Galileo-capability of the EUREF Permanent Network

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http://www.epncb.eu/

Special thanks to D. Mesmaker

ROYAL OBSERVATORY OF BELGIUM

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Tracking Network

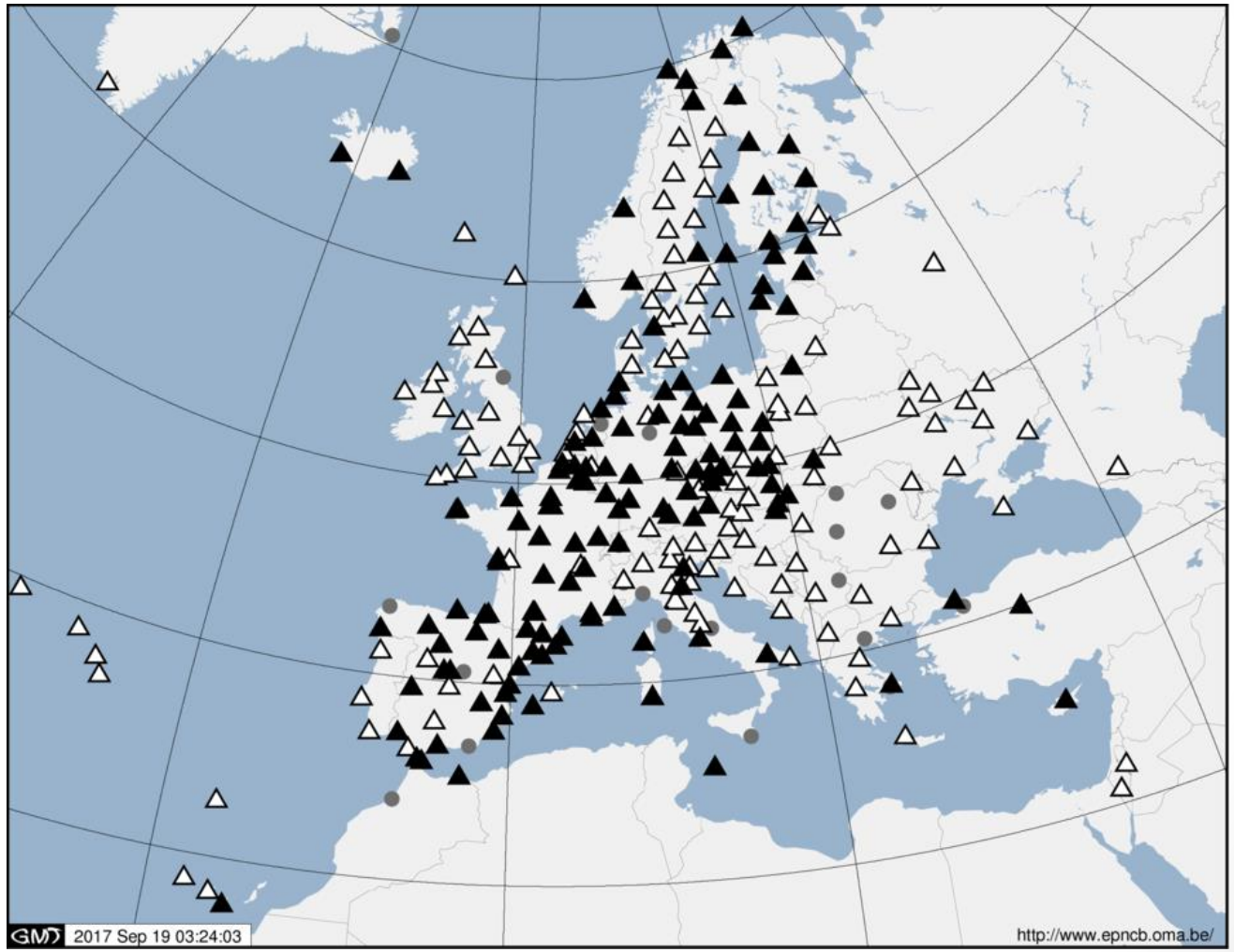
321 stations in the EPN

GPS-only : gray circles --> 32 stations (10%)

GPS+GLO: white and black triangles --> 290 stations (90%)

GPS+GLO+GAL (RNX3): black triangles --> 145 stations (45%)

Exceptionally well ?
In IGS, 43% of the stations indicate GAL tracking in site log



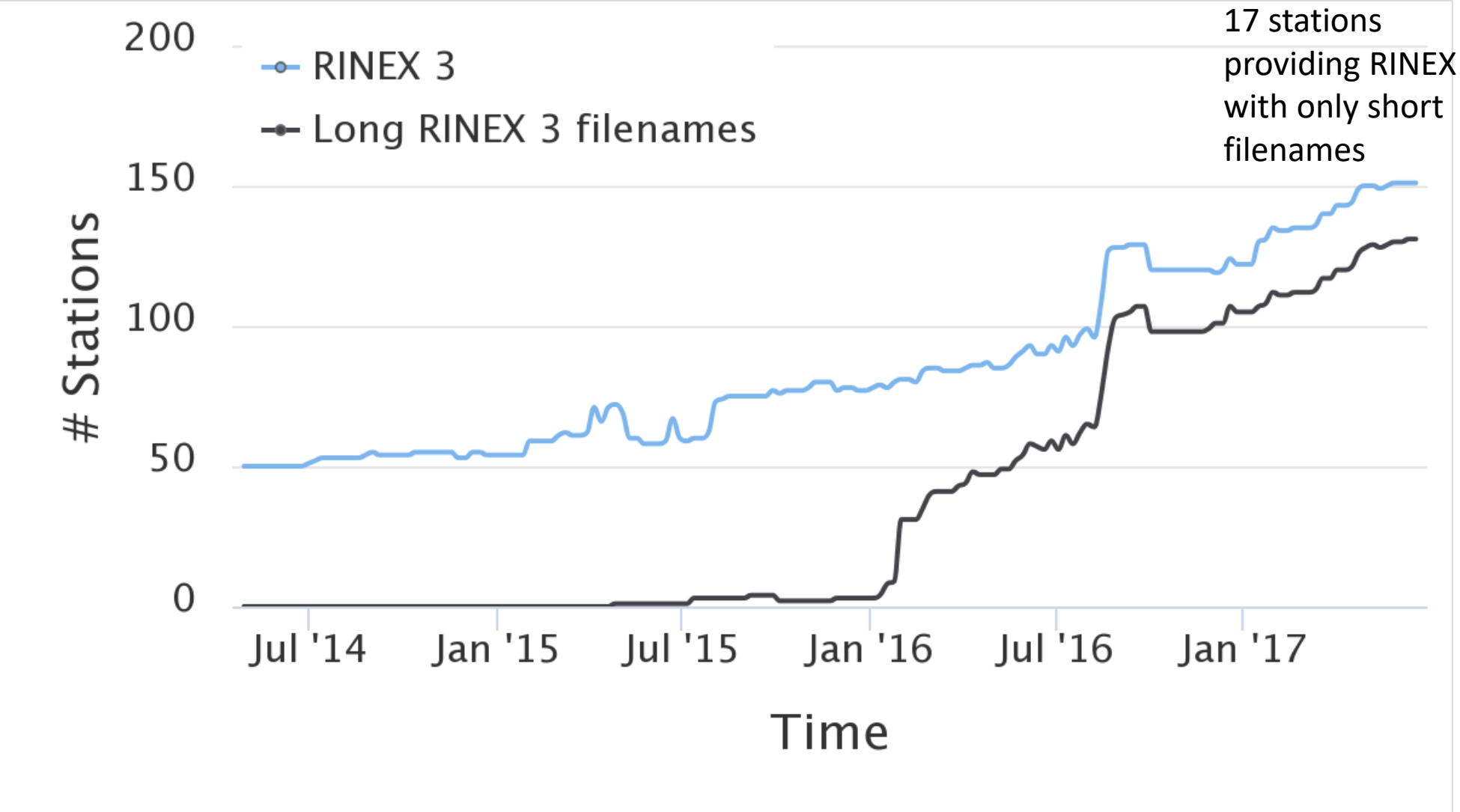
Galileo observables extracted from RINEX 3

RECEIVER TYPE	CARRIER PHASE SIGNALS				
	E1	E5a	E6	E5b	E5a+b
TPS NET-G5	L1B	L5I	L6B	L7I	L8Q
JAVAD TRE_3 DELTA	L1X	L5X		L7X	L8X
JAVAD TRE_G3TH DELTA	L1X	L5X			
LEICA GR10	L1C	L5Q		L7Q	L8Q
LEICA GR25	L1C	L5Q		L7Q	L8Q
LEICA GR25	L1C	L5Q		L7Q	
LEICA GR25 (KURE, TOR2)	L1C				L8Q
LEICA GR30	L1C	L5Q		L7Q	L8Q
LEICA GR50	L1C	L5Q		L7Q	L8Q
LEICA GRX1200+GNSS	L1X	L5X	L6A	L7X	L8Q
LEICA GRX1200+GNSS	L1C	L5Q		L7Q	L8Q
LEICA GRX1200+GNSS	L1X	L5X		L7X	L8Q
SEPT POLARX4	L1C	L5Q		L7Q	L8Q
SEPT POLARX4TR	L1C	L5Q		L7Q	L8Q
TRIMBLE NETR9	L1X	L5X		L7X	L8X
TRIMBLE SPS855	L1X	L5X		L7X	L8X

Signal complexity is not reflected by RINEX 2 format

12 EPN stations provide Galileo obs. only in RINEX 2

Usage of RINEX 3 long filenames



17 stations providing RINEX 3 with only short filenames

[IGSSTATION-6938] RINEX 3.03 usage in the IGS network

Feb 2, 2017

We recommend that all files be submitted using the latest RINEX 3 format (3.03) and from experience it is possible that a simple receiver firmware or a vendor RINEX translation tool update will generate the RINEX 3.03 , in particular if you operate NETR9 receivers or POLARX4 please investigate to keep your receiver and data files up to date.

TODAY in EPN:

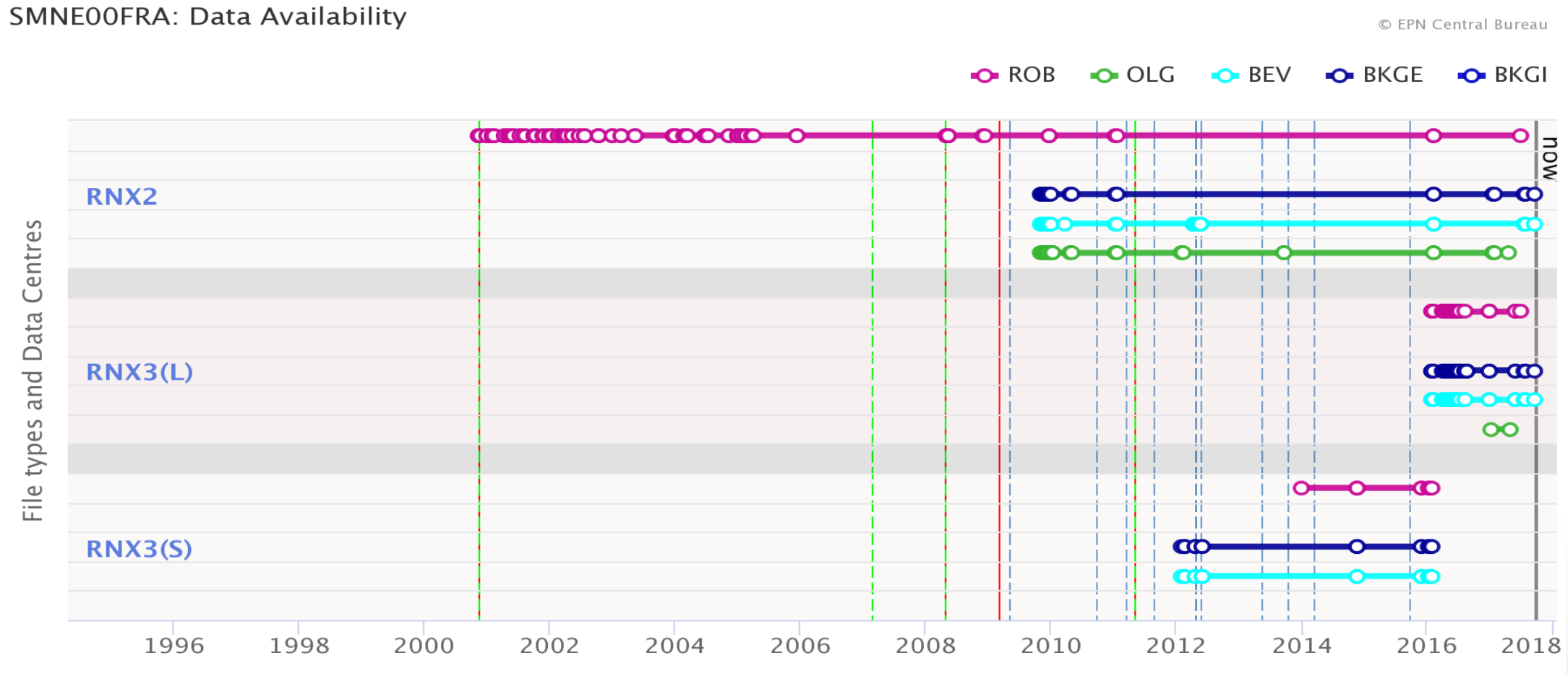
- 56% stations providing RINEX 3.02
- 44% stations providing RINEX 3.03

Lessons learned from Data Format

→ Work to be done at station manager level

Availability of RINEX 3 files

Browse data directories at 2 regional data centers (BKG, BEV) and historical data center (ROB)



Reliability RINEX 3 data flow

Missing epochs (file completeness) in daily files

- 94% of RINEX 2 and RINEX 3 have same number of epochs
- 4% of RINEX 2 files have more epochs than RINEX 3
- 2% of RINEX 3 files have more epochs than RINEX 2

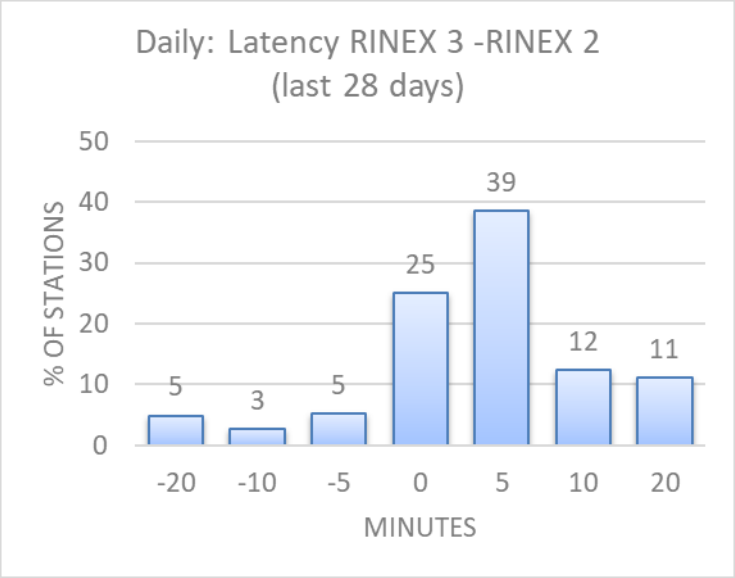
Data availability

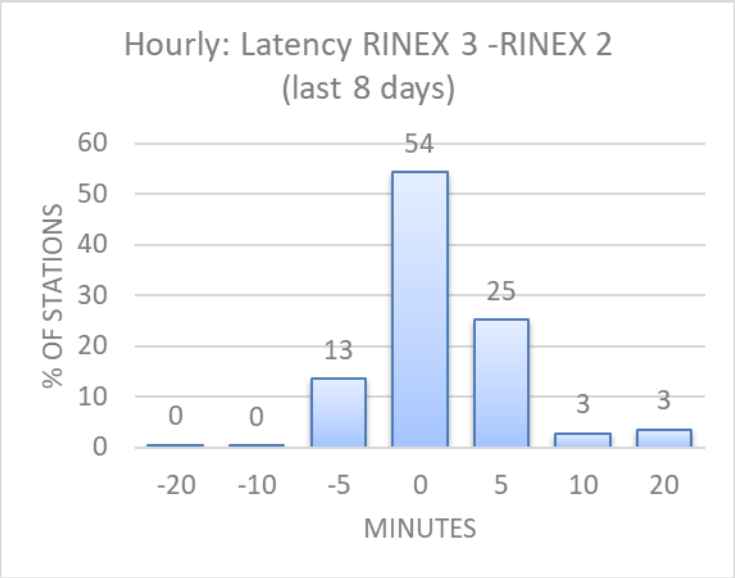
- Daily RINEX 2 : 1.7% missing files
- Daily RINEX 3 : 1.9% missing files
- Hourly RINEX 2: 1.7% missing files
- Hourly RINEX 3: 14.9% missing files

Data latency

- 62% of daily RINEX 3 files arrive later than RINEX 2
- 31% of hourly RINEX 3 files arrive later than RINEX 2

→ **Hourly RINEX 3 data flow less reliable than RINEX 2**





Data Quality Monitoring - Design

GPS + GLO + GAL + …(on RINEX 2 ONLY GPS/GLO)

- 2016: Daily quality checks for recent data – historical data running in background - G-nut/Anubis*
- 2017: Skyplots - G-nut/Anubis higher verbosity

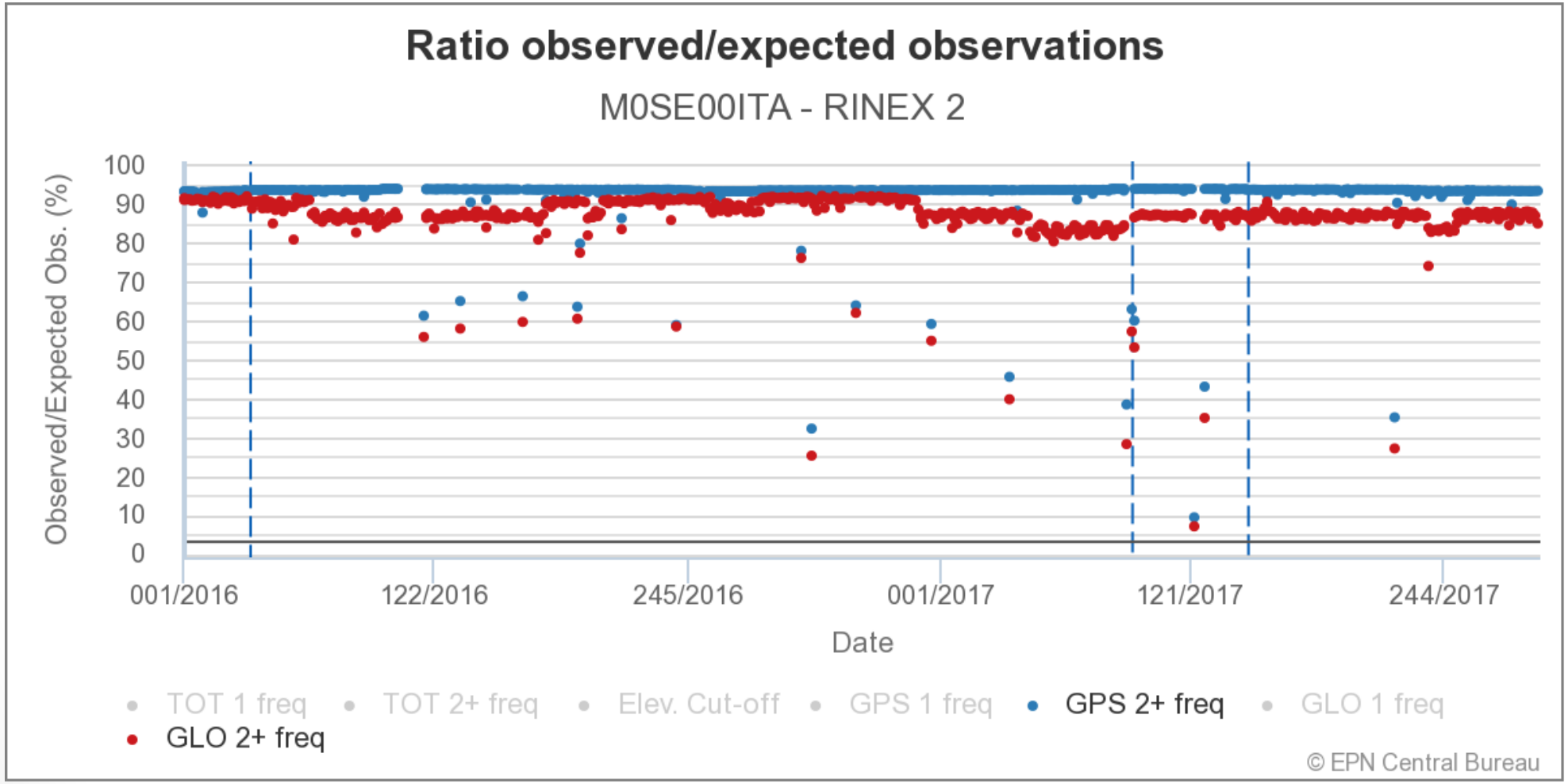
Self-developed plotting scripts on top of Anubis

**Václavovic P, Dousa J (2016)*

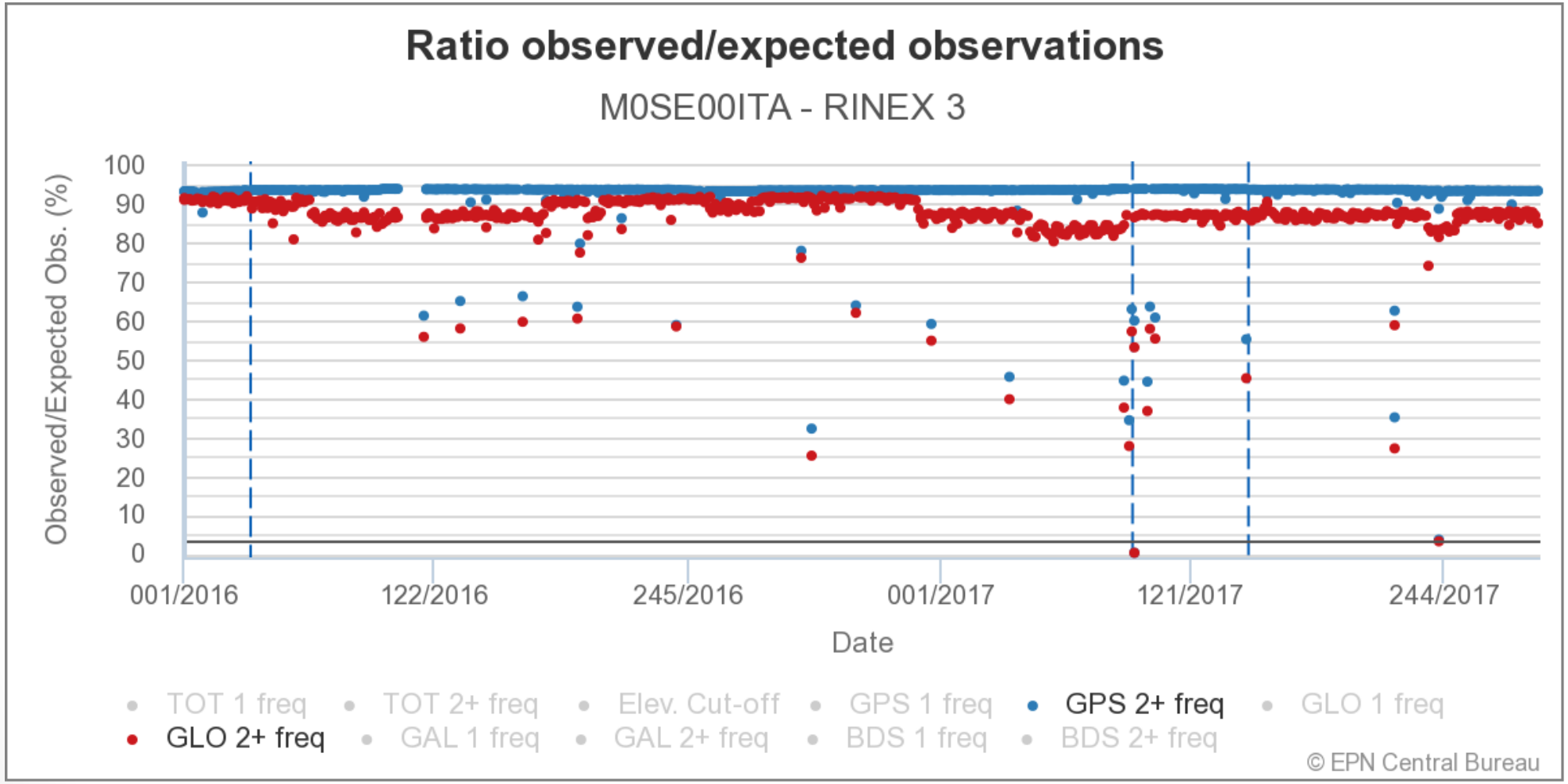
Daily Monitored Quantities

- % observed/expected observations (single frequency and 2+ frequency)
  - For each constellation + total (mean)
- Max. # of observations
  - For each constellation + total (sum)
- Number of cycle slips (x1000/nr. Obs)
  - For each constellation
- Average RMS of code multipath
  - For each frequency and each constellation
- 2 runs:
  - Once with navigation messages
  - Rerun, when precise multi-GNSS orbits become available

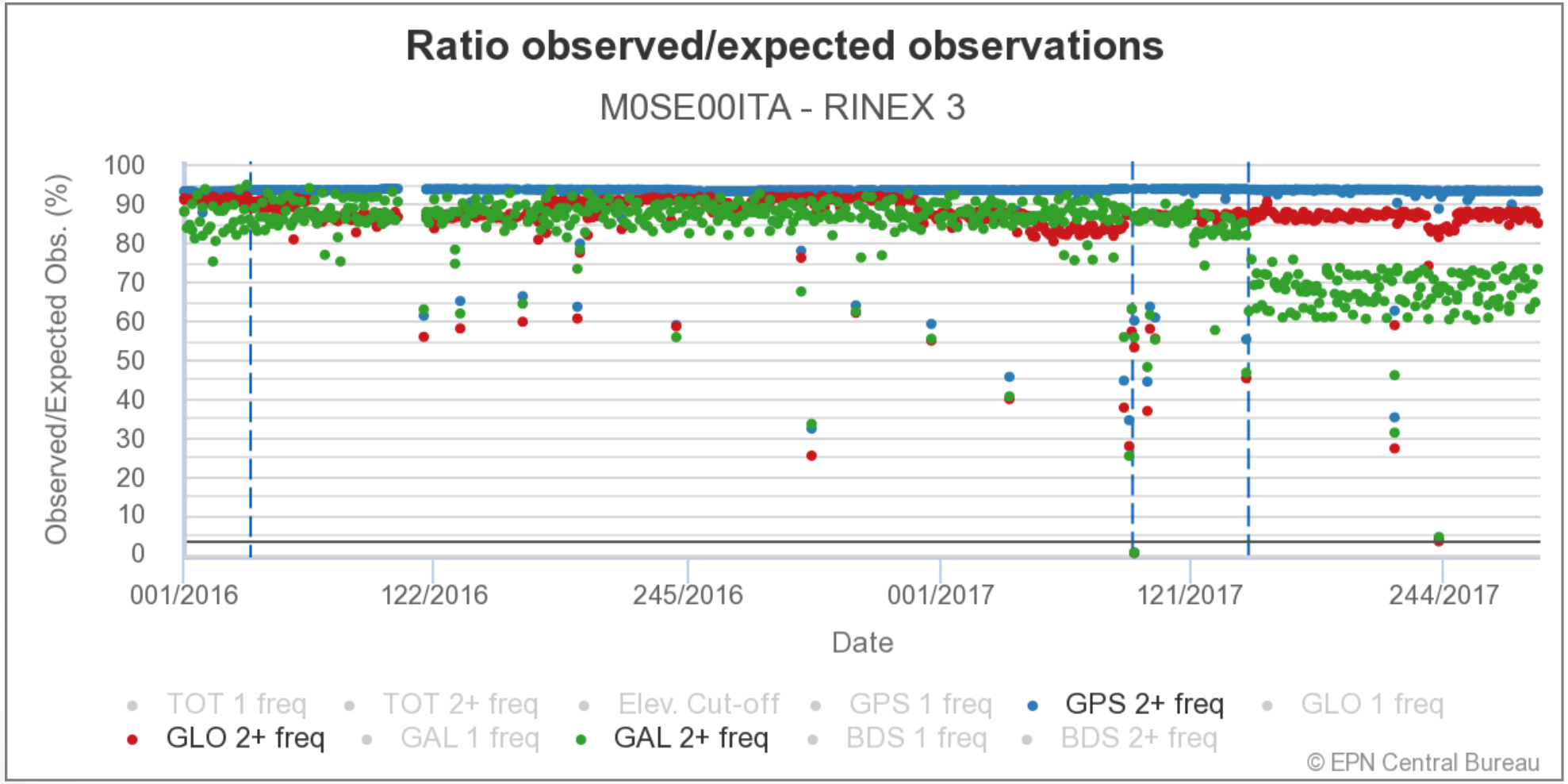
Simultaneous Galileo and BeiDou tracking



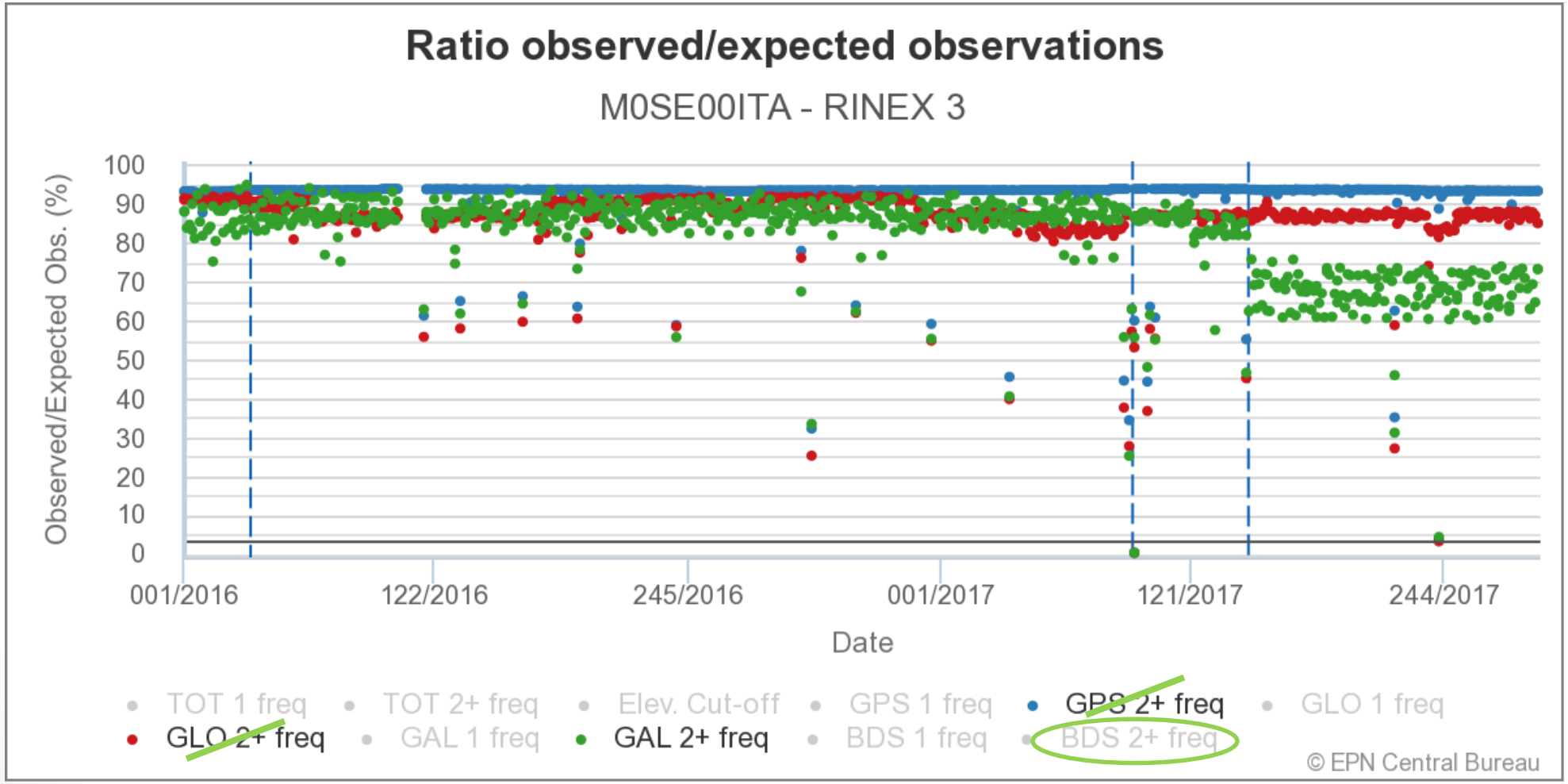
Simultaneous Galileo and BeiDou tracking



Simultaneous Galileo and BeiDou tracking



Simultaneous Galileo and BeiDou tracking



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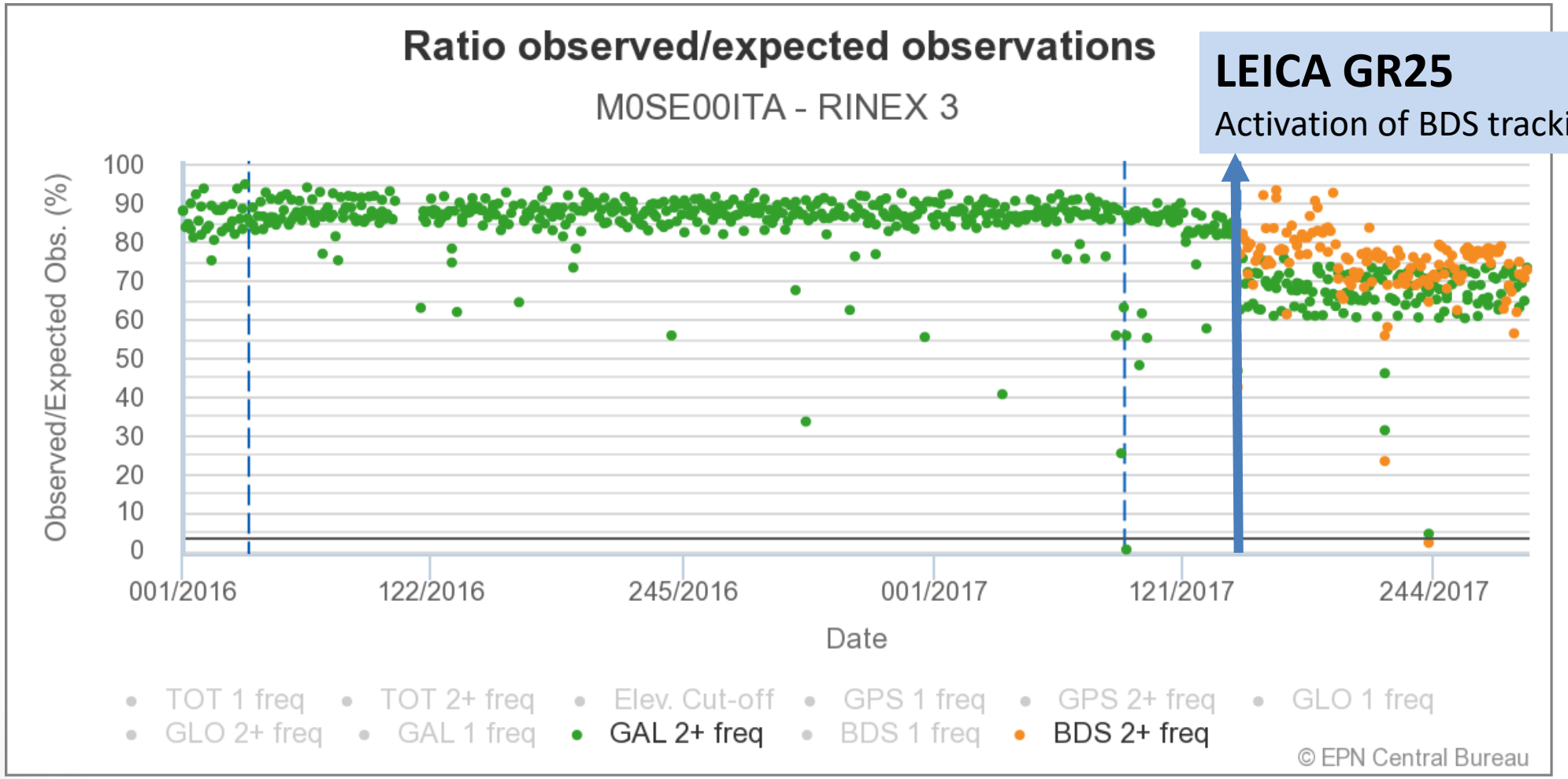

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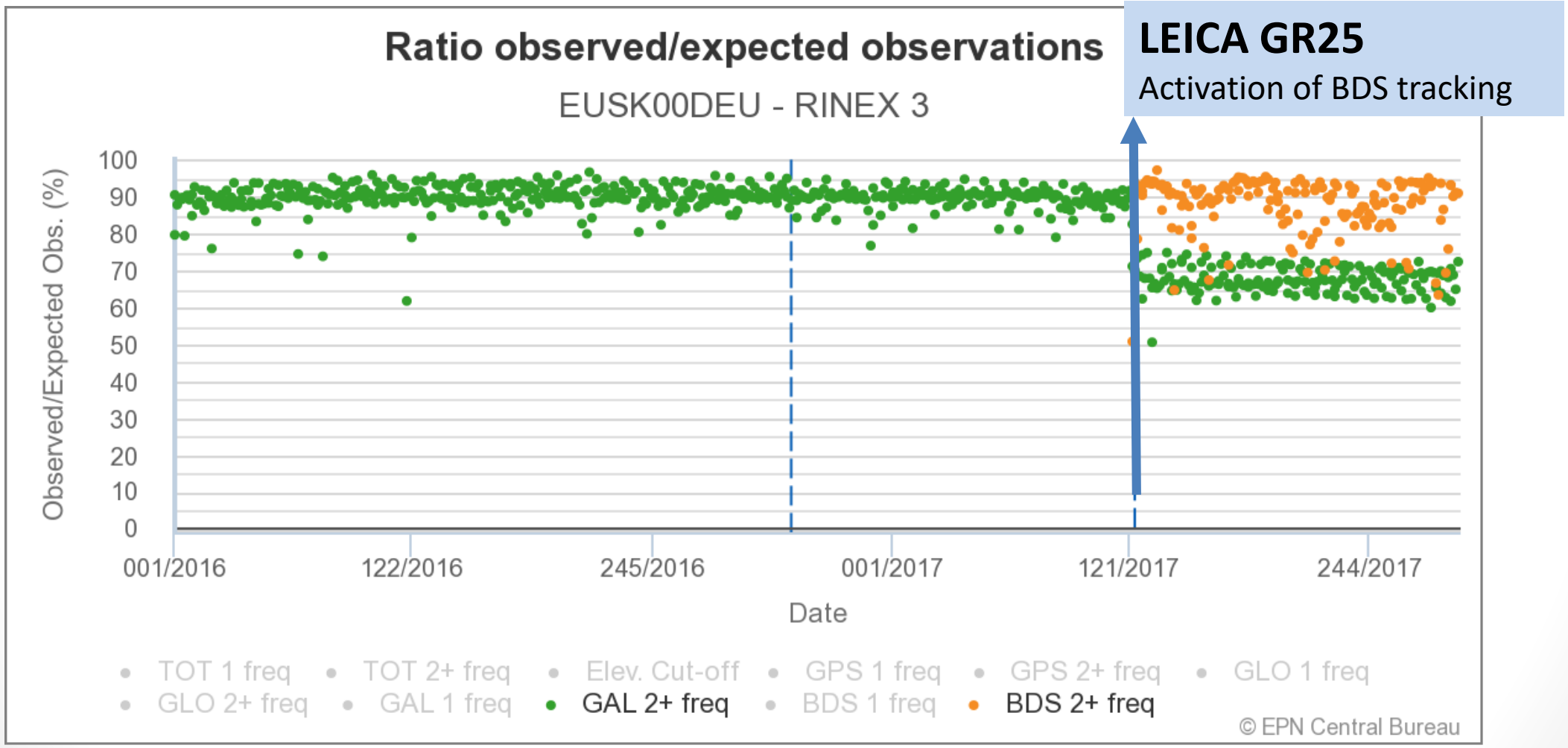
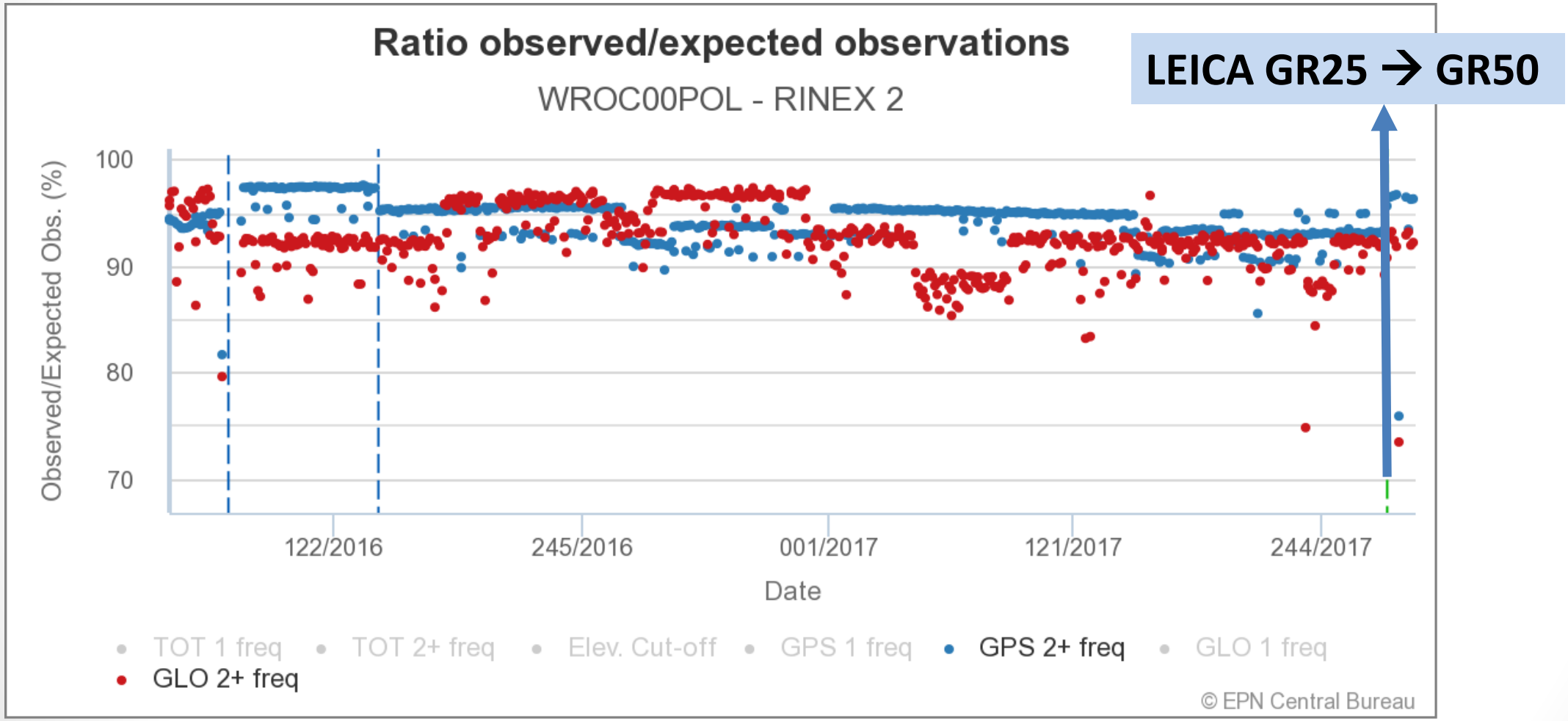


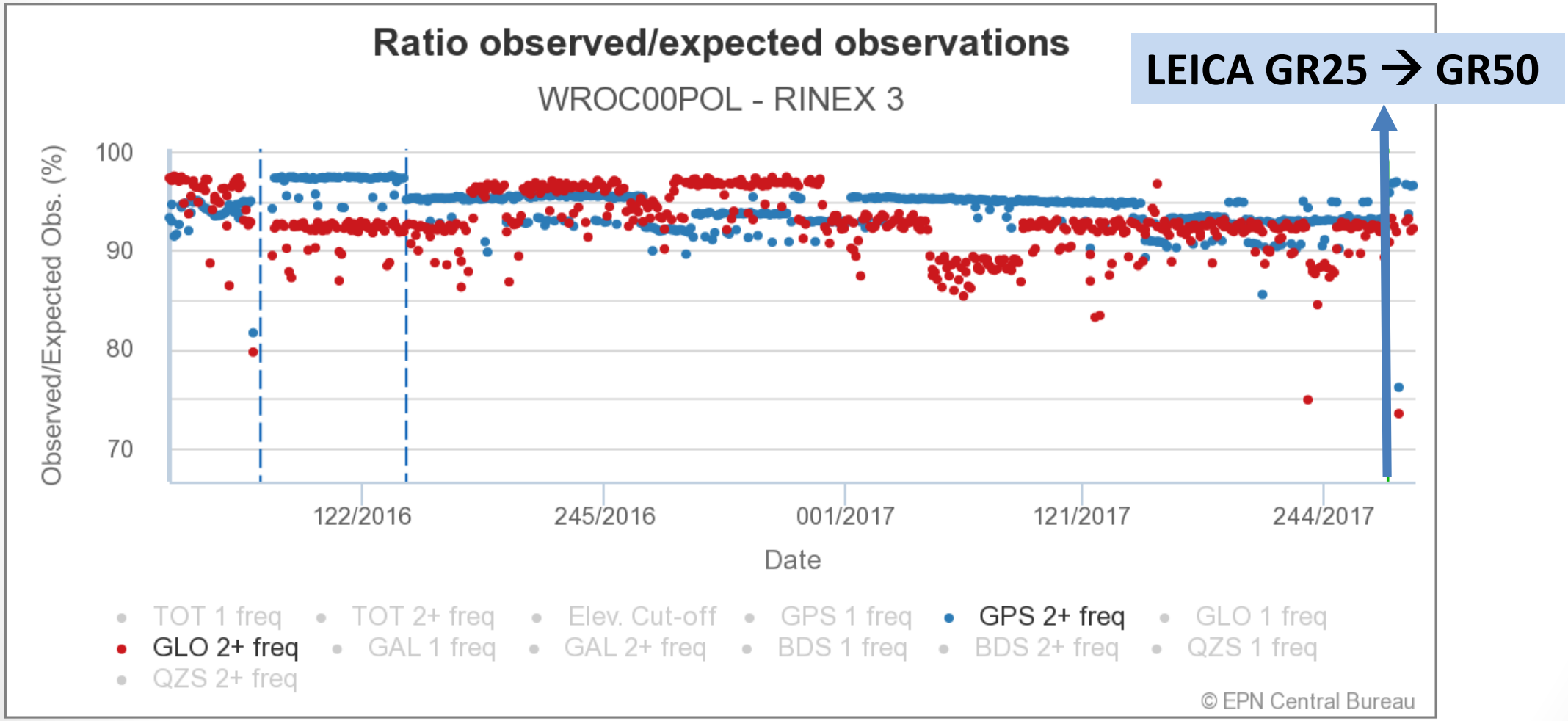
LEICA GR25

Activation of BDS tracking

Importance of up to date receiver firmware (1)



Importance of receiver upgrade (2)



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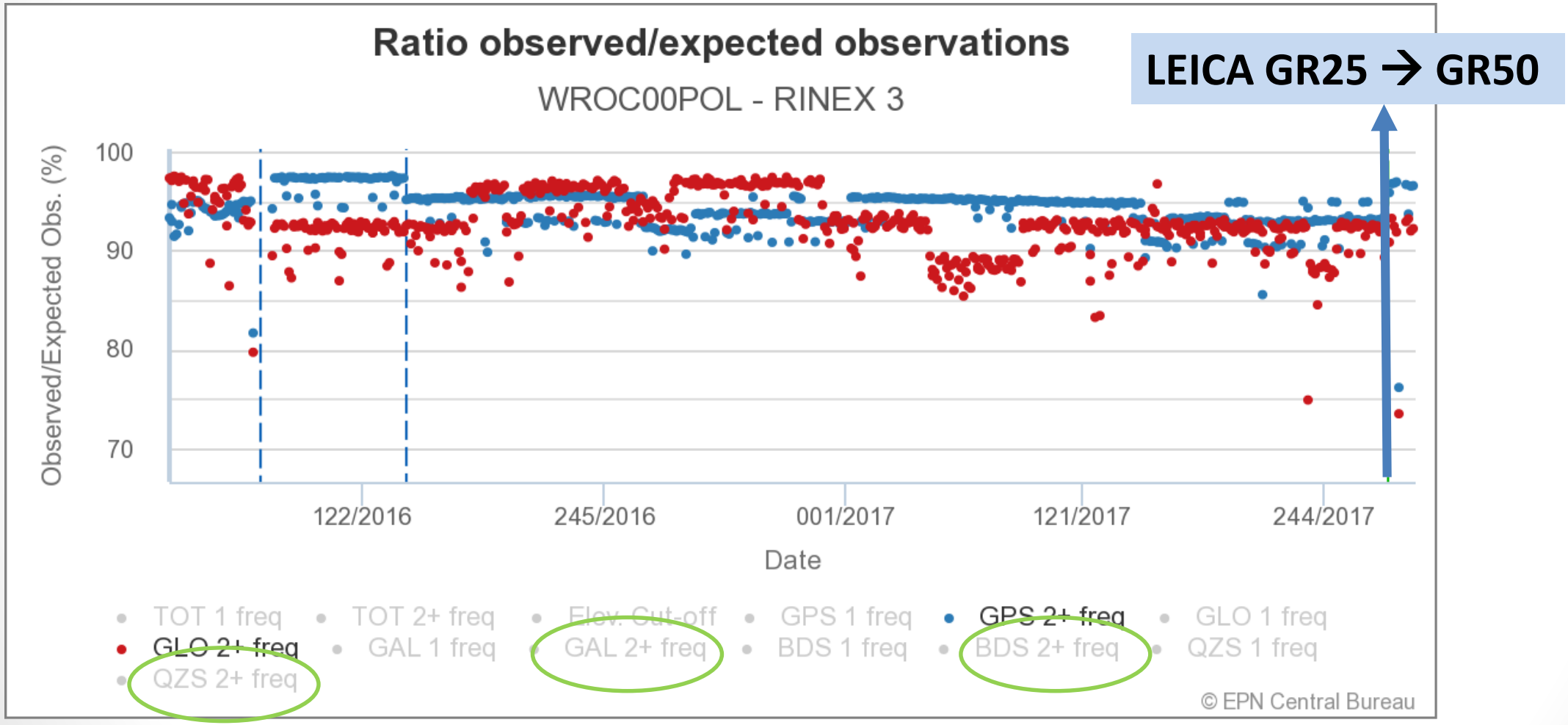
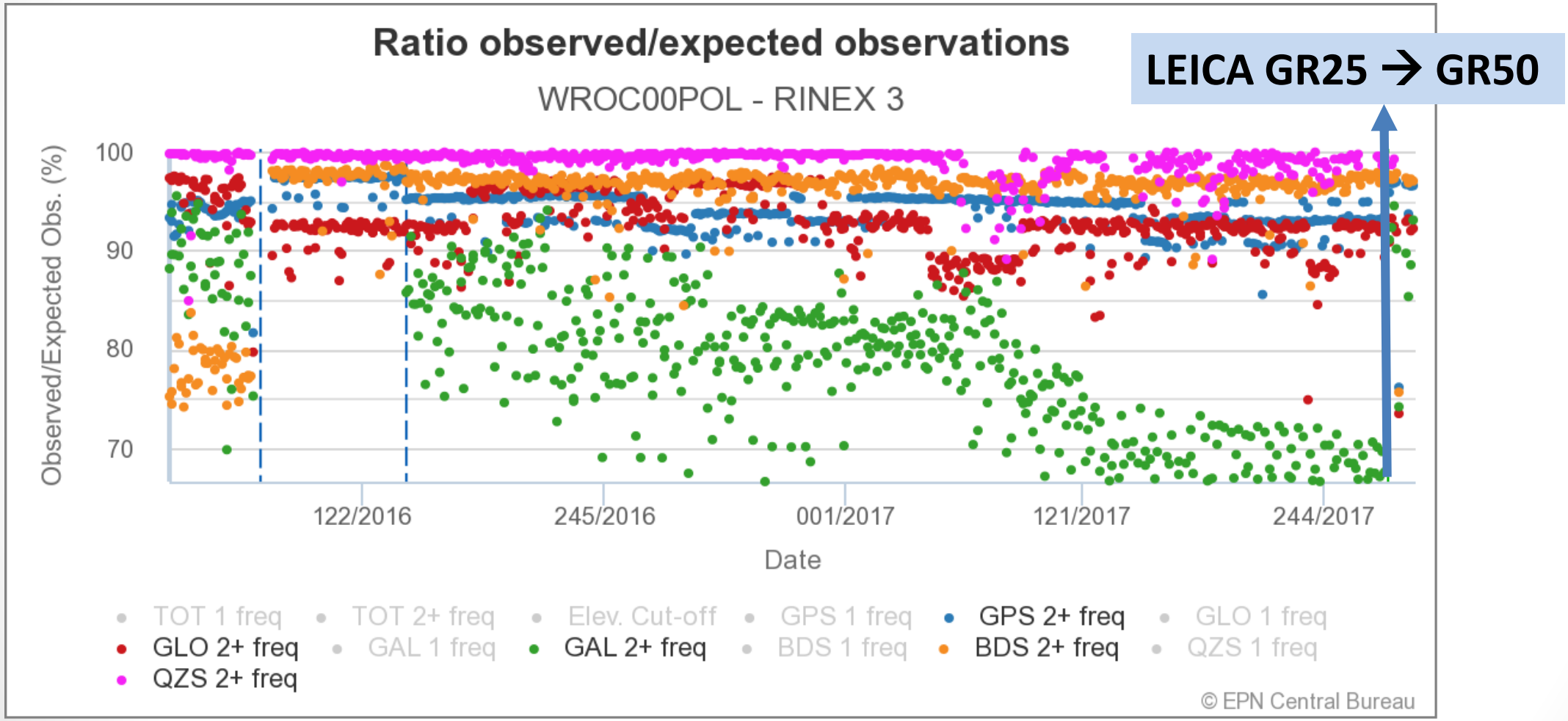
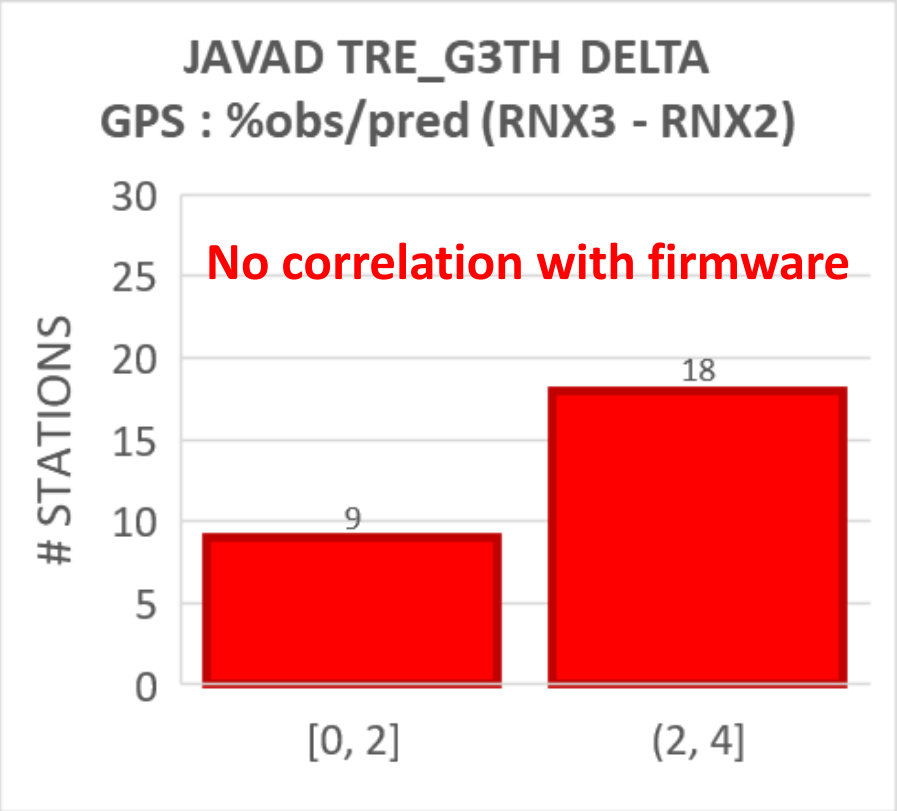


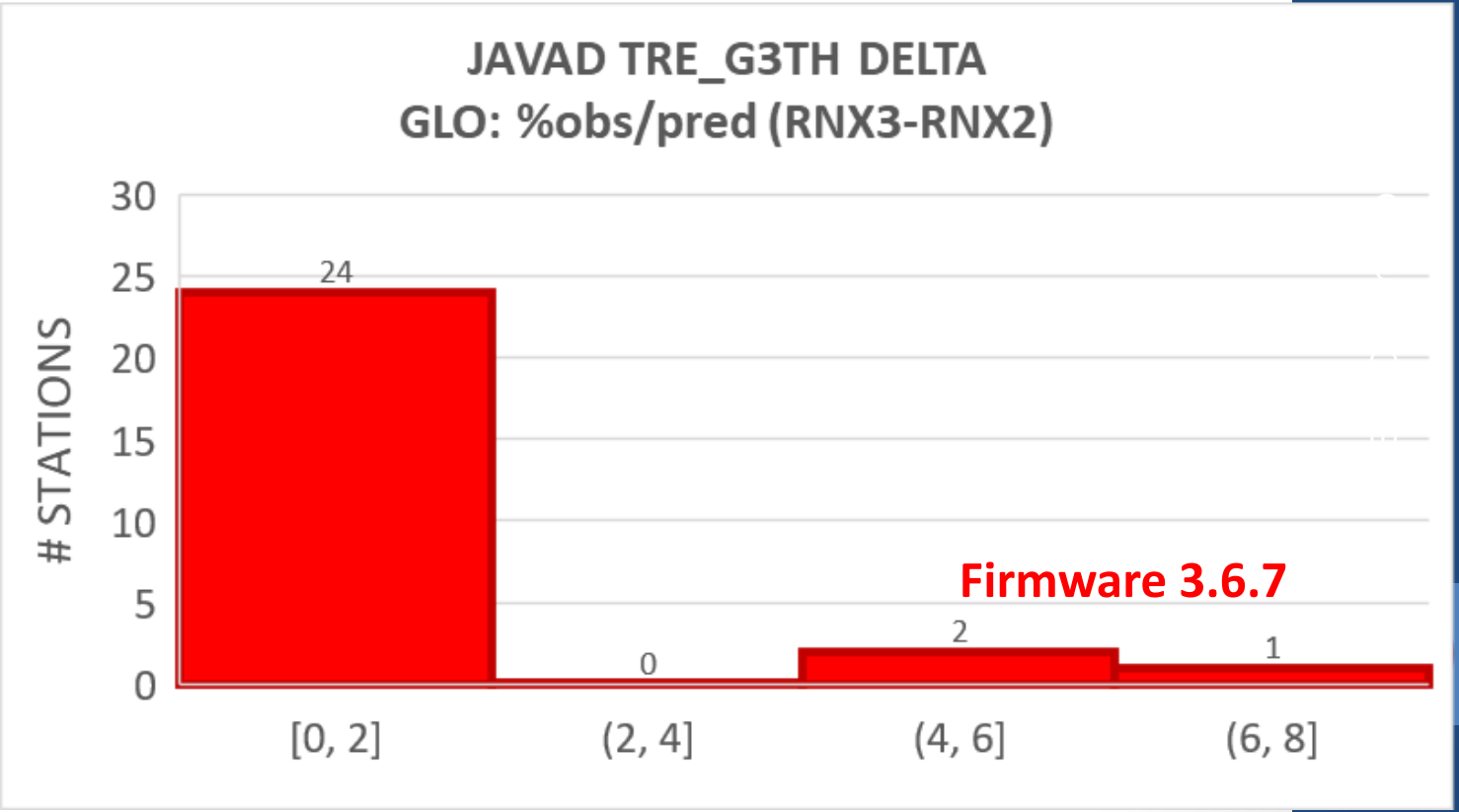
Importance of receiver upgrade (3)



Larger number of GPS/GLO obs. in RINEX 3

Comparison of % obs./expected dual+ freq. from RINEX 2 with RINEX 3 (GPS and GLONASS only)





Lessons learned from data quality checks

- For analysists:
  - Use RINEX 3 when available, even if only processing GPS+GLO
- For station managers:
  - Keep receiver firmware up to date
  - Prioritize satellite systems tracked
    - In EPN: GPS+GLO+GAL

Data analysis

RECEIVER TYPE	CARRIER PHASE SIGNALS				
	E1	E5a	E6	E5b	E5a+b
TPS NET-G5	L1B	L5I	L6B	L7I	L8Q
JAVAD TRE_3 DELTA	L1X	L5X		L7X	L8X
JAVAD TRE_G3TH DELTA	L1X	L5X			
					L8Q
					L8Q
					L8Q
					L8Q
					L8Q
					L8Q
					L8Q
LEICA GRX1200+GNSS	L1X	L5X		L7X	L8Q
SEPT POLARX4	L1C	L5Q		L7Q	L8Q
SEPT POLARX4TR	L1C	L5Q		L7Q	L8Q
TRIMBLE NETR9	L1X	L5X		L7X	L8X
TRIMBLE SPS855	L1X	L5X		L7X	L8X

Bernese 5.2: dual frequency processing

Need to tell Bernese which obs. to be used

ftp://ftp.aiub.unibe.ch/BSWUSER52/GEN/OBS_GAL.SEL

First freq. L1C L1X L1B

Second freq. L5Q L5I L5X L7Q L7X L7I L8Q L8X L6A L6B L6X

Data analysis

STATION 1					STATION2				
E01	C1X	C5X	L1X	L5X	E01	C1X	C5X	L1X	L5X
E02	C1X	C5X	L1X	L5X	E02	C1X	C5X	L1X	L5X
E08	C1X	C5X	L1X	L5X	E08	C1X	C5X	L1X	L5X
E09	C1X	C5X	L1X	L5X	E09	C1X	C5X	L1X	L5X
E11	C1X	C5X	L1X	L5X	E11	C1X	C5X	L1X	L5X
E12	C1X	C5X	L1X	L5X	E12	C1X	C5X	L1X	L5X
E14	C1X	C5X	L1X	L5X	E14	C1X	C5X	L1X	L5X
E18	C1X	C5X	L1X	L5X	E18	C1X	C5X	L1X	L5X
E19	C1X	C5X	L1X	L5X	E19	C1X	C5X	L1X	L5X
E20	C1X	C7X	L1X	L7X	E20	C1X	C5X	L1X	L5X
E22	C1X	C5X	L1X	L5X	E22	C1X	C5X	L1X	L5X
E24	C1X	C5X	L1X	L5X	E24	C1X	C5X	L1X	L5X
E26	C1X	C5X	L1X	L5X	E26	C1X	C5X	L1X	L5X
E30	C1X	C5X	L1X	L5X	E30	C1X	C5X	L1X	L5X

Different frequency: Problematic when forming baselines

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JAVAD TRE_G3TH DELTA	L1X	L5X			
LEICA GR10	L1C	L5Q		L7Q	L8Q
LEICA GR25	L1C	L5Q		L7Q	L8Q
LEICA GR25	L1C	L5Q		L7Q	
LEICA GR25 (KURE, TOR2)	L1C				L8Q
LEICA GR30	L1C	L5Q		L7Q	L8Q
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LEICA GRX1200+GNSS	L1X	L5X	L6A	L7X	L8Q
LEICA GRX1200+GNSS	L1C	L5Q		L7Q	L8Q
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Data analysis

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JAVAD TRE_G3TH DELTA	L1X	L5X			
LEICA GR10	L1C	L5Q		L7Q	L8Q
					L8Q
					L8Q
					L8Q
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Bernese 5.2: dual frequency processing

Need to tell Bernese which obs. to be used

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First freq. L1C L1X ~~L1B~~

Second freq. L5Q L5I L5X ~~L7Q L7X L7I L8Q L8X L6A L6B L6X~~

Careful: Data quality checks recognize L1 + L8 also as 2+freq. data

Antenna Calibrations

- 158 stations provide Galileo observations
- 11 of them have Galileo receiver antenna calibrations (all individual) ….

Final words

RINEX 3 data flow not optimal yet (hourly).

RINEX 3 data quality more reliable than RINEX 2.

ROB integrated Galileo in ROB data analysis for EUREF using Bernese V5.2 → Effort has been minimal

All ACs are encouraged to give it a try!

Fall back to RINEX 2 is necessary.

Thank you

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