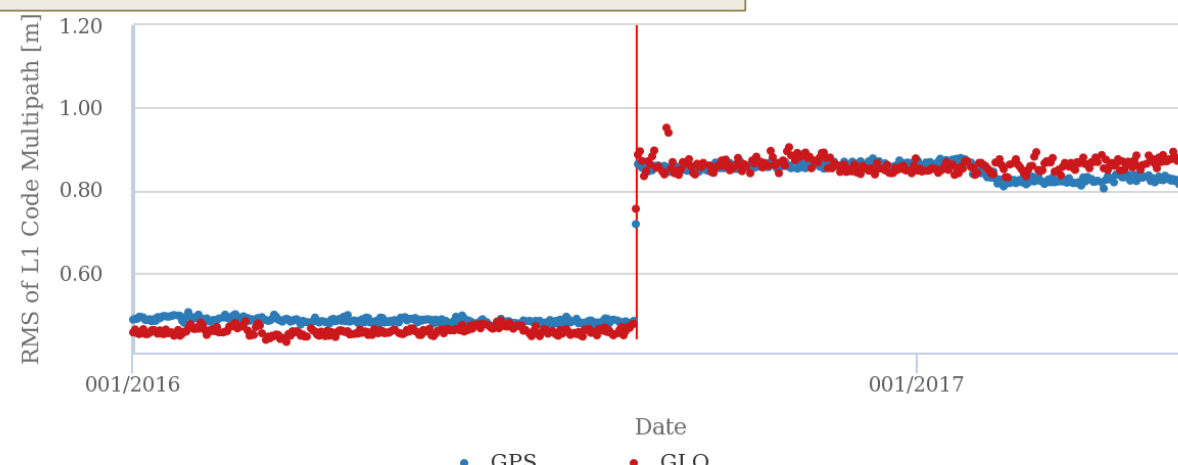
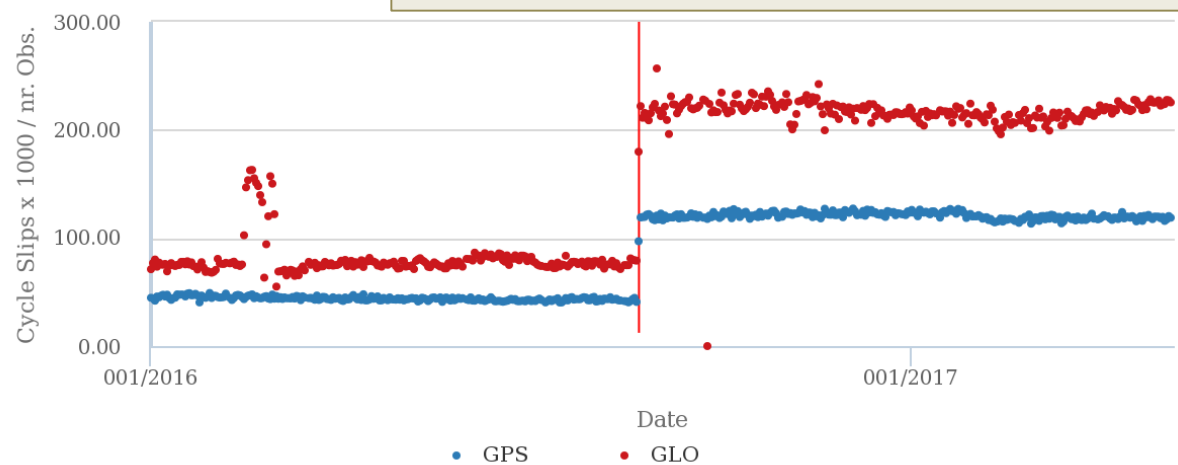


236/2016 (2016-08-23)

Antenna change

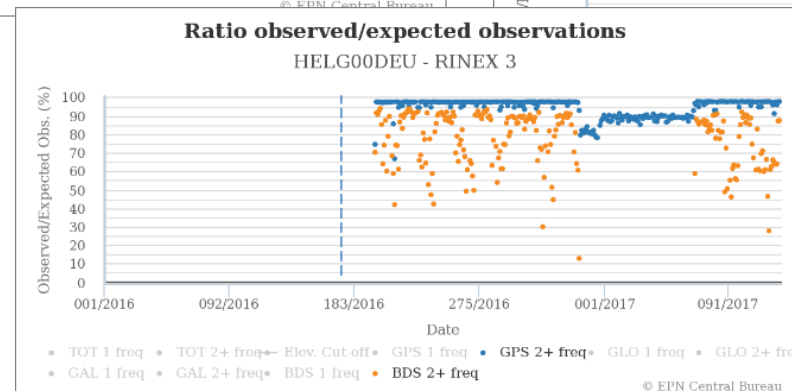
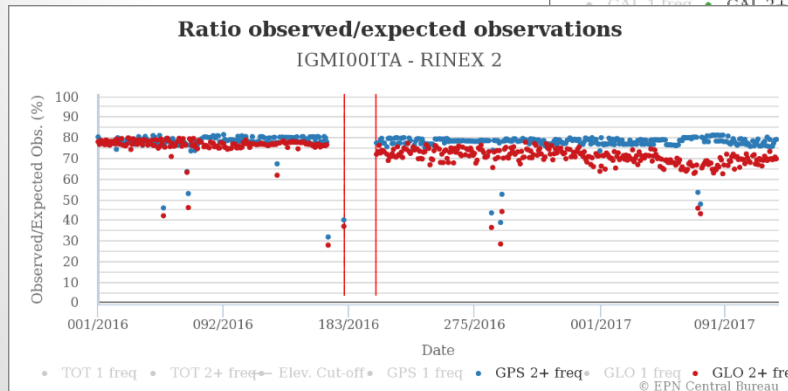
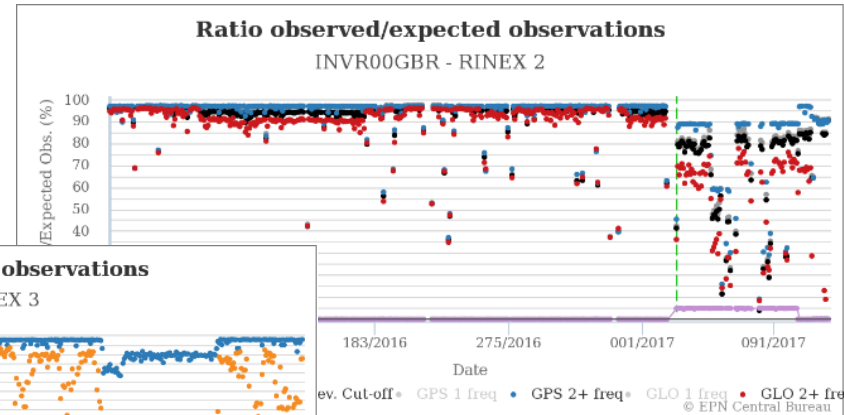
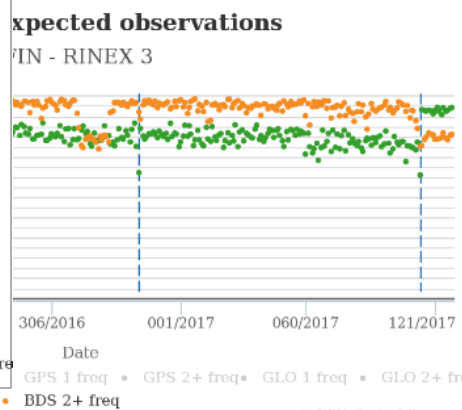
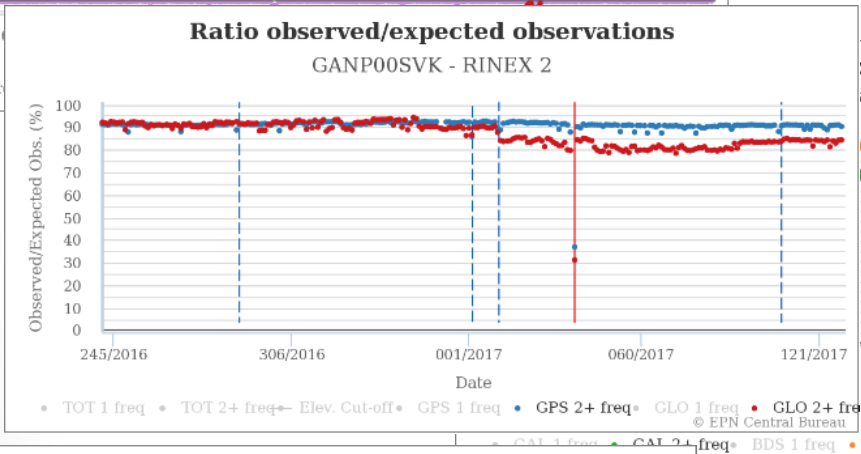
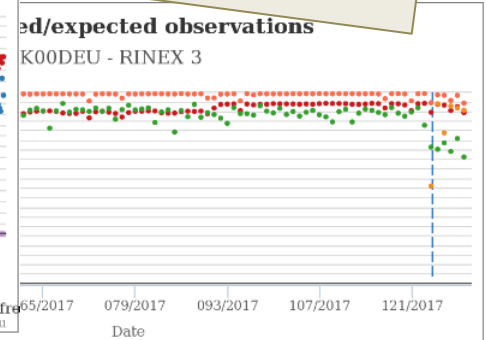
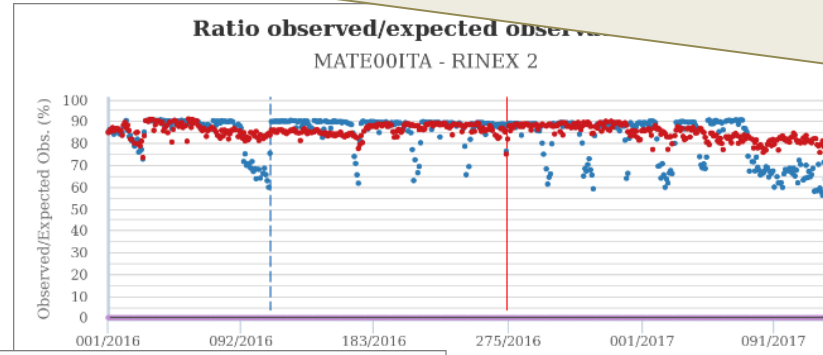
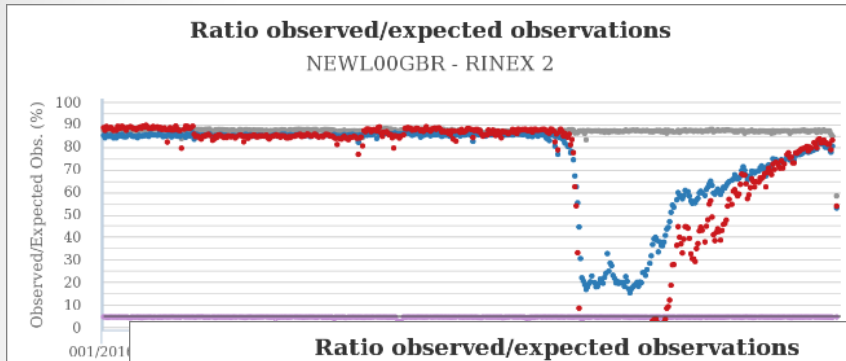
AOAD/M_T OSOD → JNSCR_C146-22-1 OSOD (Javad choking antenna)

No receiver change



Other Stations

http://www.epncb.eu/networkdata/data_quality/
Plots also available for all data in EPN historical data center at ROB



EPN Time Series

<http://www.epncb.eu/productsservices/timeseries/>

Input for the time series are

- Official cumulative EPN solution, released each 15 weeks by Reference Frame coordinator
- Extended cumulative solution= official cum. solution + more recent final and rapid combined EPN solutions
 - based on cumulative solution computed at EPN CB

For both solutions, time series with

- position residuals after estimation of position/velocity and introduction of discontinuities
- positions (ITRS, ETRS89)

EPN Time Series

RESULTS

MULTI-YEAR EPN SOLUTION

EPN station position time series:

WROC00POL (Wroclaw, Poland) [Class A]

Other residual position time series: [ITRF2014](#), [IGS](#), [Nevada Geodetic Laboratory](#)

OFFICIAL, SOLUTIONS INCLUDED UP TO 04-02-2017 (GPS WK 1934) ([READ MORE](#))



Official Time Series up to week 1934

Extended Time Series up to week 1947/1

Residual Position Time Series

Position Time Series in ITRS (IGb08)

Position Time Series in ETRS89 (ETRF2000)

Official Station Velocities published by EUREF:

Frame	V_{North} [mm/yr]	V_{East} [mm/yr]	V_{Up} [mm/yr]
IGb08	14.9 ± 0.03	20.2 ± 0.02	0.2 ± 0.08
ETRF2000	0.0 ± 0.03	-0.4 ± 0.02	-0.7 ± 0.08

[Download Residual Position Time Series data](#)

EPN Time Series

RESULTS

MULTI-YEAR EPN SOLUTION

EPN station position time series:

WROC00POL (Wroclaw, Poland) [Class A]

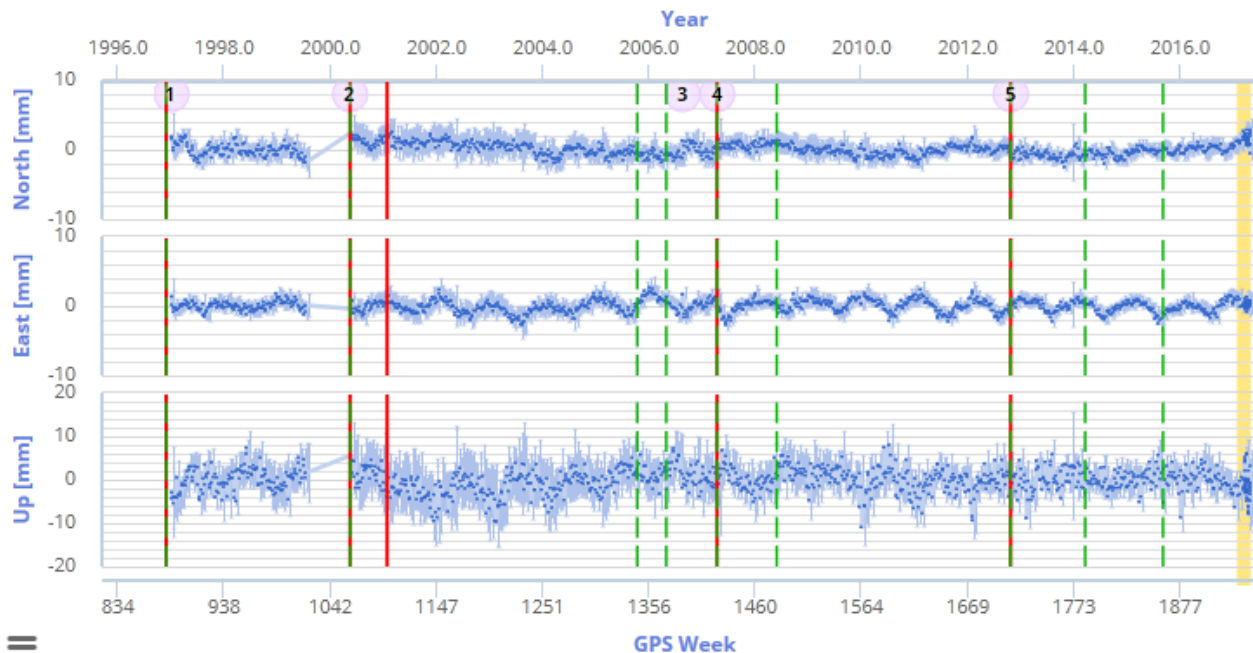
Other residual position time series: [ITRF2014](#), [IGS](#), [Nevada Geodetic Laboratory](#)

EXTENDED, SOLUTIONS INCLUDED UP TO 01-05-2017 (GPS WK 1947) ([READ MORE](#))

WROC00POL 12217M001

Residual Position Time Series
(Extended EPN Solution C1934U)

— Discontinuity ● Discontinuity
— Antenna Change — Receiver Change
— Firmware Change



© EPN Central Bureau

Official Time Series up to week 1934

Extended Time Series up to week 1947/1

Residual Position Time Series

Position Time Series in ITRS (IGb08)

Position Time Series in ETRS89 (ETRF2000)

Official Station Velocities published by EUREF:

Frame	V_{North} [mm/yr]	V_{East} [mm/yr]	V_{Up} [mm/yr]
IGb08	14.9 ± 0.03	20.2 ± 0.02	0.2 ± 0.08
ETRF2000	0.0 ± 0.03	-0.4 ± 0.02	-0.7 ± 0.08

Dynamic plots

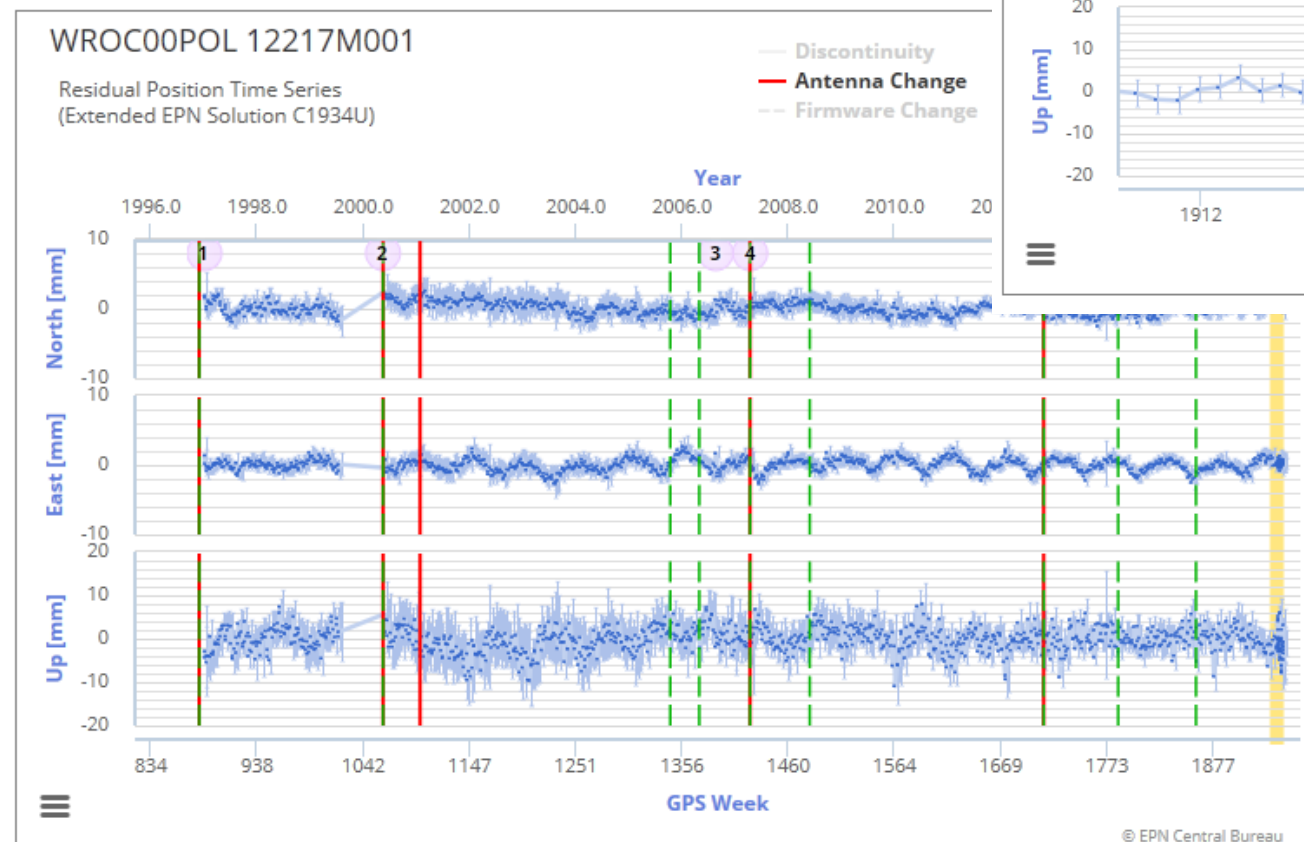
EPN Time Series

MULTI-YEAR EPN SOLUTION

EPN station position time series:

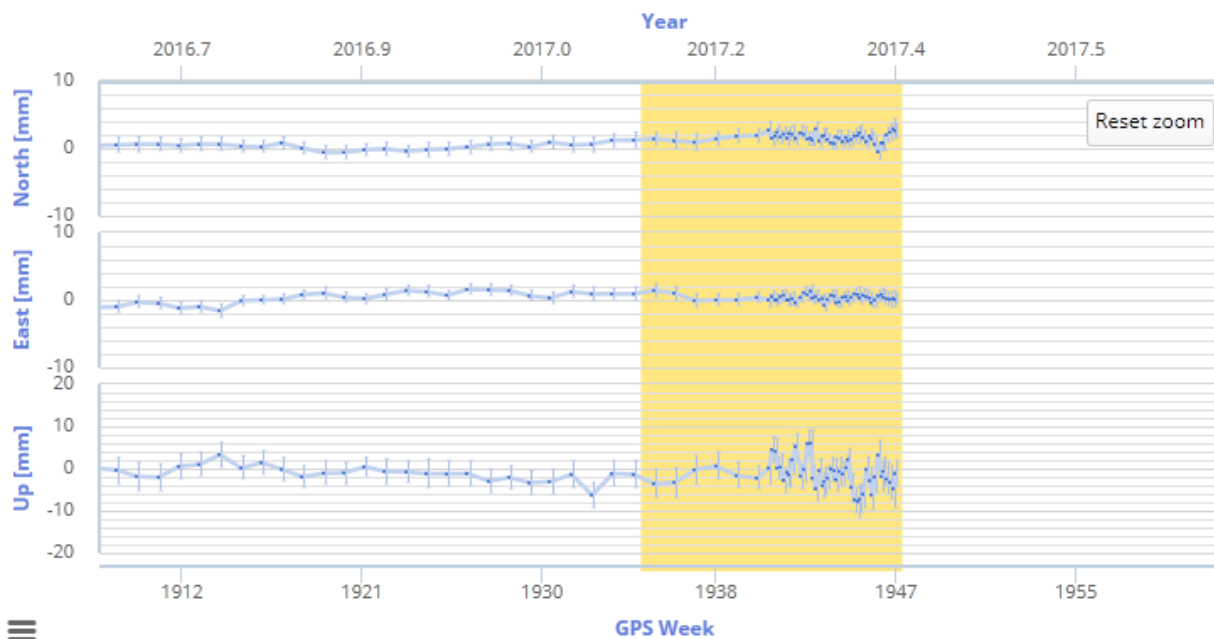
WROC00POL (Wroclaw, Poland) [Class A]

EXTENDED, SOLUTIONS INCLUDED UP TO 01-05-2017 (GPS WK 1947) ([READ MORE](#))



WROC00POL 12217M001

Residual Position Time Series
(Extended EPN Solution C1934U)



Official Station Velocities published by EUREF:

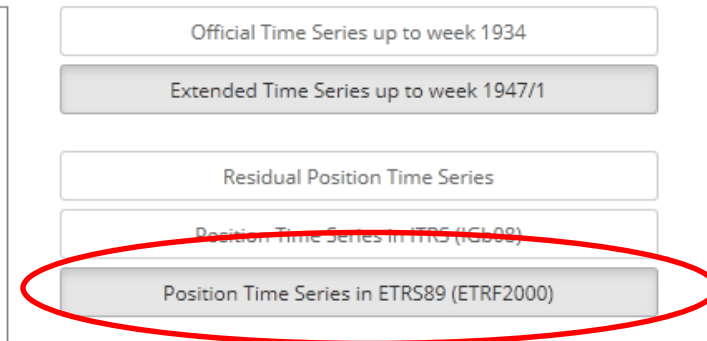
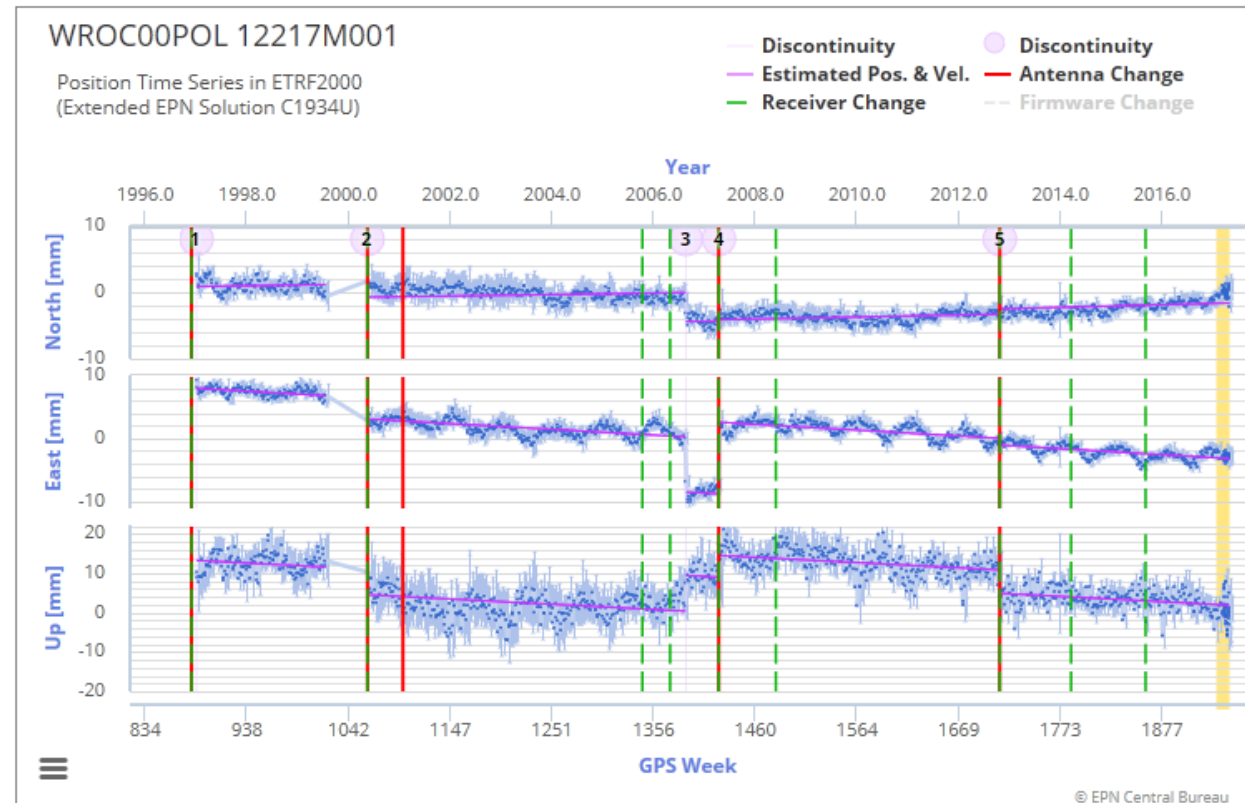
Frame	V_{North} [mm/yr]	V_{East} [mm/yr]	V_{Up} [mm/yr]
IGb08	14.9 ± 0.03	20.2 ± 0.02	0.2 ± 0.08
ETRF2000	0.0 ± 0.03	-0.4 ± 0.02	-0.7 ± 0.08

Dynamic plots

EPN Time Series

RESULTS

EXTENDED, SOLUTIONS INCLUDED UP TO 01-05-2017 (GPS WK 1947) ([READ MORE](#))



Official Station Velocities published by EUREF:

Frame	V_{North} [mm/yr]	V_{East} [mm/yr]	V_{Up} [mm/yr]
ETRF2000	0.0 ± 0.03	-0.4 ± 0.02	-0.7 ± 0.08

1. POSITIONS/VELOCITIES PUBLISHED BY EUREF

EUREF has classified WROC00POL (Wroclaw, Poland) as a **class A station** which means that it can be used as fiducial station for EUREF densifications.

LATEST RELEASE

EPN_A_ETRF2000_C1934.SSC - EPN_A_IGb08_C1934.SSC (March 25, 2017)

ETRF2000	epoch t_0	Position (m)			Velocity (m/y)		
		X	Y	Z	V_X	V_Y	V_Z
302/2012 - 035/2017	001/2005	3835751.622 ± 0.000	1177249.745 ± 0.000	4941605.050 ± 0.001	-0.0003 ± 0.0000	-0.0006 ± 0.0000	-0.0005 ± 0.0001
111/2007 - 301/2012	001/2005	3835751.626 ± 0.000	1177249.747 ± 0.000	4941605.054 ± 0.000	-0.0003 ± 0.0000	-0.0006 ± 0.0000	-0.0005 ± 0.0001
232/2006 - 103/2007	001/2005	3835751.627 ± 0.000	1177249.736 ± 0.000	4941605.050 ± 0.001	-0.0003 ± 0.0000	-0.0005 ± 0.0000	-0.0005 ± 0.0001
146/2000 - 232/2006	001/2005	3835751.616 ± 0.000	1177249.742 ± 0.000	4941605.045 ± 0.000	-0.0003 ± 0.0001	-0.0005 ± 0.0000	-0.0005 ± 0.0001
002/1997 - 200/1999	001/2005	3835751.618 ± 0.000	1177249.746 ± 0.000	4941605.052 ± 0.000	-0.0003 ± 0.0001	-0.0005 ± 0.0000	-0.0005 ± 0.0001



Position Time Series in ETRF2000

Official Station Velocities published by EUREF:

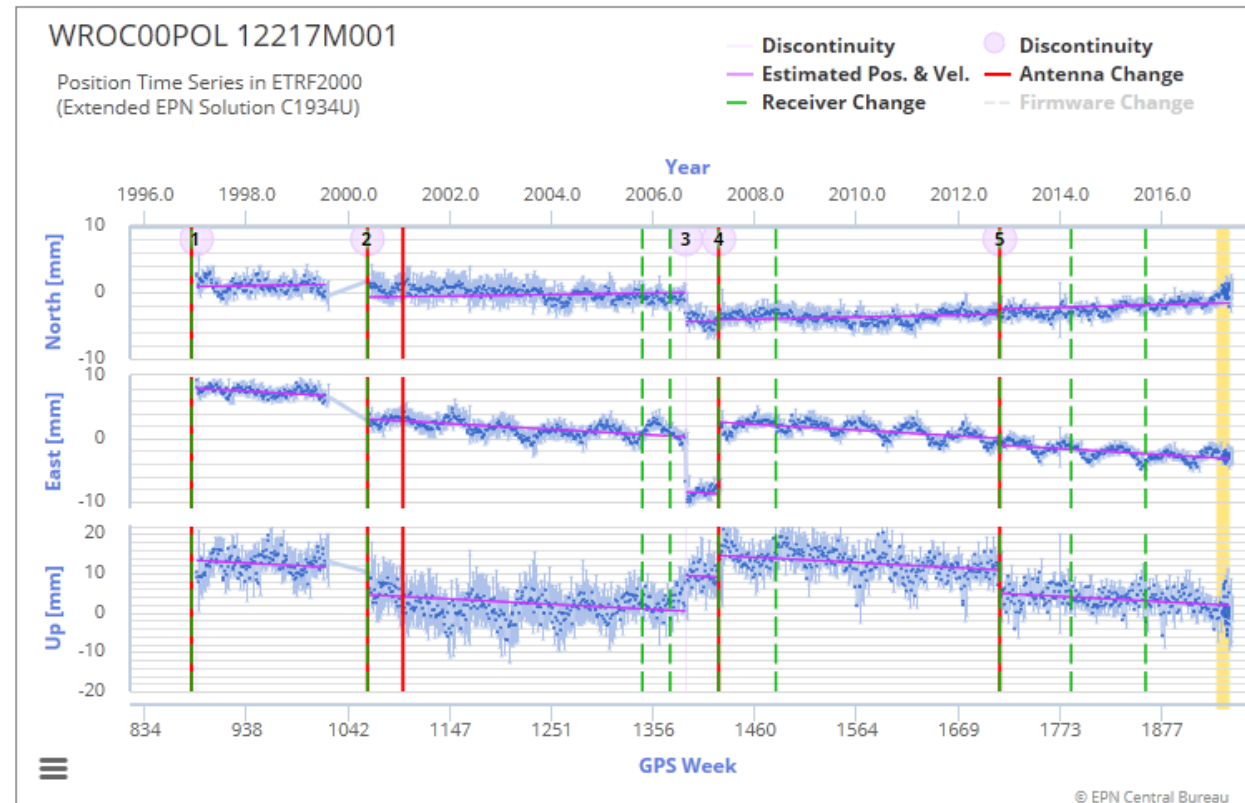
Frame	V_{North} [mm/yr]	V_{East} [mm/yr]	V_{Up} [mm/yr]
ETRF2000	0.0 ± 0.03	-0.4 ± 0.02	-0.7 ± 0.08

Estimated ETRF2000 pos/vel
(taking validity epochs into account)
+ Residual position time series
⇒ Variation of the position of the station
in ETRF2000

EPN Time Series

RESULTS

EXTENDED, SOLUTIONS INCLUDED UP TO 01-05-2017 (GPS WK 1947) ([READ MORE](#))



Official Time Series up to week 1934

Extended Time Series up to week 1947/1

Residual Position Time Series

Position Time Series in ITRF (ICL00)

Position Time Series in ETRF2000


Official Station Velocities published by EUREF:

Frame	V_{North} [mm/yr]	V_{East} [mm/yr]	V_{Up} [mm/yr]
ETRF2000	0.0 ± 0.03	-0.4 ± 0.02	-0.7 ± 0.08

Estimated ETRF2000 pos/vel
(taking validity epochs into account)
+ Residual position time series
⇒ Variation of the position of the station
in ETRF2000


Where to find all this info on EPN CB?

EPN Data Quality



ROYAL OBSERVATORY
OF BELGIUM

EUREF Permanent GNSS Network



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Network Status

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Maps **UPDATED**

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FUTURE

Proposed Stations **UPDATED**

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EPN Data Availability & Latency



EUREF Permanent GNSS Network



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Data Latency **NEW**

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Contributing Agencies

NEW

POST-PROCESSED PRODUCTS

Daily/Weekly Combined EPN Positions ▶

Tropospheric Delays **REPRO2**

EPN-repro1

EPN-repro2 **NEW**

MULTI-YEAR PRODUCTS

Positions & Velocities

Position Time Series **UPDATED**

EPN Densification

REAL-TIME PRODUCTS

Satellite Orbit & Clock

Correction Streams

SERVICES

ETRF/ITRF Coordinate

Transformation



Summary

- Upgraded tools to monitor EPN station performance → data bases
 - Availability, latency
 - Data quality
 - Integration of RINEX 3
- Full exploitation of the data bases is ongoing
 - Correlations of all types of time series
 - Additional administrator tools are under development
- More results next year!



Other ideas/requests?

epncb@oma.be

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