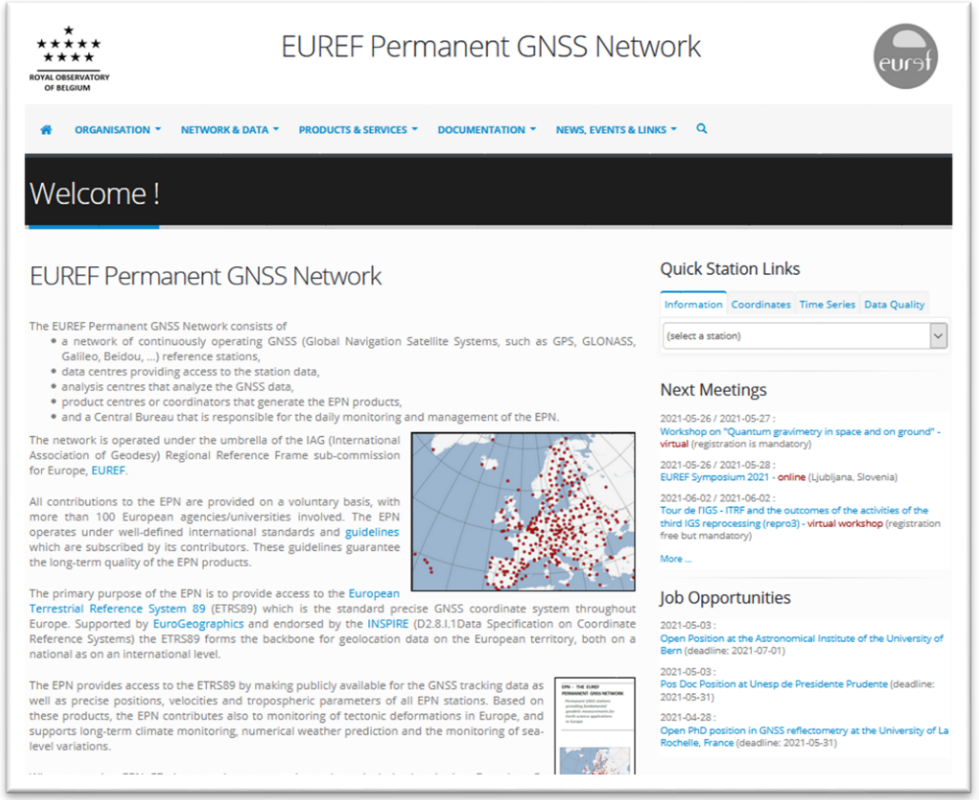
Performance of the EUREF Permanent GNSS Network

Carine Bruyninx, J. Legrand, A. Fabian

Royal Observatory of Belgium

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

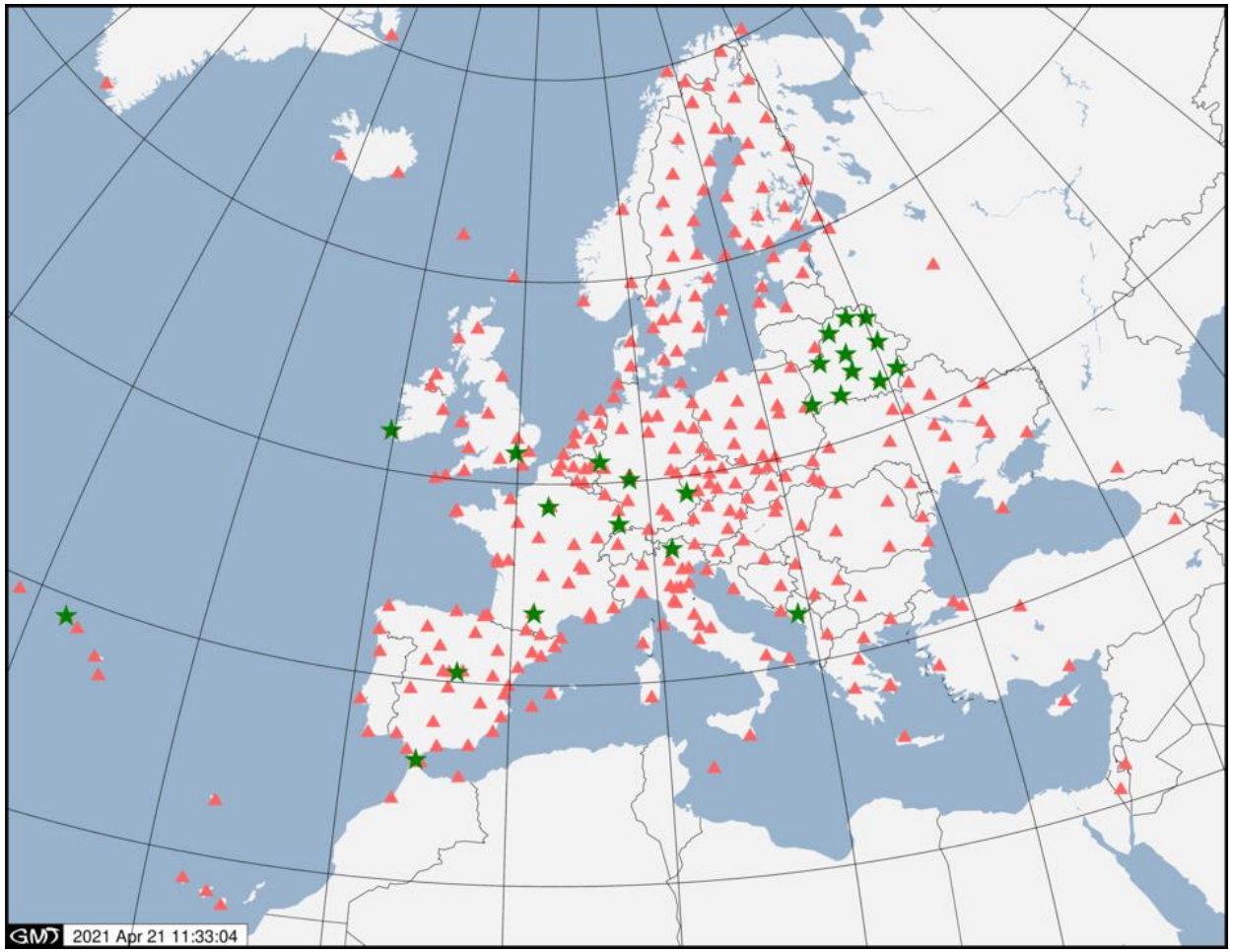


Changes in station network since May 2019

363 EPN stations

★ 28 new EPN stations

First EPN stations in Montenegro and Belarus!

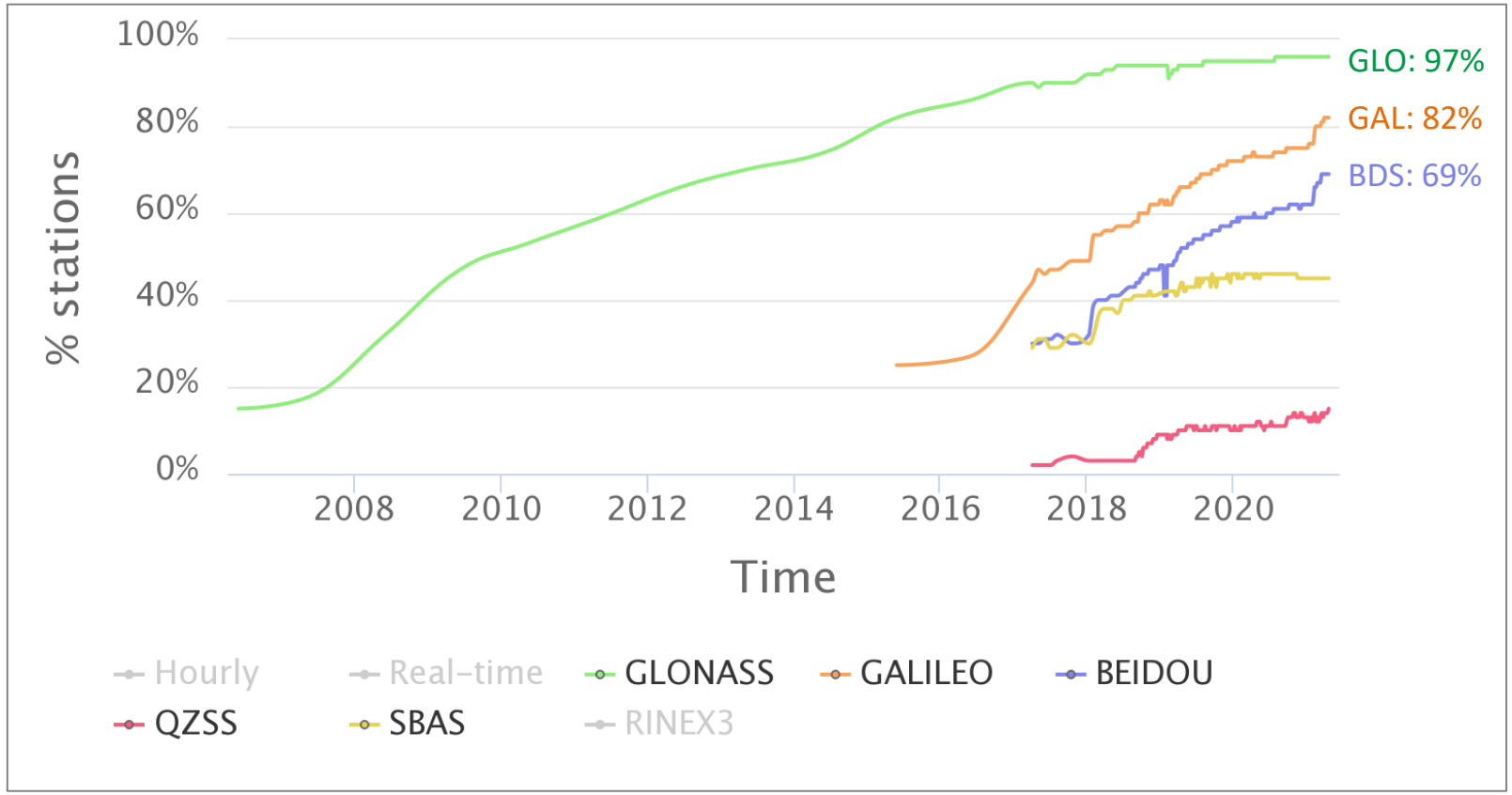


Decommissioned stations:
BZRG00ITA, CASB00IRL, EDIN00GBR, PFA200AUT, TARI00ESP

Inactive stations
BISK00CZE, VACO00CZE, DYNG00GRC, ELBA00ITA, UNTR00ITA, ENIS00GBR

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

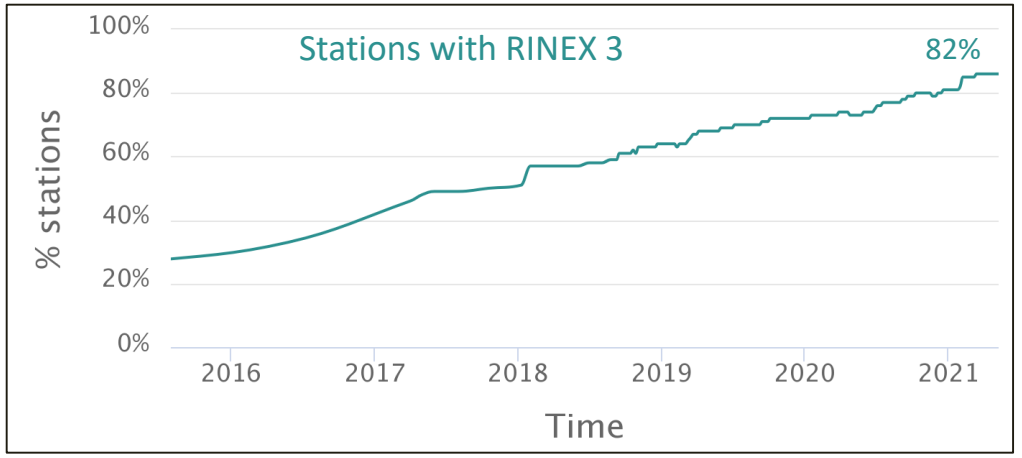
Tracked Constellations

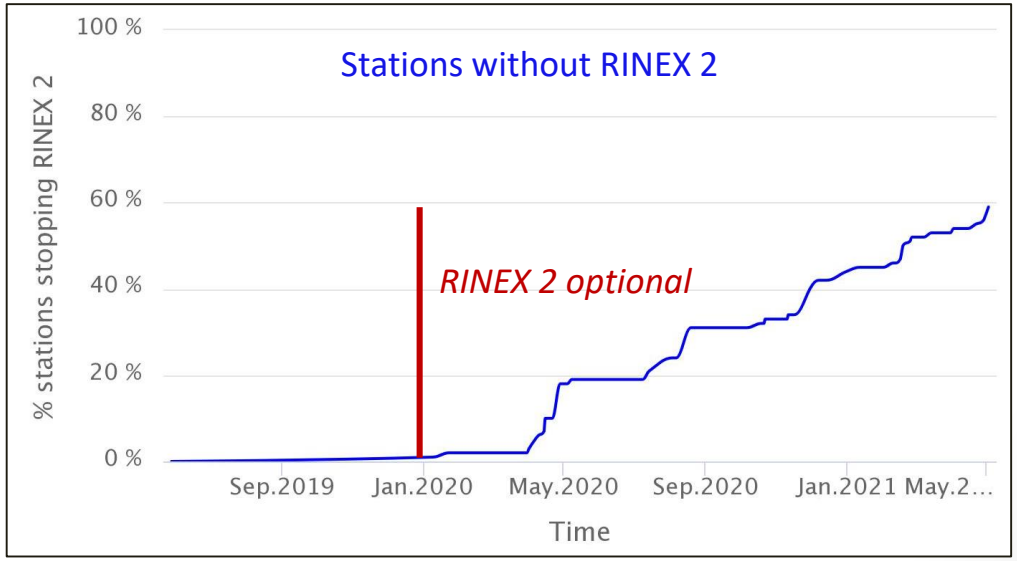


RINEX format

From 1st 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

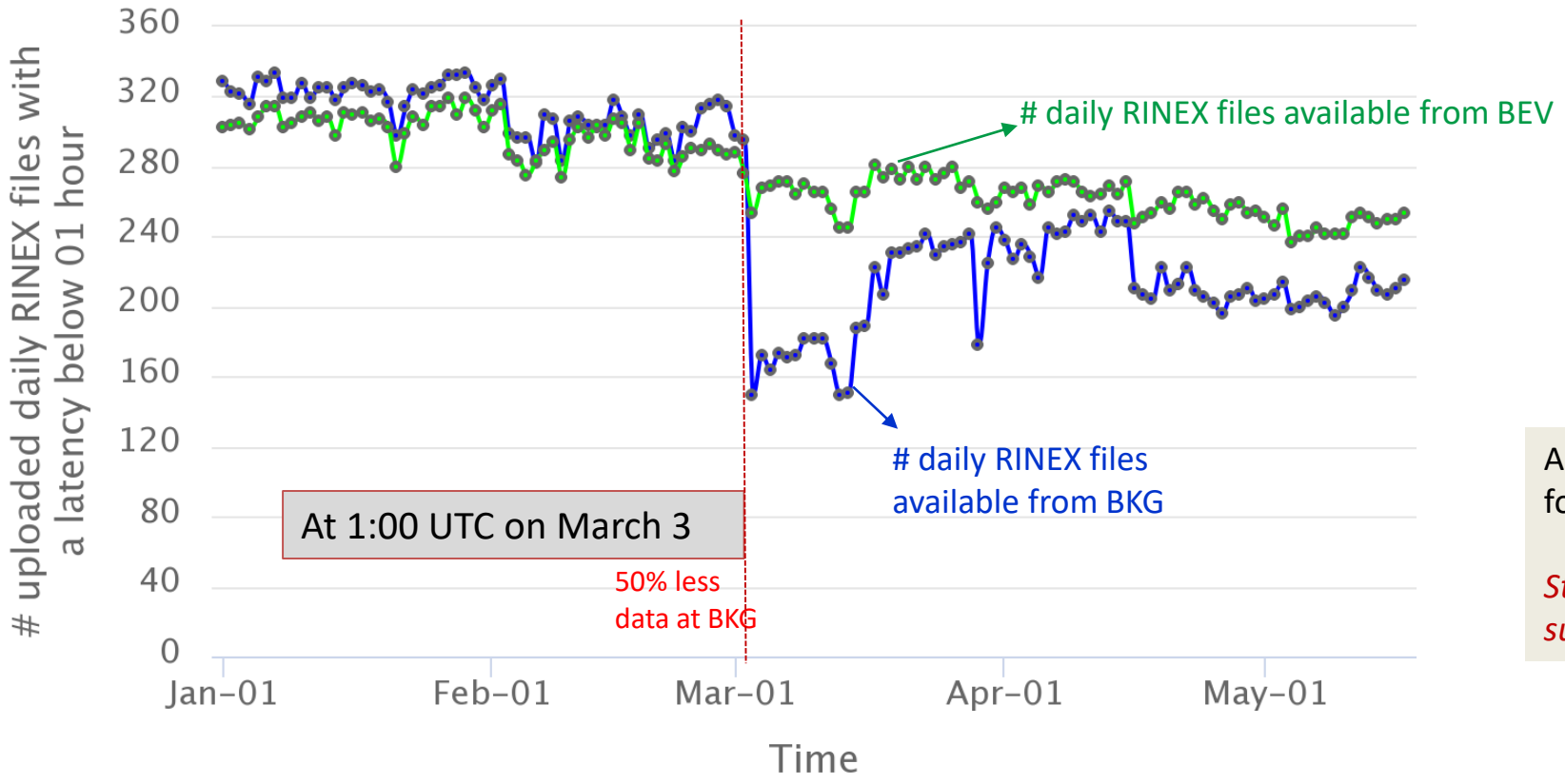




ROYAL OBSERVATORY OF BELGIUM

Availability of daily RINEX data

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



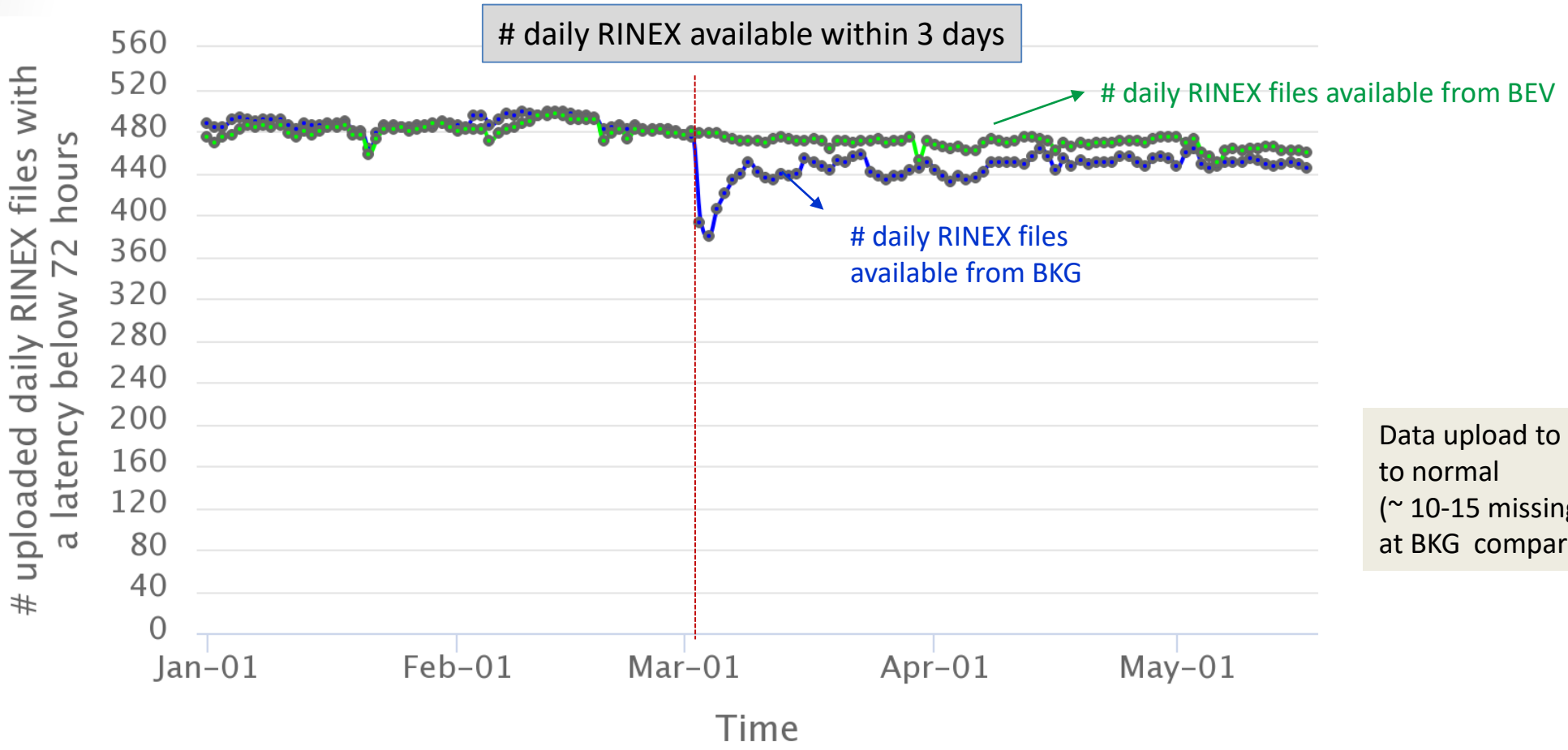
A lot of stations were not ready for switch to sftp!

Station managers should subscribe to EUREF mail

ROYAL OBSERVATORY OF BELGIUM

Availability of daily RINEX data

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



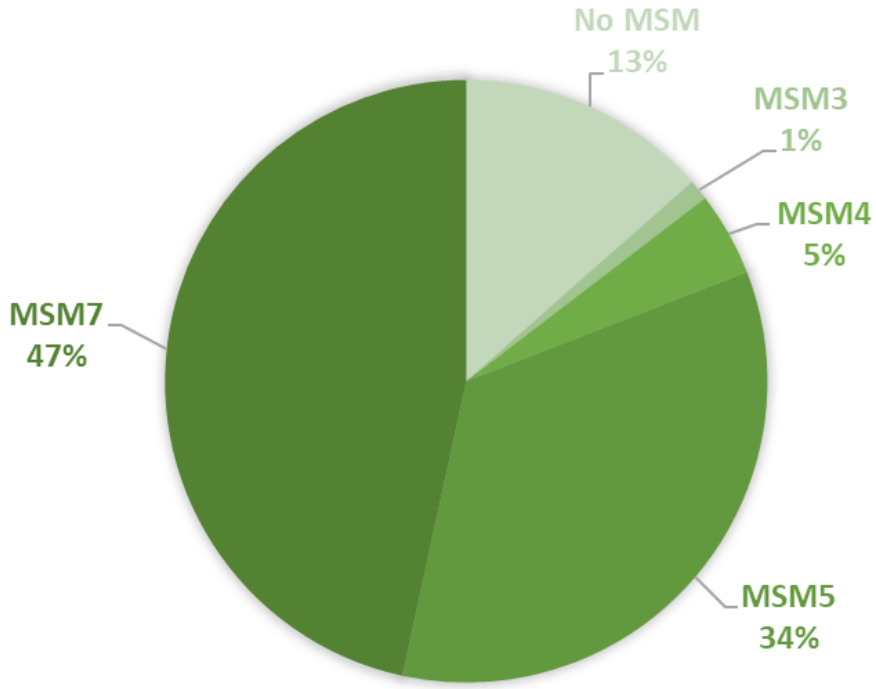
Data upload to BKG almost back to normal
(~ 10-15 missing daily data files at BKG compared to BEV)

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, with high resolution

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

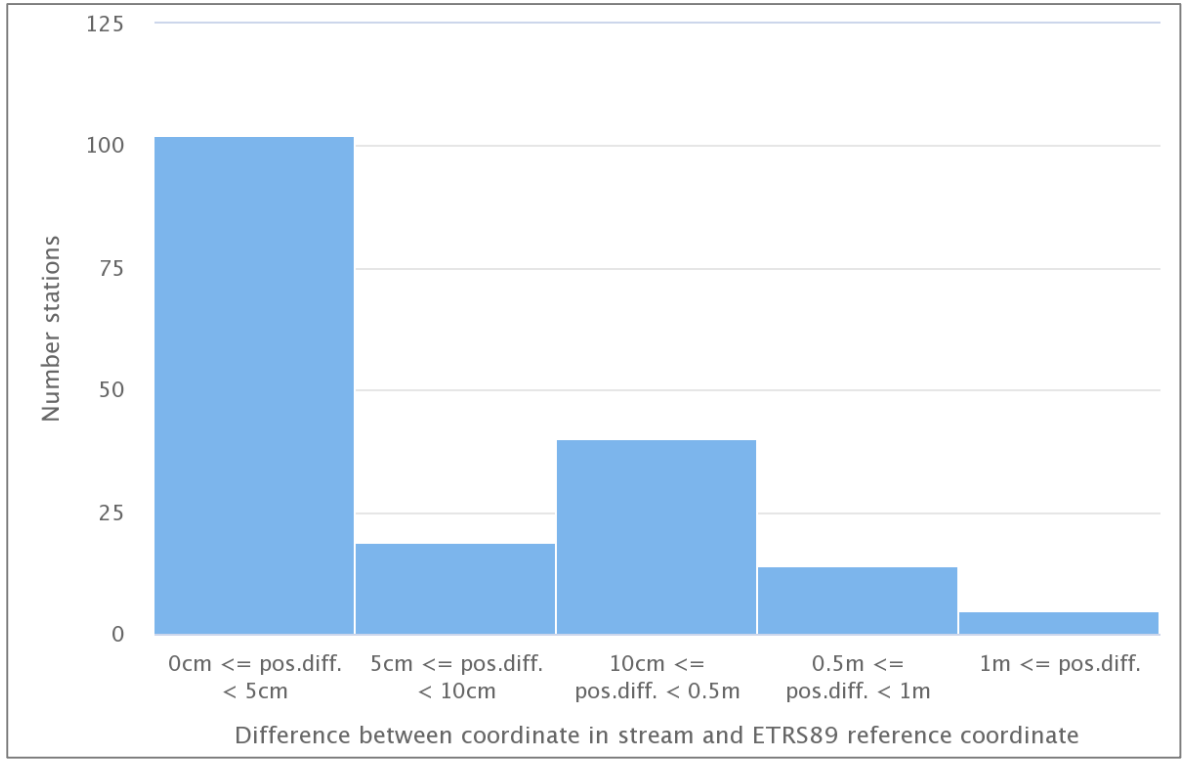
Access to ETRS89 requires reliable ETRS89 positions in stream

20-Jan-2020 EUREF mail 10121 Reminder: ETRS89 coordinates in real-time EPN data streams

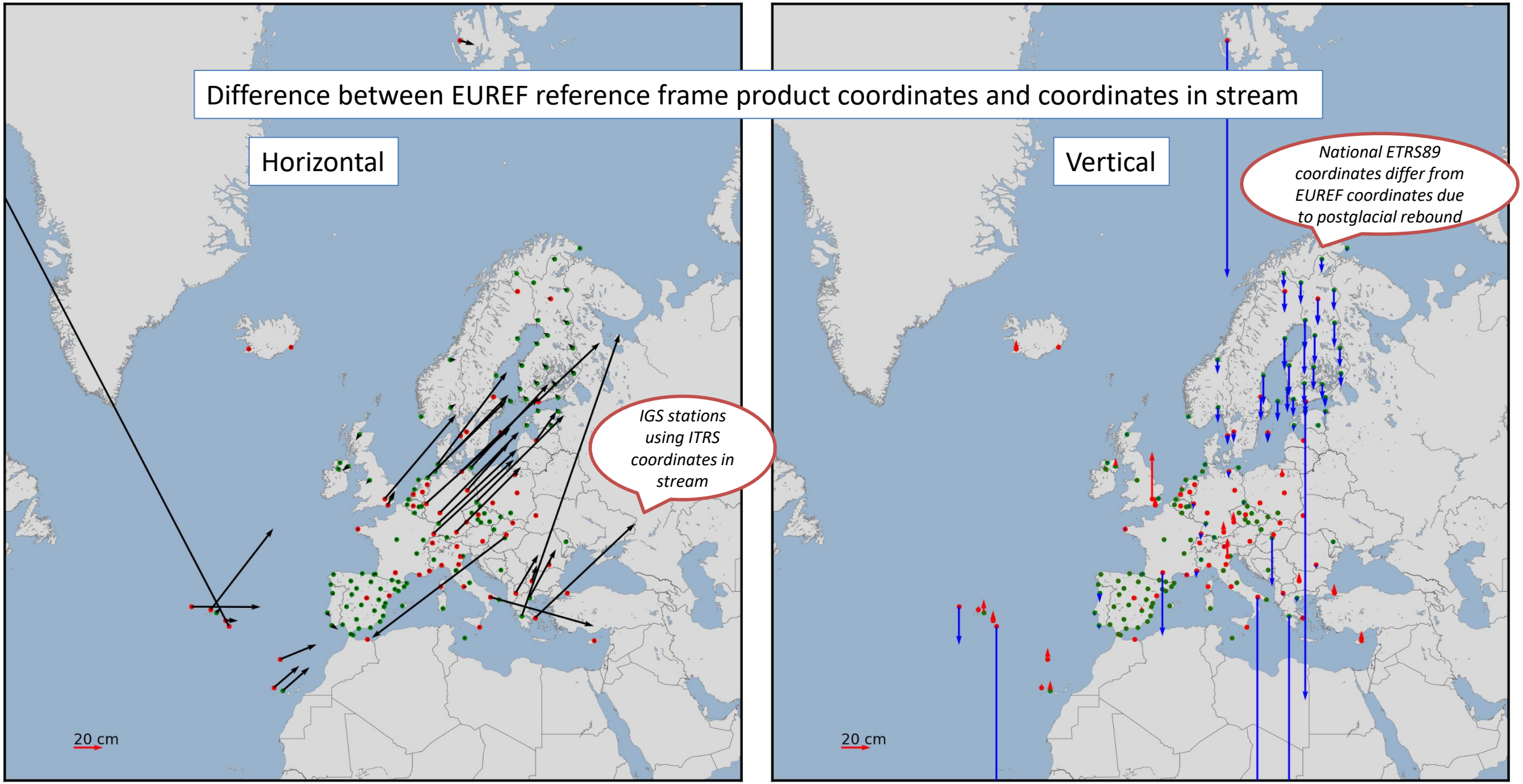
- 14 streams with more than 50 cm position deviation from ETRS89
- 78 streams with more than 5 cm position deviation from ETRS89

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



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.

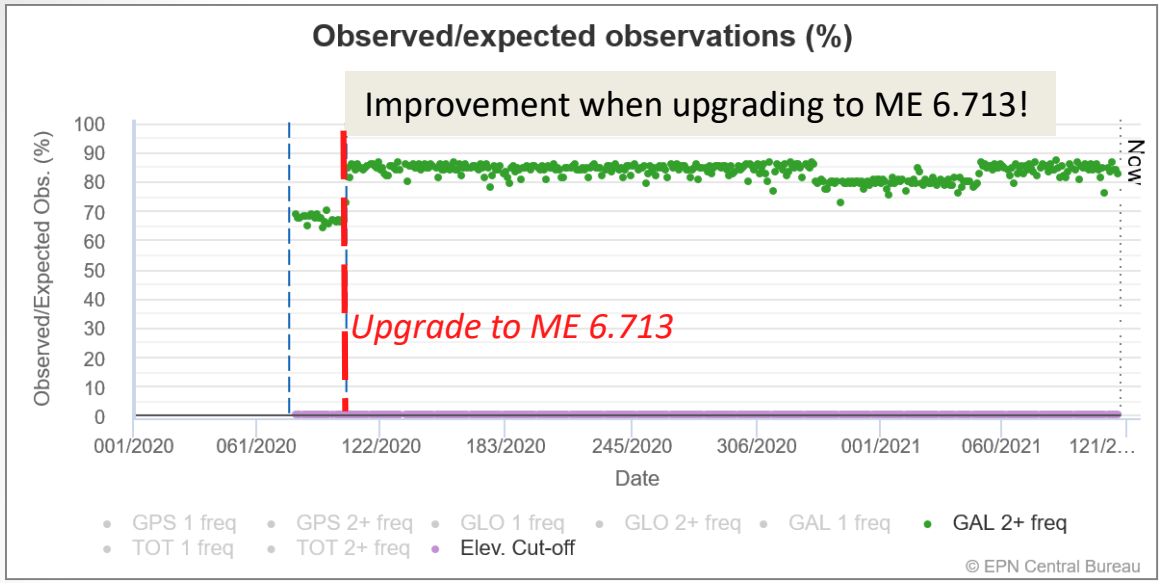
***Solution** provided by LEICA:*
- *Update to ME FW 6.713*
- *deactivate BeiDou, L2C (GPS, GLO)*

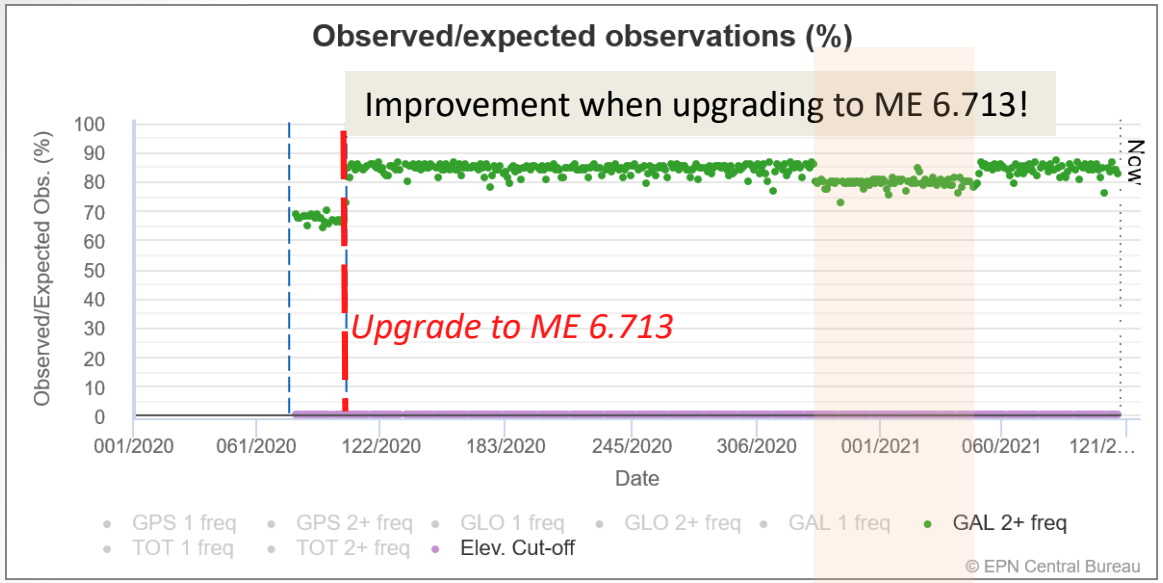
EUREF symposium 2021:
Based on site log info and/or quality checks

We suspect that the following EPN stations need to implement proposed solutions:
(status end of April 2021!)

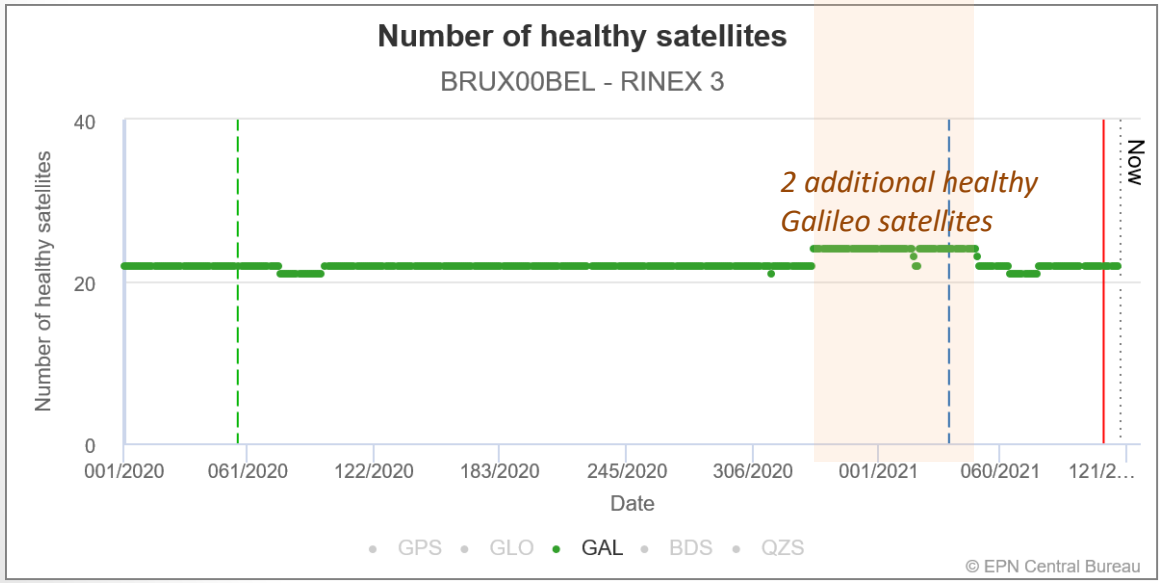
```
CNIV00UKR DNMU00UKR GSR100SVN POLV00UKR PRYL00UKR IGEO00MDA MIKL00UKR MARP00UKR

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

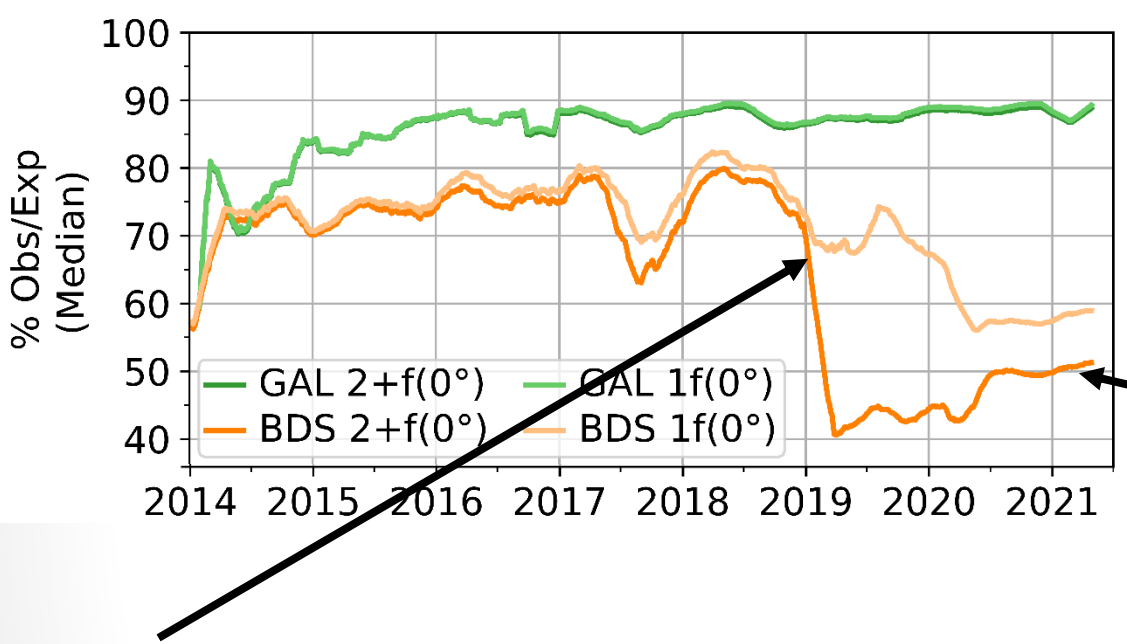




But even with ME 6.713 …



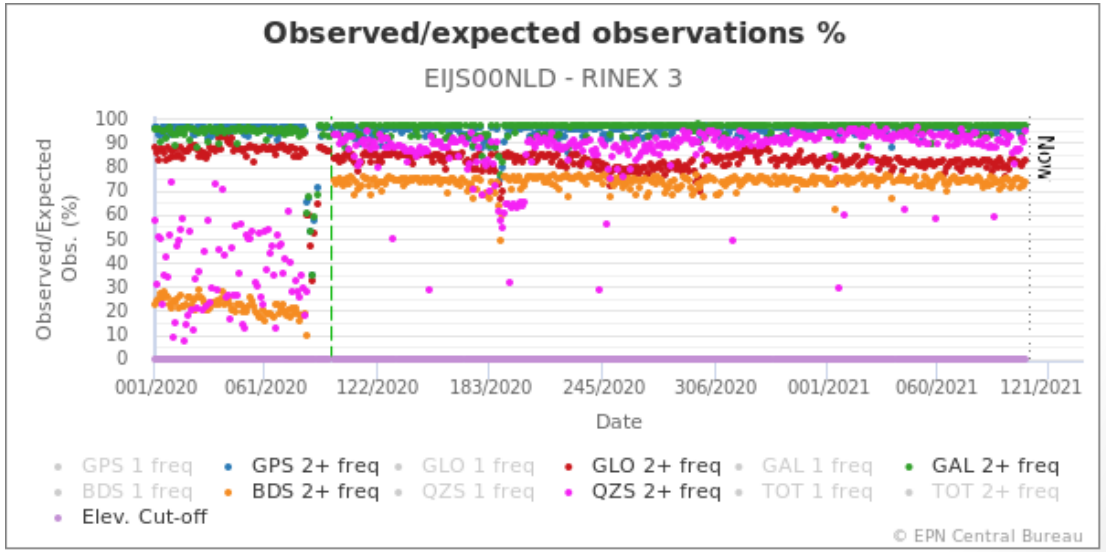
EPN Data Quality – *BeiDou tracking*



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

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



News

- New RINEX format 3.05 published on 1 December, 2020

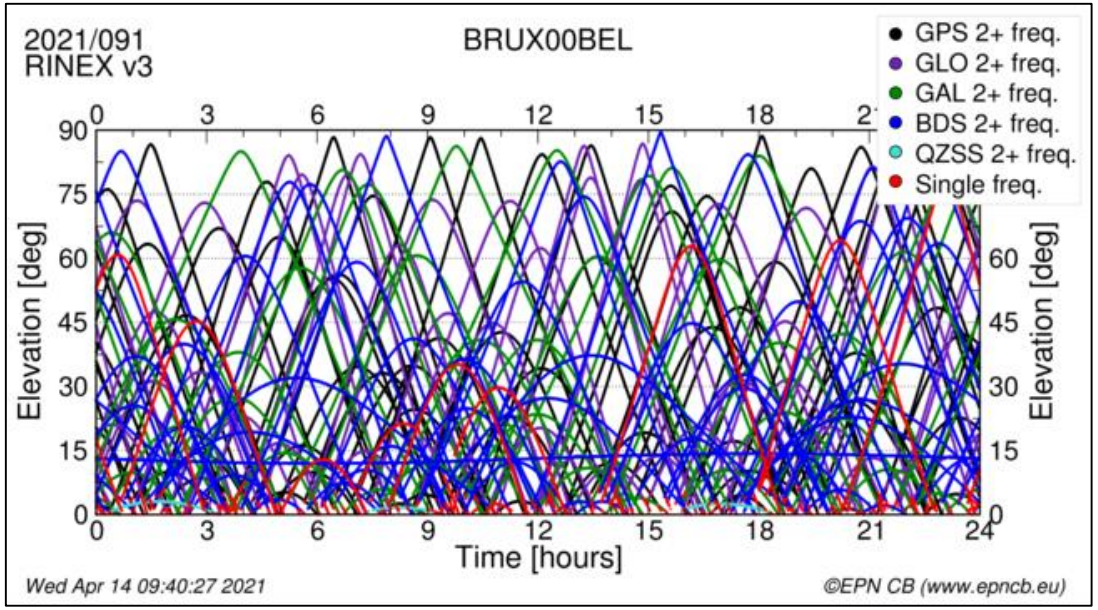
  http://epncb.oma.be/_documentation/formats/rinex.php

News

- New RINEX format 3.05 published on 1 December, 2020

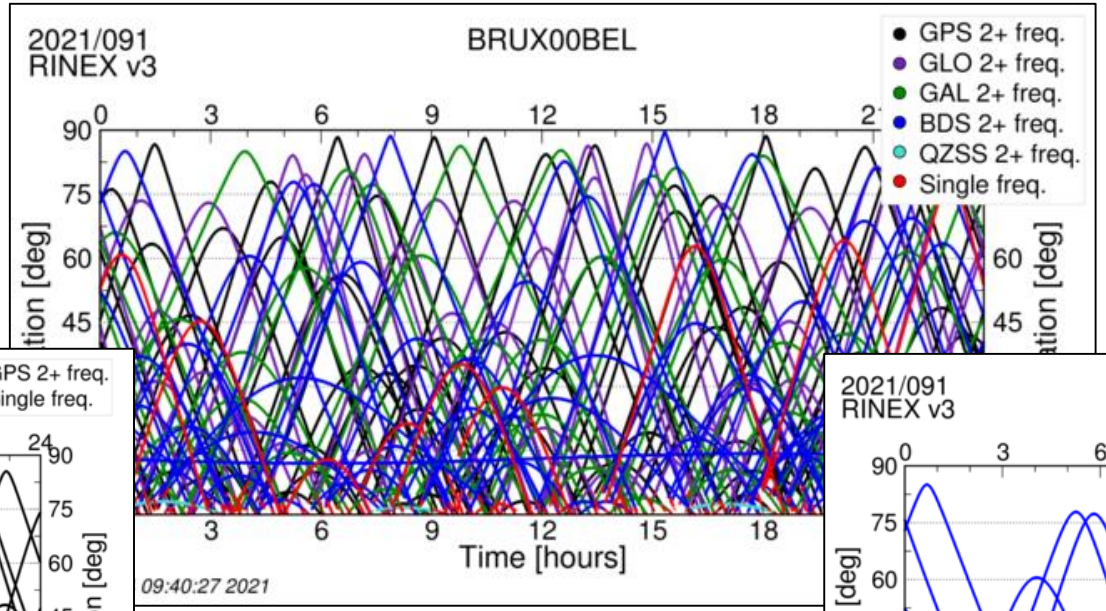
  http://epncb.oma.be/_documentation/formats/rinex.php

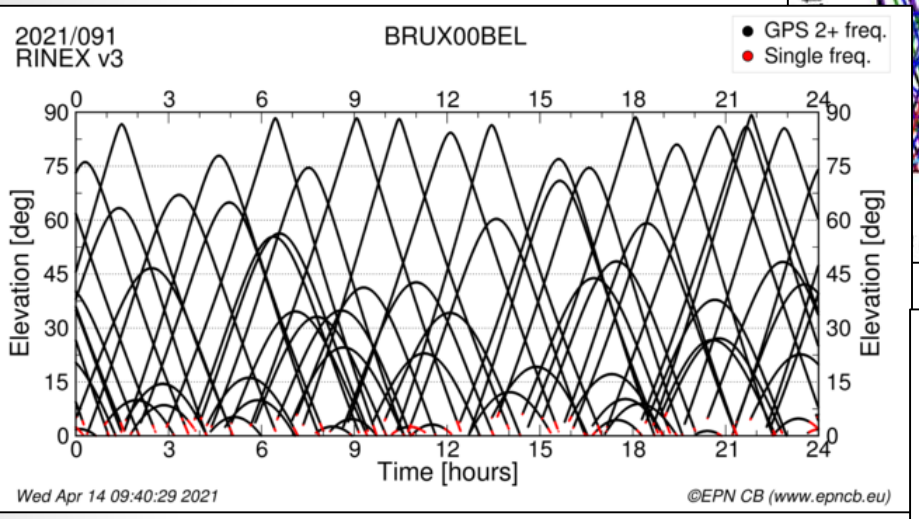
- Monthly sky plots per constellation

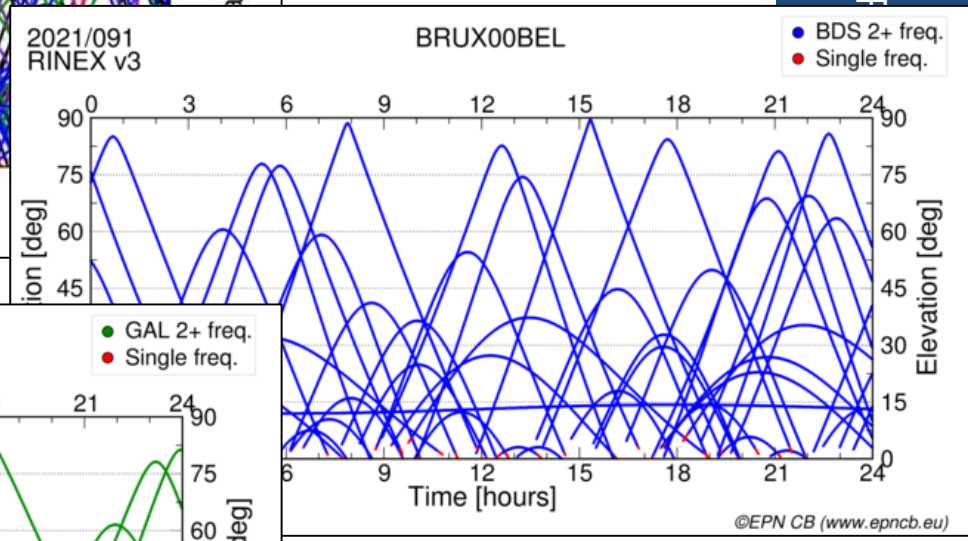

2021/091
RINEX v3
BRUX00BEL
GPS 2+ freq.
GLO 2+ freq.
GAL 2+ freq.
BDS 2+ freq.
QZSS 2+ freq.
Single freq.
Elevation [deg]
Time [hours]
Wed Apr 14 09:40:27 2021
©EPN CB (www.epncb.eu)

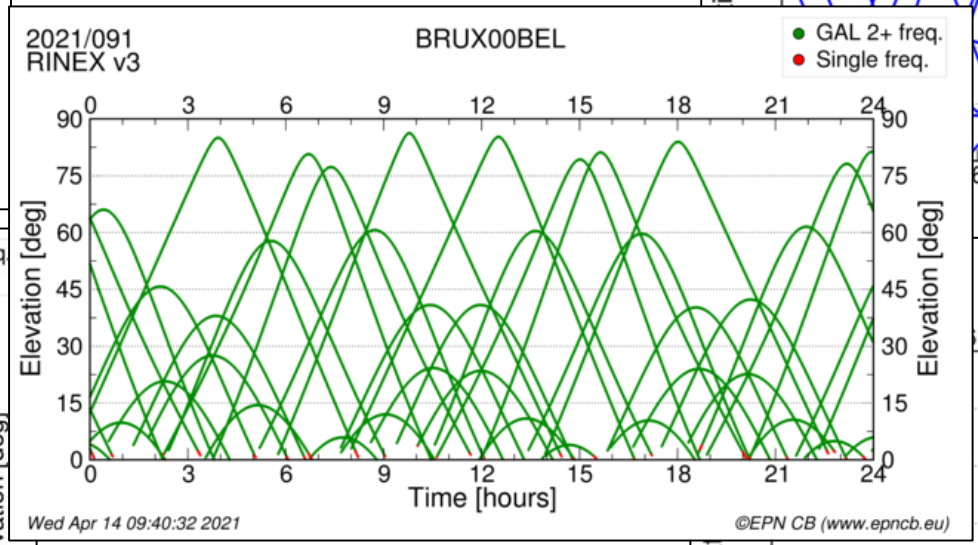
ROYAL OBSERVATORY OF BELGIUM

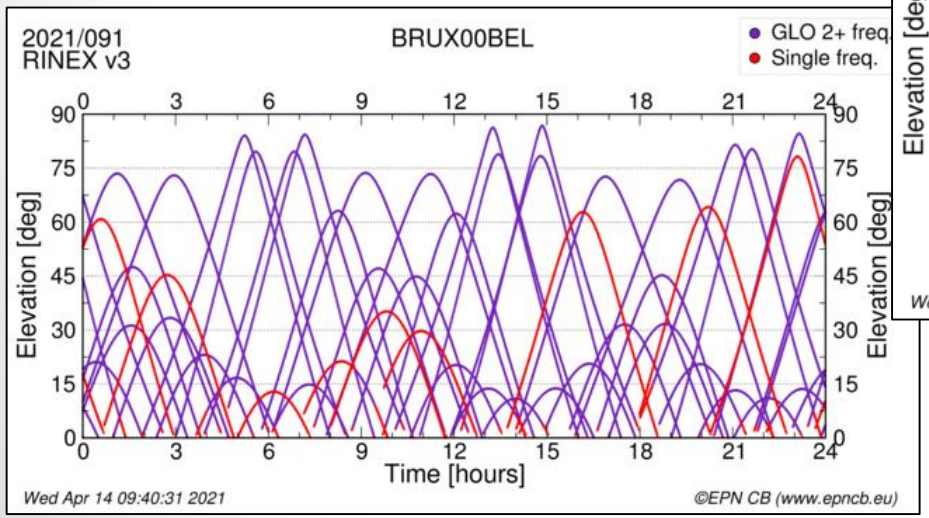
EUF

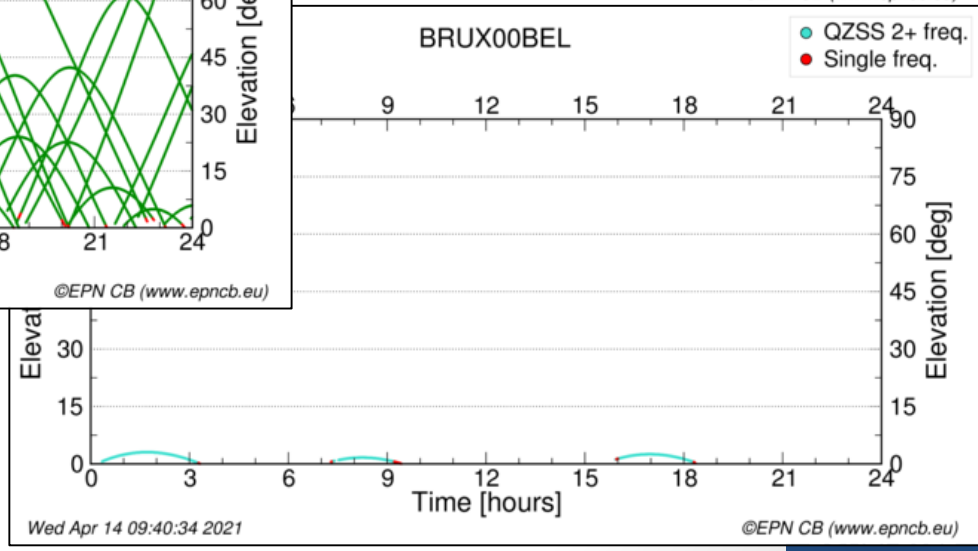












News

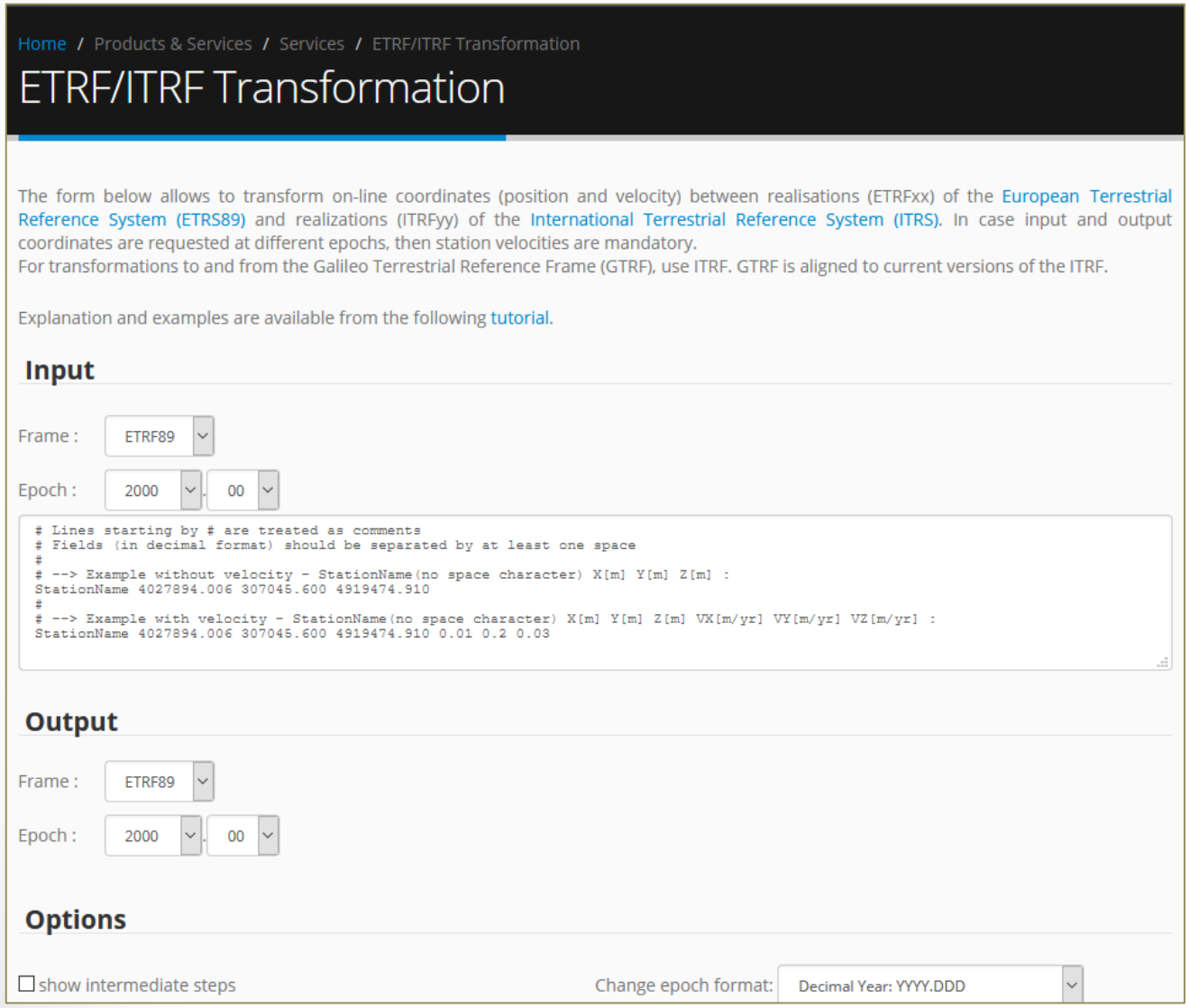
- New RINEX format 3.05 published on 1 December, 2020

  http://epncb.oma.be/_documentation/formats/rinex.php

- Monthly sky plots per constellation

- API for coordinate transformation

API for on-line coordinate transformation



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

News

- New RINEX format 3.05 published on 1 December, 2020

  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^{3}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)
  - 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

EPN Central Bureau
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).

ROYAL OBSERVATORY OF BELGIUM

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

EUREF2021