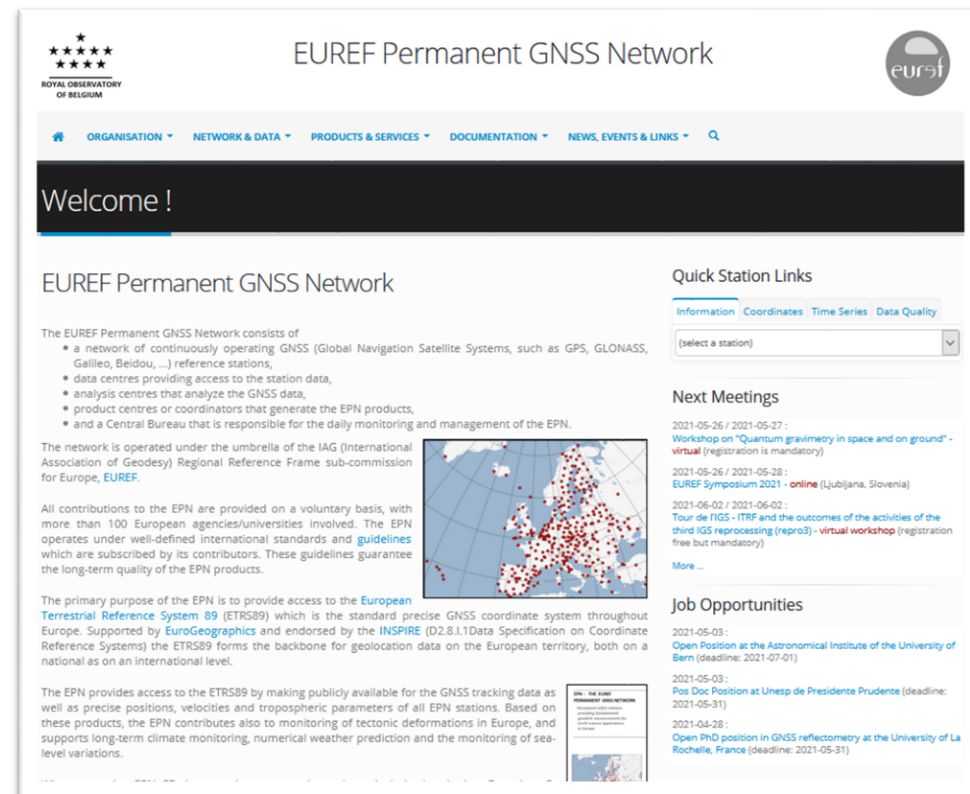


# Performance of the EUREF Permanent GNSS Network

Carine Bruyninx, J. Legrand, A. Fabian

Royal Observatory of Belgium

EPN Central Bureau, <https://epncb.oma.be/>



The screenshot displays the official website of the EUREF Permanent GNSS Network. At the top, the Royal Observatory of Belgium logo is visible alongside the site title. A navigation bar includes links for Organisation, Network & Data, Products & Services, Documentation, and News, Events & Links. A prominent 'Welcome!' banner is followed by a detailed description of the network's structure and its role in providing precise GNSS data across Europe. A map of Europe illustrates the extensive network of stations. The right sidebar offers quick access to station information, upcoming meetings, and job opportunities.



ROYAL  
OBSERVATORY  
OF BELGIUM

EUREF Symposium, 26-28/05/2021, Ljubljana, Slovenia



EUREF2021

# Changes in station network since May 2019

363 EPN stations

★ 28 new EPN stations

First EPN stations in Montenegro  
and Belarus!

Decommissioned stations:

BZRG00ITA, CASB00IRL, EDIN00GBR, PFA200AUT,  
TARI00ESP

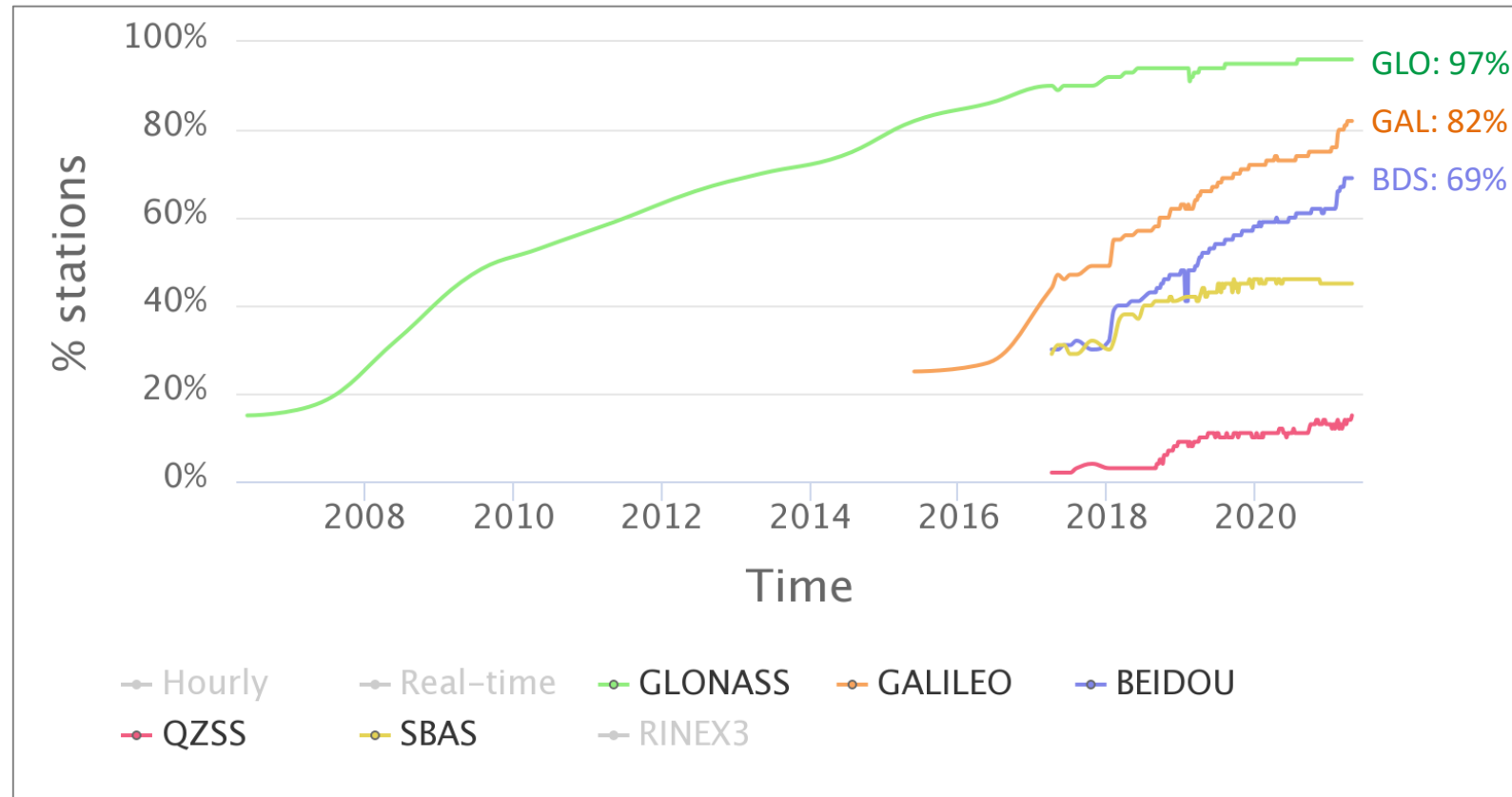
Inactive stations

BISK00CZE, VACO00CZE, DYNG00GRC,  
ELBA00ITA, UNTR00ITA, ENIS00GBR

- No budget to keep station alive
- Problematic data provision to EUREF



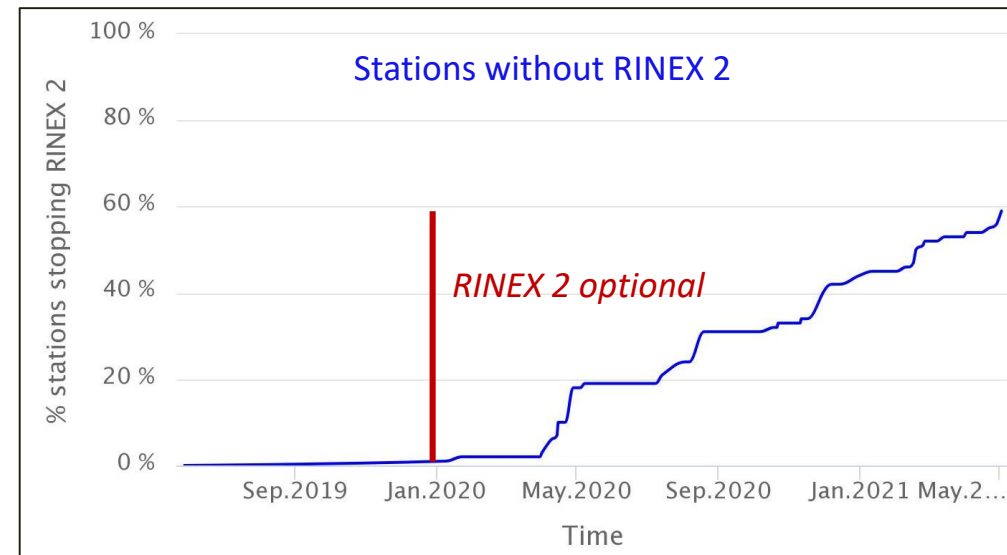
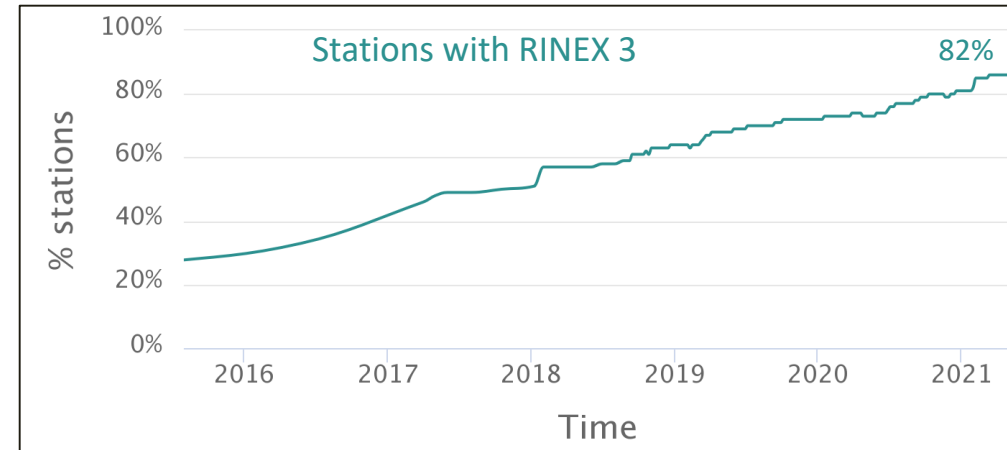
# Tracked Constellations



# RINEX format

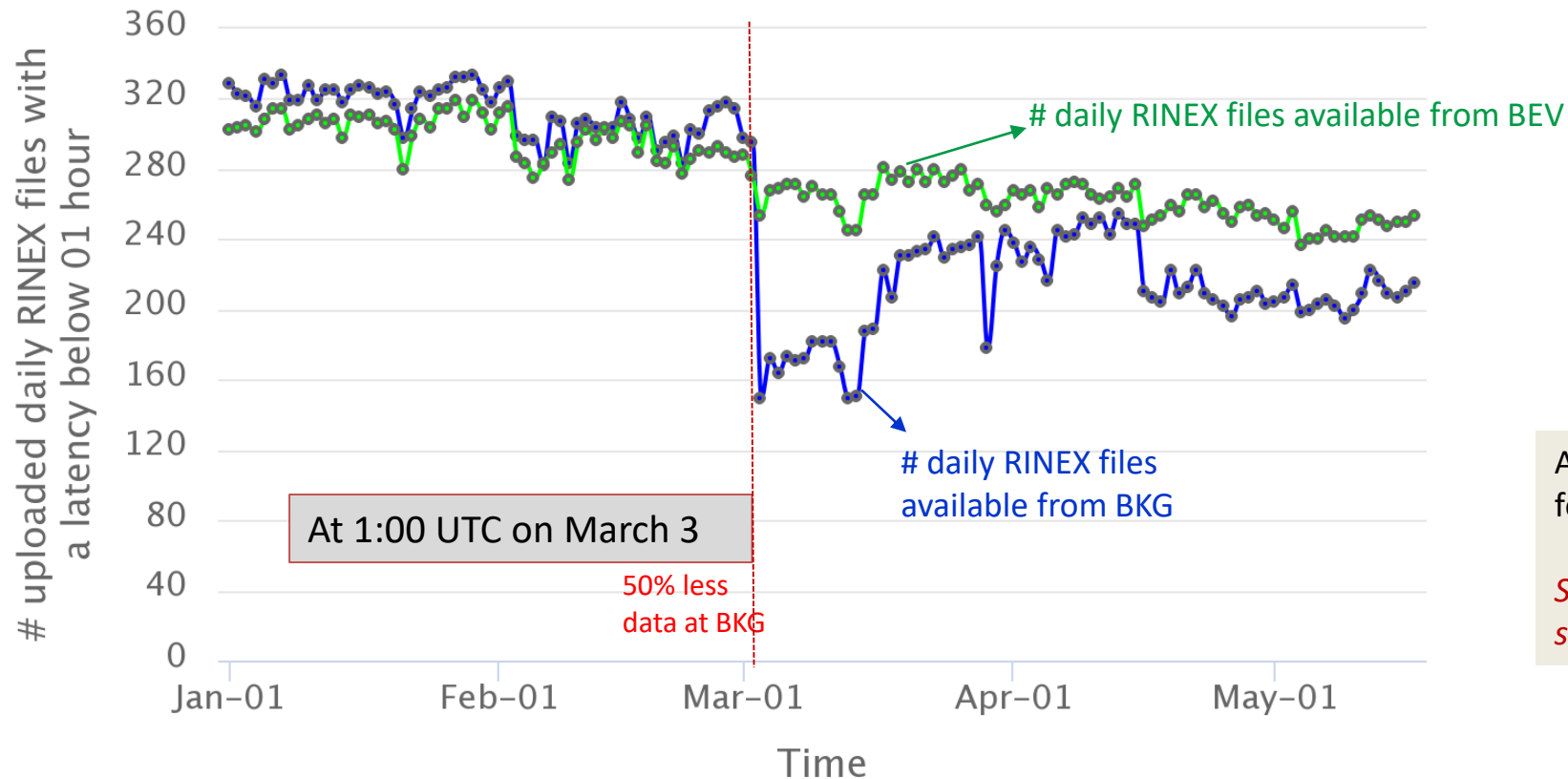
From 1<sup>st</sup> Jan. 2020

- RINEX 3 data submission mandatory for stations:
  - tracking more than two frequencies
  - tracking satellite systems in addition to GPS and GLONASS
- RINEX must be created from RAW receiver data
- RINEX 2 → RINEX 3 not allowed !
- RINEX 2 optional



# Availability of daily RINEX data

EUREF mail 10552: BKG switch from ftp to **sftp upload from March 2, 2021**

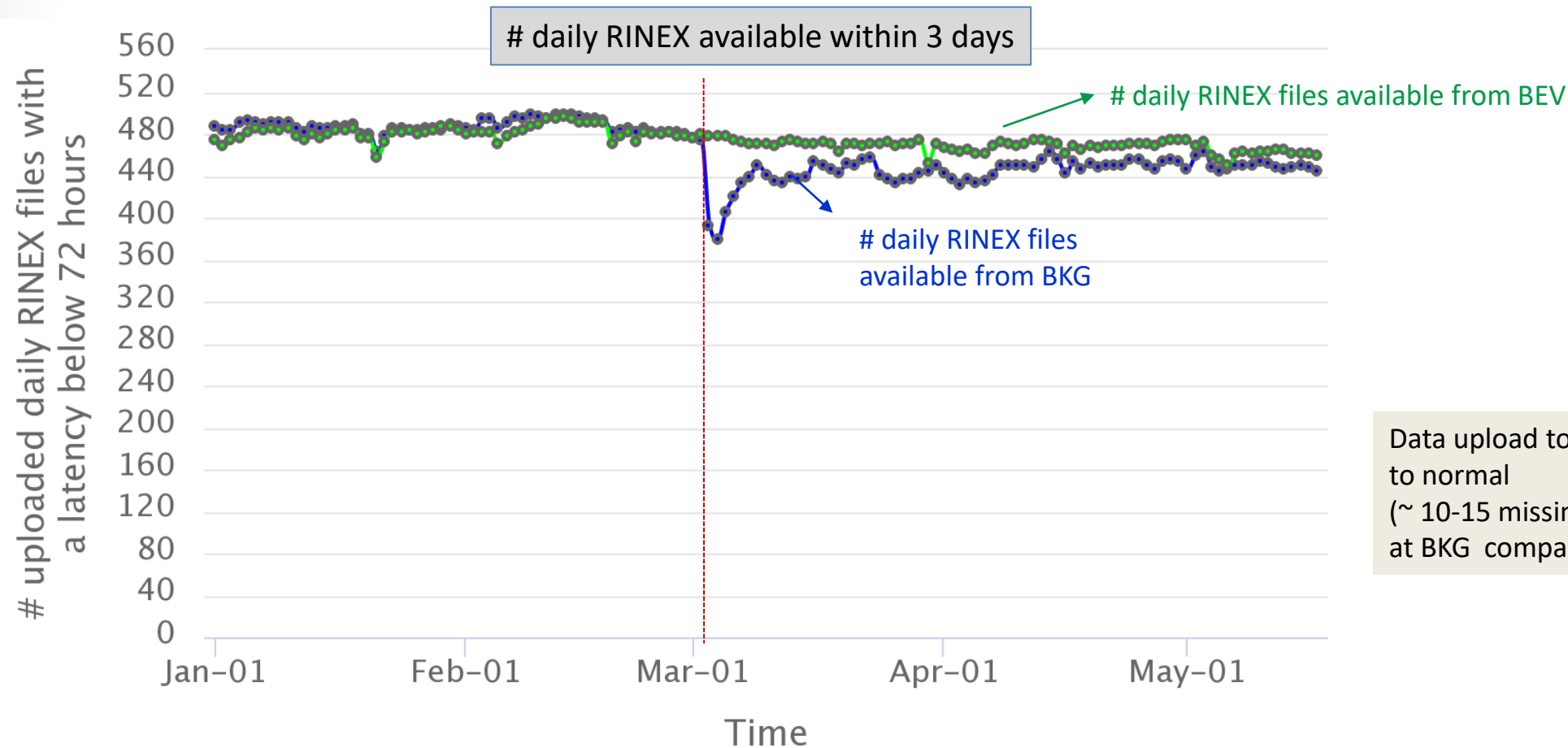


A lot of stations were not ready for switch to sftp!

*Station managers should subscribe to EUREF mail*

# Availability of daily RINEX data

EUREF mail 10552: BKG switch from ftp to **sftp upload from March 2, 2021**



Data upload to BKG almost back to normal  
(~ 10-15 missing daily data files at BKG compared to BEV)

# RTCM format

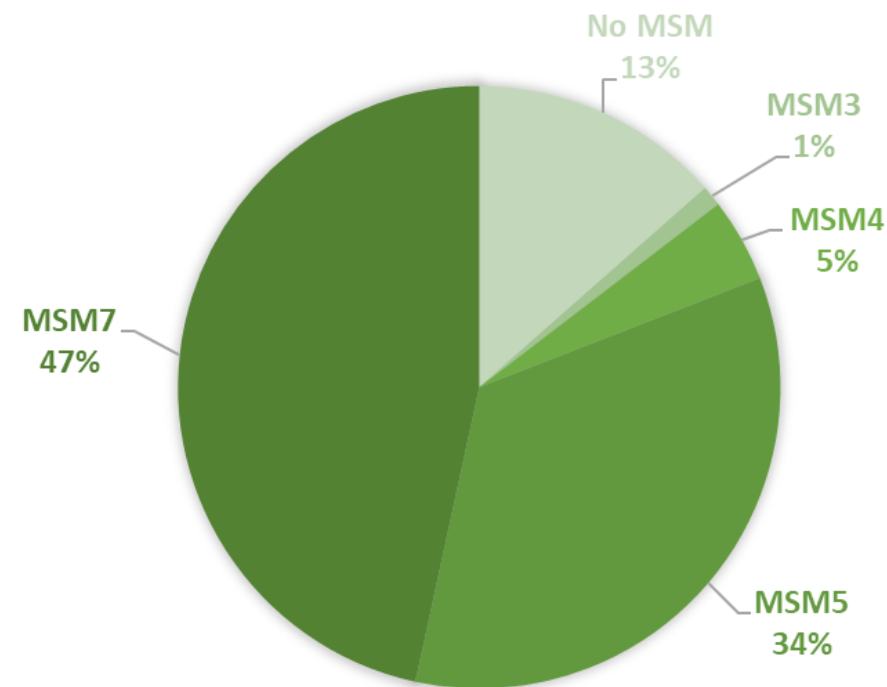
## GUIDELINES FOR EPN STATIONS & OPERATIONAL CENTRES

(last update Oct. 2019)

3.3.4 The format of the data stream should be **RTCM 3.x**. It is recommended to use RTCM-Multiple Signal Messages (**RTCM-MSM**). The advantage of the RTCM High Precision MSM (HP-MSM) message types will be the full **compatibility with RINEX 3**.

3.3.10 .... The **use of MSM 7 is recommended** while MSM4 or MSM5 are allowed.

|      |                                                                              |
|------|------------------------------------------------------------------------------|
| MSM1 | DGNSS uses, Pseudorange, (conventional and advanced)                         |
| MSM2 | RTK uses, Pseudorange only                                                   |
| MSM3 | RTK uses, Pseudorange (i.e. Code) and PhaseRange (i.e. Carrier)              |
| MSM4 | RTK uses, Pseudorange, PhaseRange, CNR (but No Doppler)                      |
| MSM5 | RTK uses, Pseudorange, PhaseRange, Doppler, CNR                              |
| MSM6 | RTK uses, Pseudorange, PhaseRange CNR, with high resolution                  |
| MSM7 | RTK uses, Pseudorange, PhaseRange, Doppler, CNR, <b>with high resolution</b> |



50% of EPN stations provide real-time streams.

From 180 real-time streams

- 3% GPS-only
- 13% GPS+GLO
- **84% GPS+GLO+GAL+...**

# Real-time EPN streams → Access to ETRS89

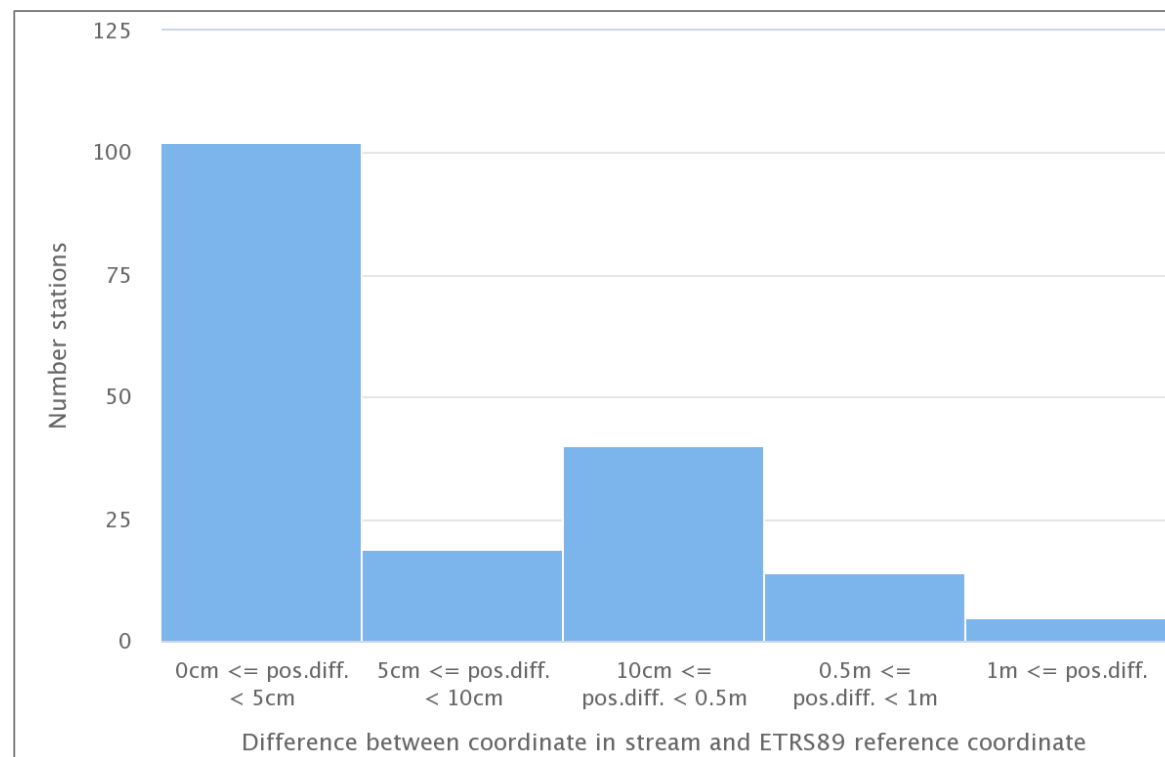
## Access to ETRS89 requires reliable ETRS89 positions in stream

20-Jan-2020 [EUREF mail 10121](#) Reminder: ETRS89 coordinates in real-time EPN data streams

- 14 streams with more than 50 cm position deviation from ETRS89
- 78 streams with more than 5 cm position deviation from ETRS89

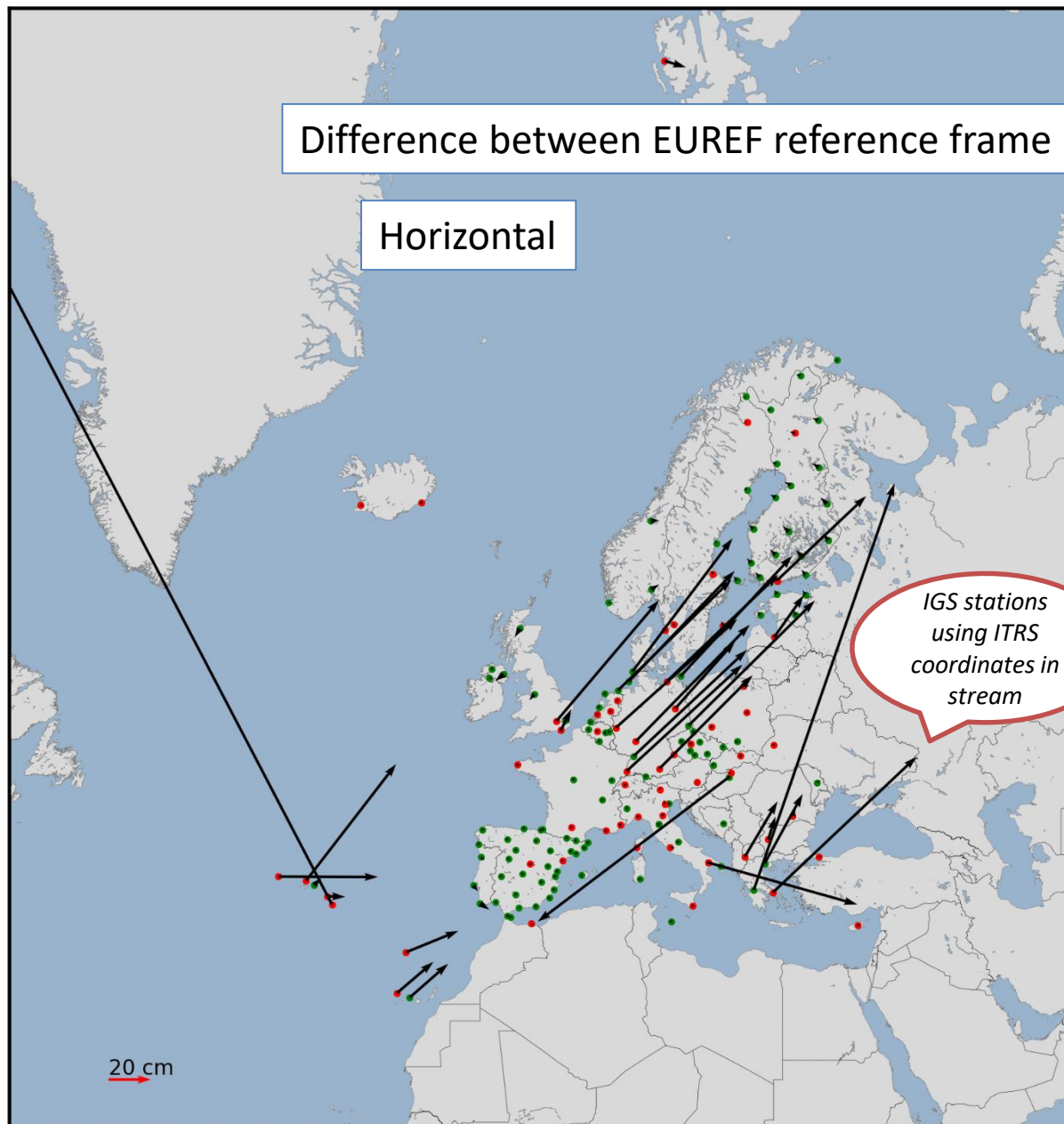
Warnings reported in individual station web page of EPN CB (Section “Data Provided”)

- **WARNING: 2021/04/21 00:01 RTCM 3.1/1006: Coordinate difference with ETRS89 (0.46 m) exceeds threshold**

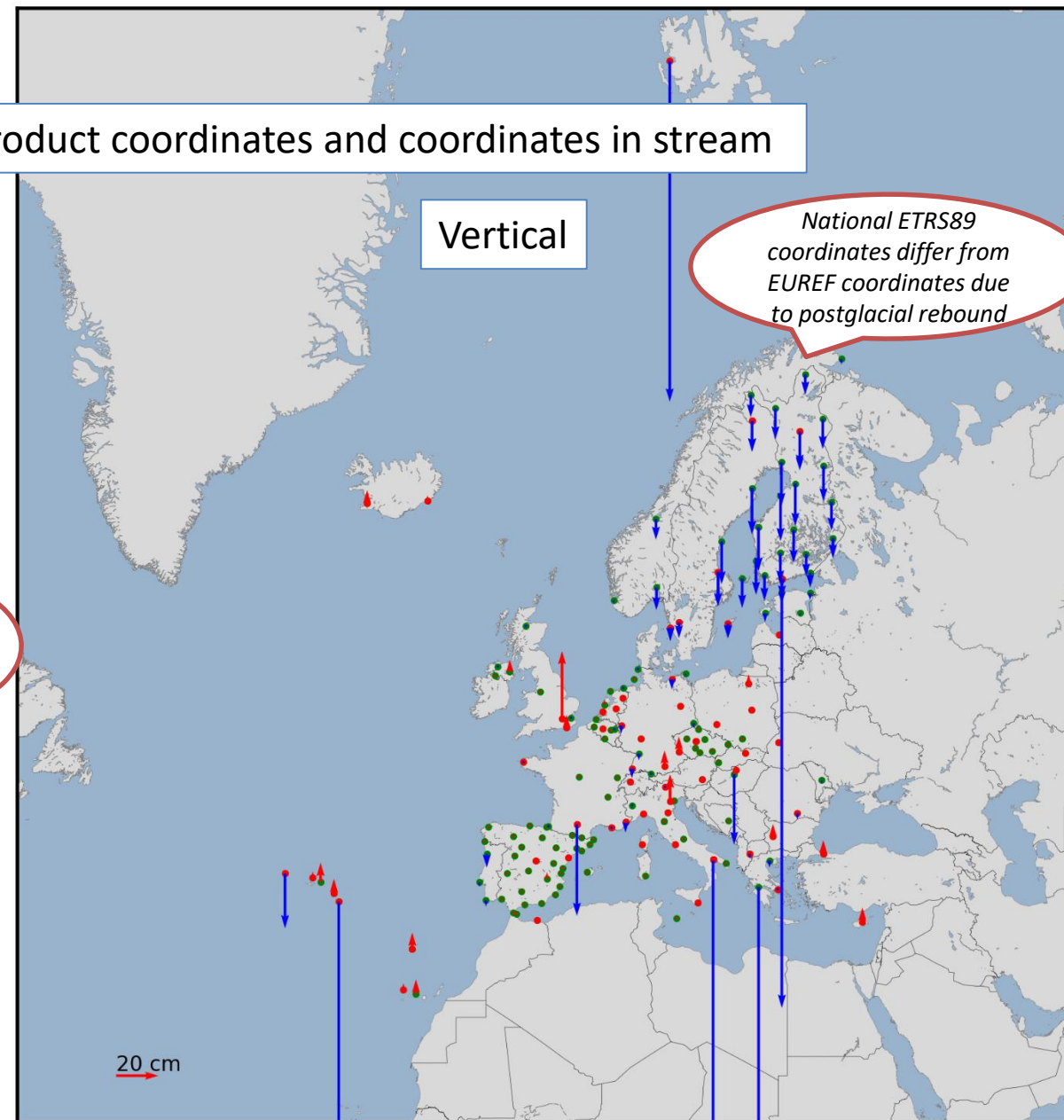


# Difference between EUREF reference frame product coordinates and coordinates in stream

Horizontal



Vertical



Status end of April 2021

# EPN Data Quality – *Galileo tracking*

Incomplete Galileo tracking at receivers with lower number of channels (~120)

## **EUREF symposium 2018:**

Drop in Galileo tracking when activating BeiDou tracking

## **EUREF symposium 2019:**

Galileo tracking also degraded at stations not tracking BeiDou

*February 2019, more than 20 operational Galileo satellites.*

*Average drop of 10% in Observed/Expected for Galileo for receivers with lower number of channels.*

### **Solution** provided by LEICA:

- *Update to ME FW 6.713*
- *deactivate BeiDou, L2C (GPS, GLO)*

## **EUREF symposium 2021:**

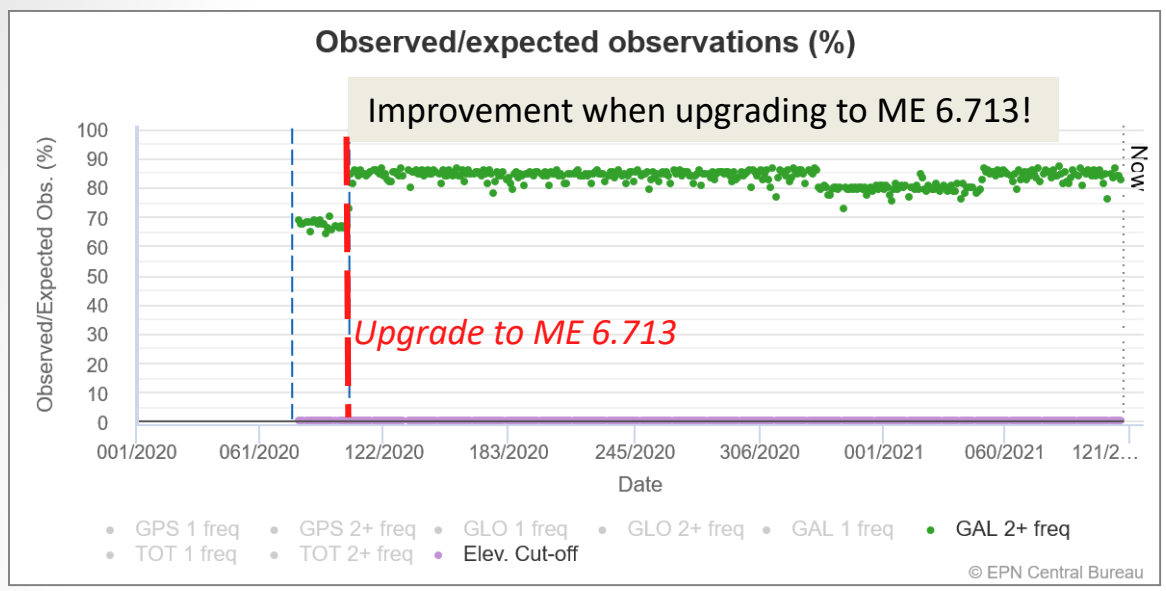
Based on site log info and/or quality checks

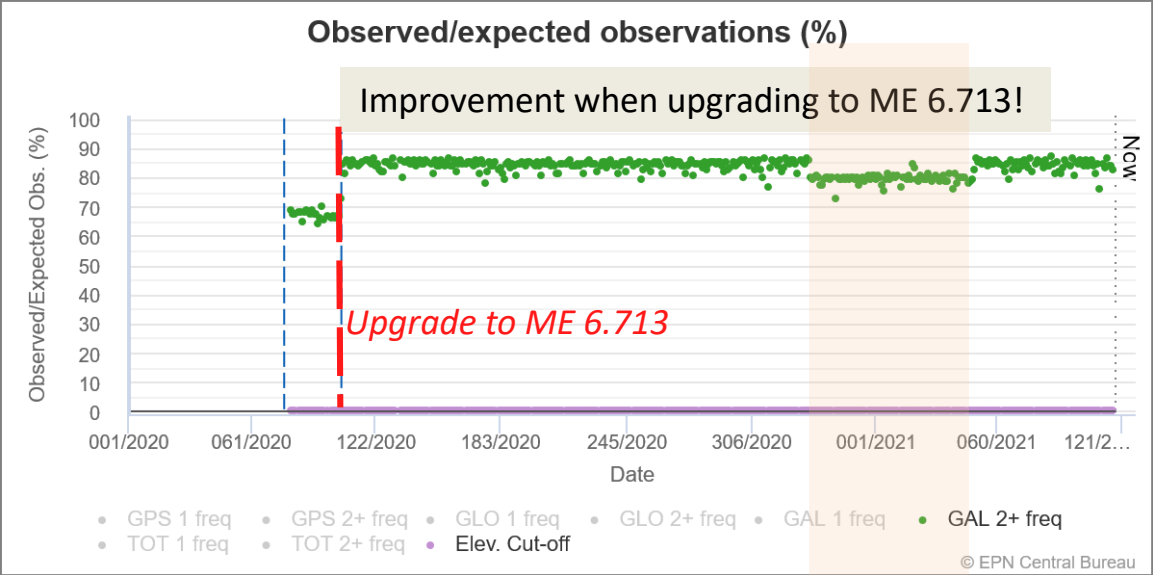
We suspect that the following EPN stations need to implement proposed solutions:

*(status end of April 2021!)*

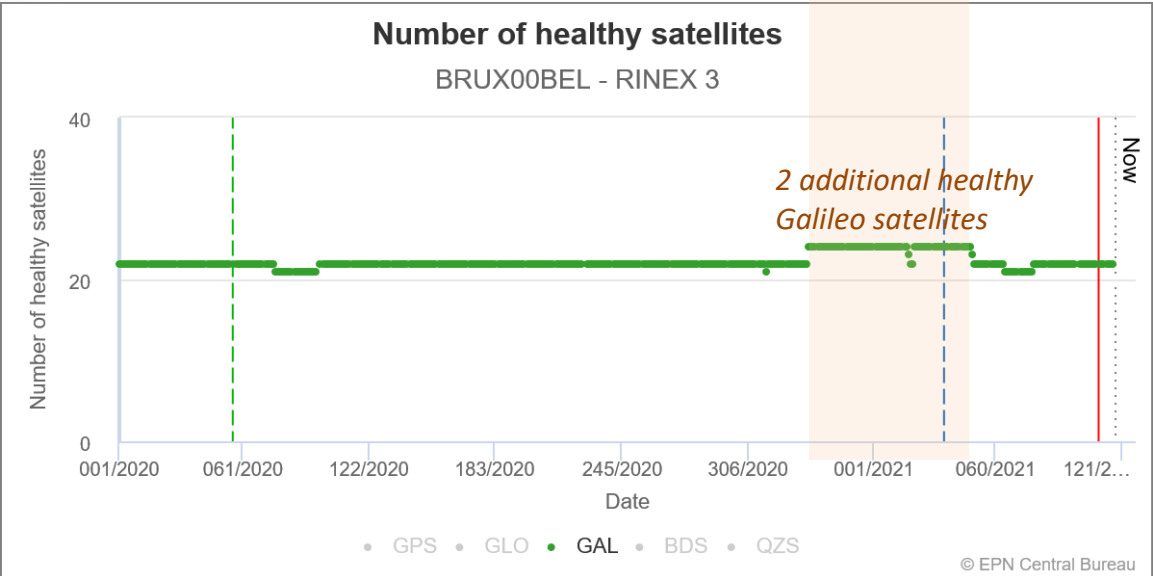
CNIV00UKR DNMU00UKR GSR100SVN POLV00UKR PRYL00UKR IGEO00MDA MIKL00UKR MARP00UKR

AUTN00FRA BRMF00FRA BSCN00FRA CAEN00FRA EGLT00FRA ENTZ00FRA FOYL00GBR GRAC00FRA GUIP00FRA ISTA00TUR LIL200FRA  
LROC00FRA MARS00FRA MLVL00FRA PUYV00FRA SCOA00FRA  
TLMF00FRA VFCH00FRA

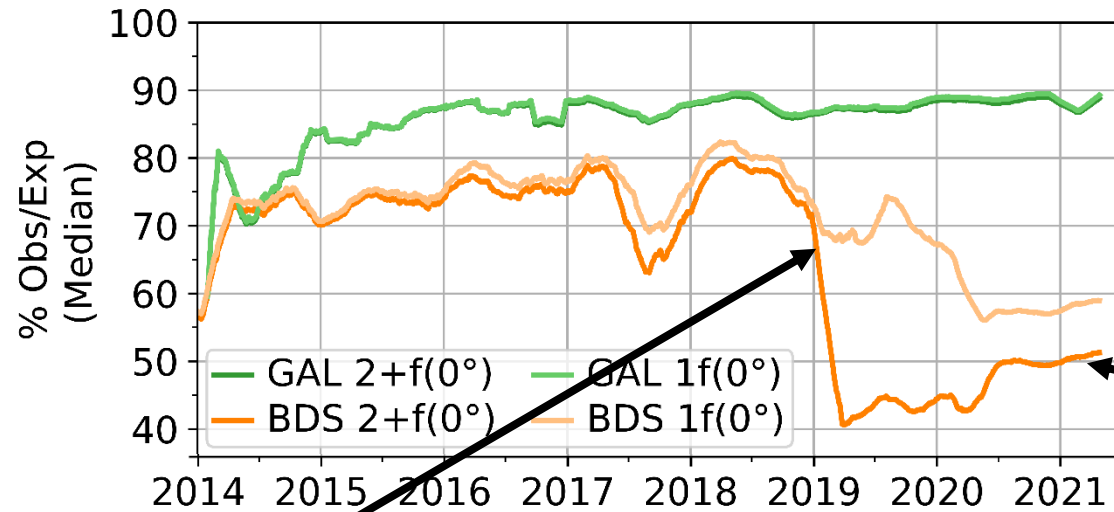




But even with ME 6.713 ...



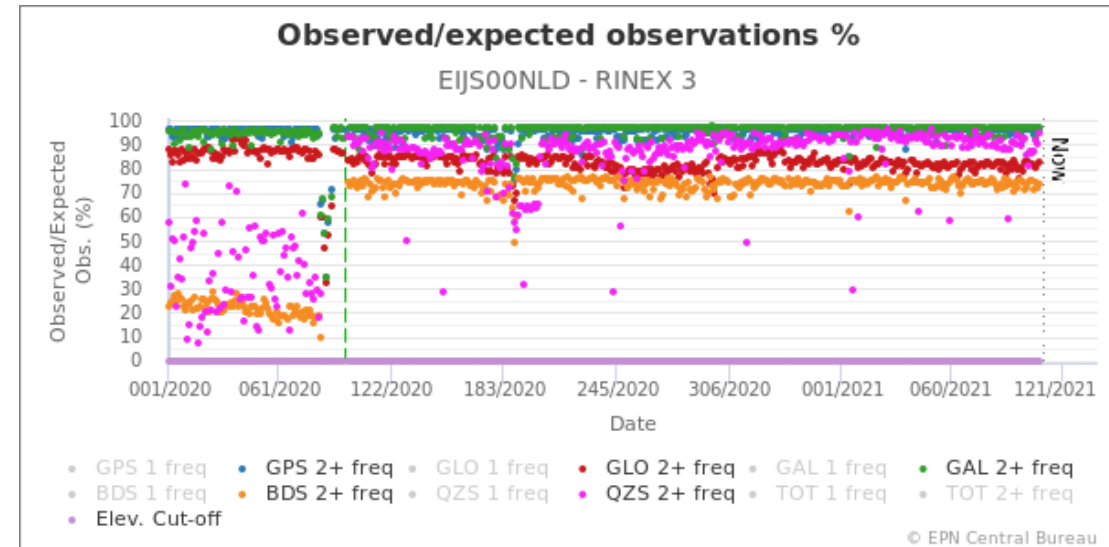
# EPN Data Quality — *BeiDou tracking*



Today: Slow improvement thanks to modernization of equipment in some stations

End 2018: Decrease of dual frequency BeiDou observations in EPN due to new BeiDou-3 satellites

Many EPN stations incapable of observing dual frequency data of Beidou-3 satellites

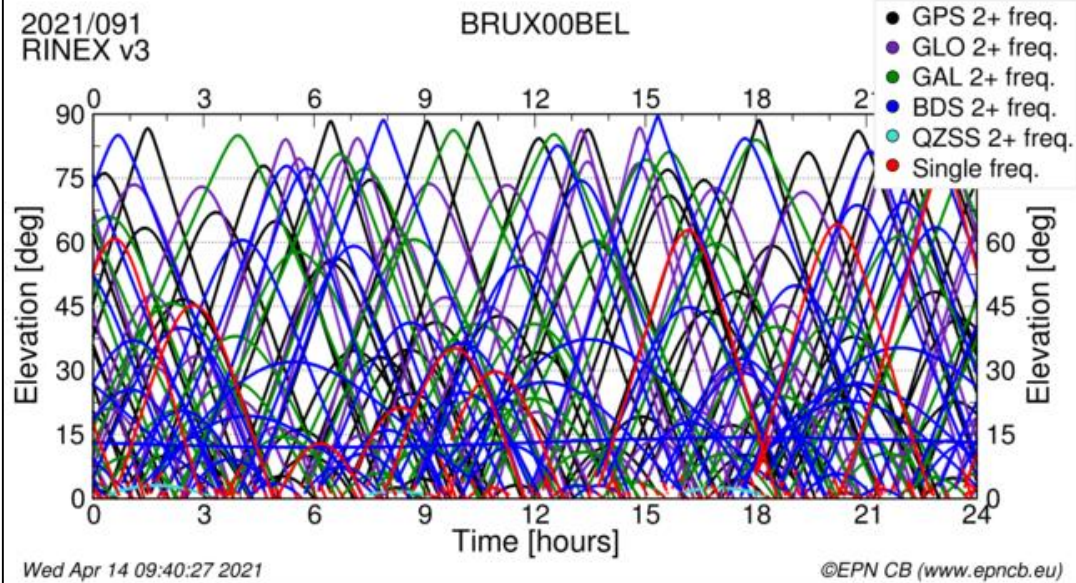


# News

- New RINEX format 3.05 published on 1 December, 2020  
<http://epncb.oma.be/documentation/formats/rinex.php>

# News

- New RINEX format 3.05 published on 1 December, 2020  
[http://epncb.oma.be/\\_documentation/formats/rinex.php](http://epncb.oma.be/_documentation/formats/rinex.php)
- Monthly sky plots per constellation



ROYAL  
OBSERVATORY  
OF BELGIUM

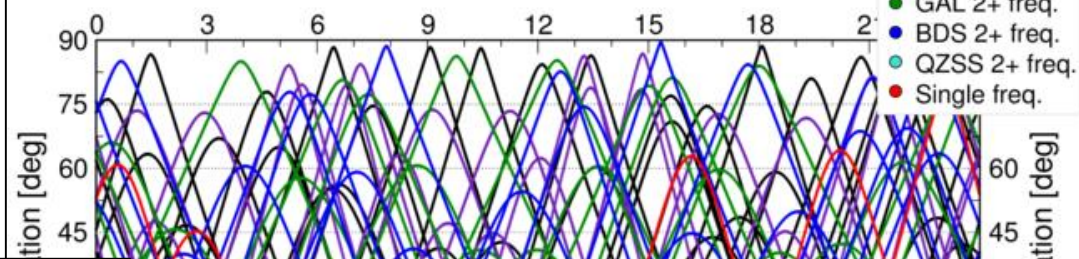
EUREF Symposium, 26-28/05/2021, Ljubljana, Slovenia



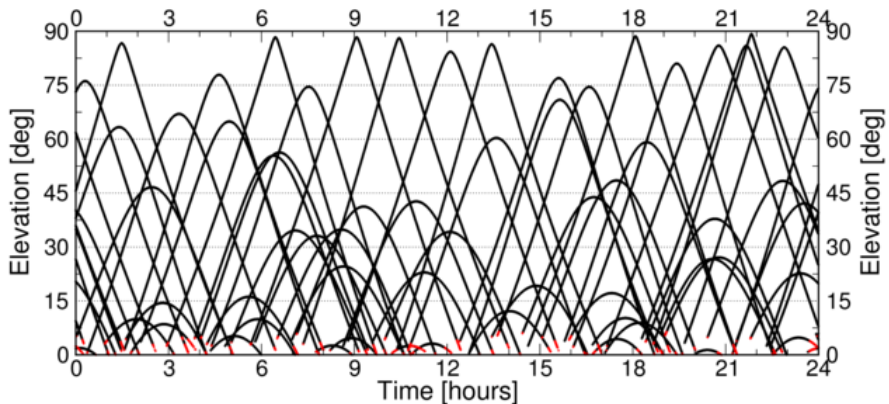
EUREF2021

2021/091  
RINEX v3

BRUX00BEL

2021/091  
RINEX v3

BRUX00BEL

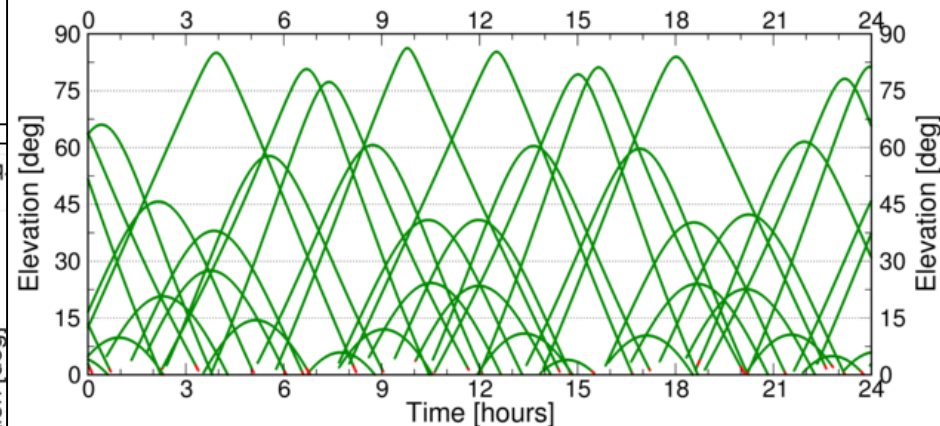


Wed Apr 14 09:40:29 2021

©EPN CB (www.epncb.eu)

2021/091  
RINEX v3

BRUX00BEL

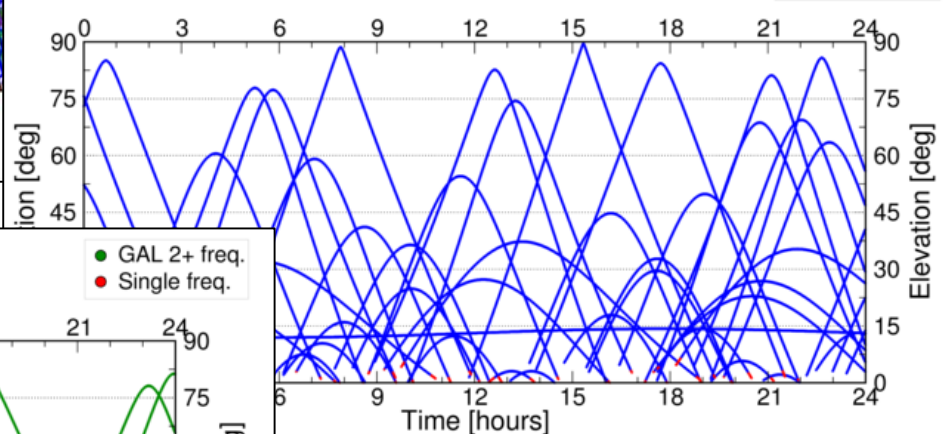


Wed Apr 14 09:40:32 2021

©EPN CB (www.epncb.eu)

2021/091  
RINEX v3

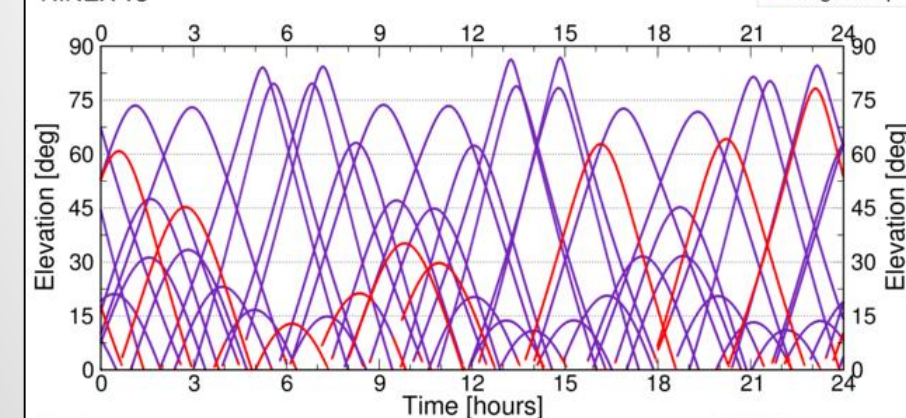
BRUX00BEL



©EPN CB (www.epncb.eu)

2021/091  
RINEX v3

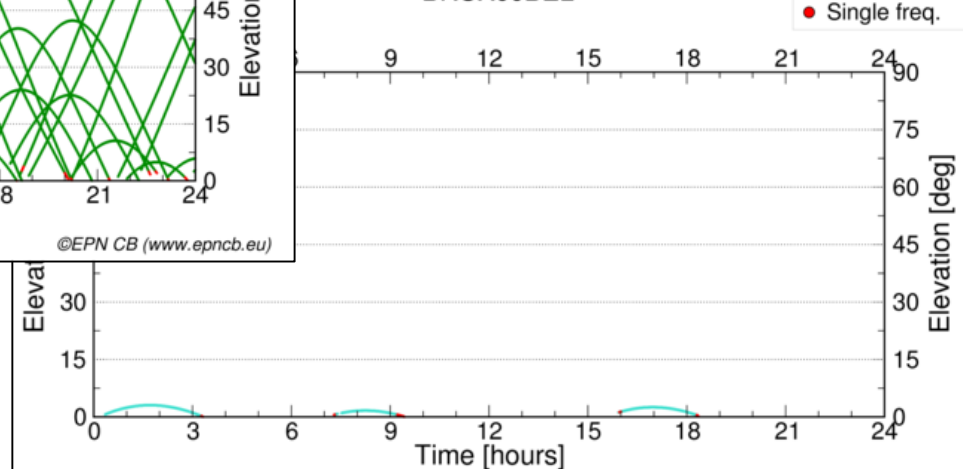
BRUX00BEL



Wed Apr 14 09:40:31 2021

©EPN CB (www.epncb.eu)

BRUX00BEL



Wed Apr 14 09:40:34 2021

©EPN CB (www.epncb.eu)

# News

- New RINEX format 3.05 published on 1 December, 2020  
[http://epncb.oma.be/\\_documentation/formats/rinex.php](http://epncb.oma.be/_documentation/formats/rinex.php)
- Monthly sky plots per constellation
- API for coordinate transformation

# API for on-line coordinate transformation

Home / Products & Services / Services / ETRF/ITRF Transformation

## ETRF/ITRF Transformation

The form below allows to transform on-line coordinates (position and velocity) between realisations (ETRFxx) of the [European Terrestrial Reference System \(ETRS89\)](#) and realizations (ITRFyy) of the [International Terrestrial Reference System \(ITRS\)](#). In case input and output coordinates are requested at different epochs, then station velocities are mandatory. For transformations to and from the Galileo Terrestrial Reference Frame (GTRF), use ITRF. GTRF is aligned to current versions of the ITRF.

Explanation and examples are available from the following [tutorial](#).

### Input

Frame :

Epoch :  .

```
# Lines starting by # are treated as comments
# Fields (in decimal format) should be separated by at least one space
#
# --> Example without velocity - StationName(no space character) X[m] Y[m] Z[m] :
StationName 4027894.006 307045.600 4919474.910
#
# --> Example with velocity - StationName(no space character) X[m] Y[m] Z[m] VX[m/yr] VY[m/yr] VZ[m/yr] :
StationName 4027894.006 307045.600 4919474.910 0.01 0.2 0.03
```

### Output

Frame :

Epoch :  .

### Options

☐ show intermediate steps

Change epoch format:

[http://epncb.oma.be/\\_productsservices/coord\\_trans/](http://epncb.oma.be/_productsservices/coord_trans/)

**Test API** created for coordinate transformation

Interested to test and help to improve API?

Contact [epncb@oma.be](mailto:epncb@oma.be)

# News

- New RINEX format 3.05 published on 1 December, 2020  
[http://epncb.oma.be/\\_documentation/formats/rinex.php](http://epncb.oma.be/_documentation/formats/rinex.php)
- Monthly skyplots per constellation
- API for coordinate transformation
- Station picture submission moved from EPN CB to M<sup>3</sup>G <https://gnss-metadata.eu>

# Conclusions

EPN = Full multi-GNSS network of 363 stations

- Real-time streams
  - Number of real-time streams stable (50%), multi-GNSS in real-time stream increases
  - Reference **coordinates in real-time streams not always reliable!**
- EUREF station managers are urged to **subscribe to EUREF mail** (send mail to [epncb@oma.be](mailto:epncb@oma.be))
  - Changes at EPN data centers!
  - Issues with specific receivers/firmware
  - EPN guidelines/recommendations
- Few data quality issues
  - **Lower-channel receivers** continue to struggle with increasing number of Galileo satellites
  - Slow improvement of BeiDou tracking thanks to modernization of equipment

*Thanks to all EPN station managers for their support to the EPN*

**Contact:**

Carine Bruyninx

[C.Bruyninx@oma.be](mailto:C.Bruyninx@oma.be)

EPN Central Bureau

[epncb@oma.be](mailto:epncb@oma.be)

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

B-1180 Brussels

BELGIUM



GNSS@ROB activities are



supported by the Solar-terrestrial Centre of Excellence



receiving funding from EU's H2020 research and innovation programme (GA 871121)



receiving funding from Belgian Science Policy Office (GA FSIRI/33/EPI).