# Performance of the EUREF Permanent GNSS Network

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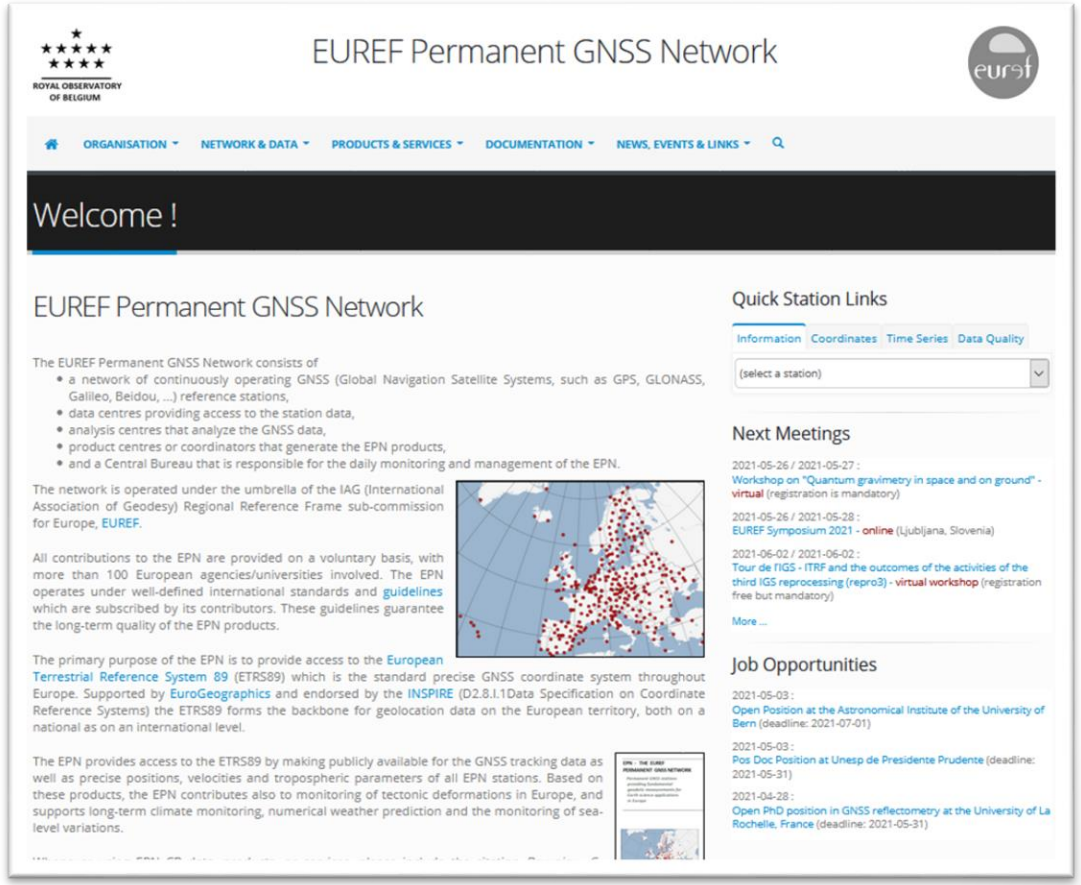
A. Miglio, F. Bamahry, E. Pottiaux

*Royal Observatory of Belgium*






ROYAL OBSERVATORY OF BELGIUM
EUREF Symposium, June 5-7,2024, Barcelona, Spain
EUREF2024

# Outline

- Status of EPN tracking network
- Changes at the EPN CB
- Follow-up on EUREF resolutions
- Summary

# New EPN stations since June 2023

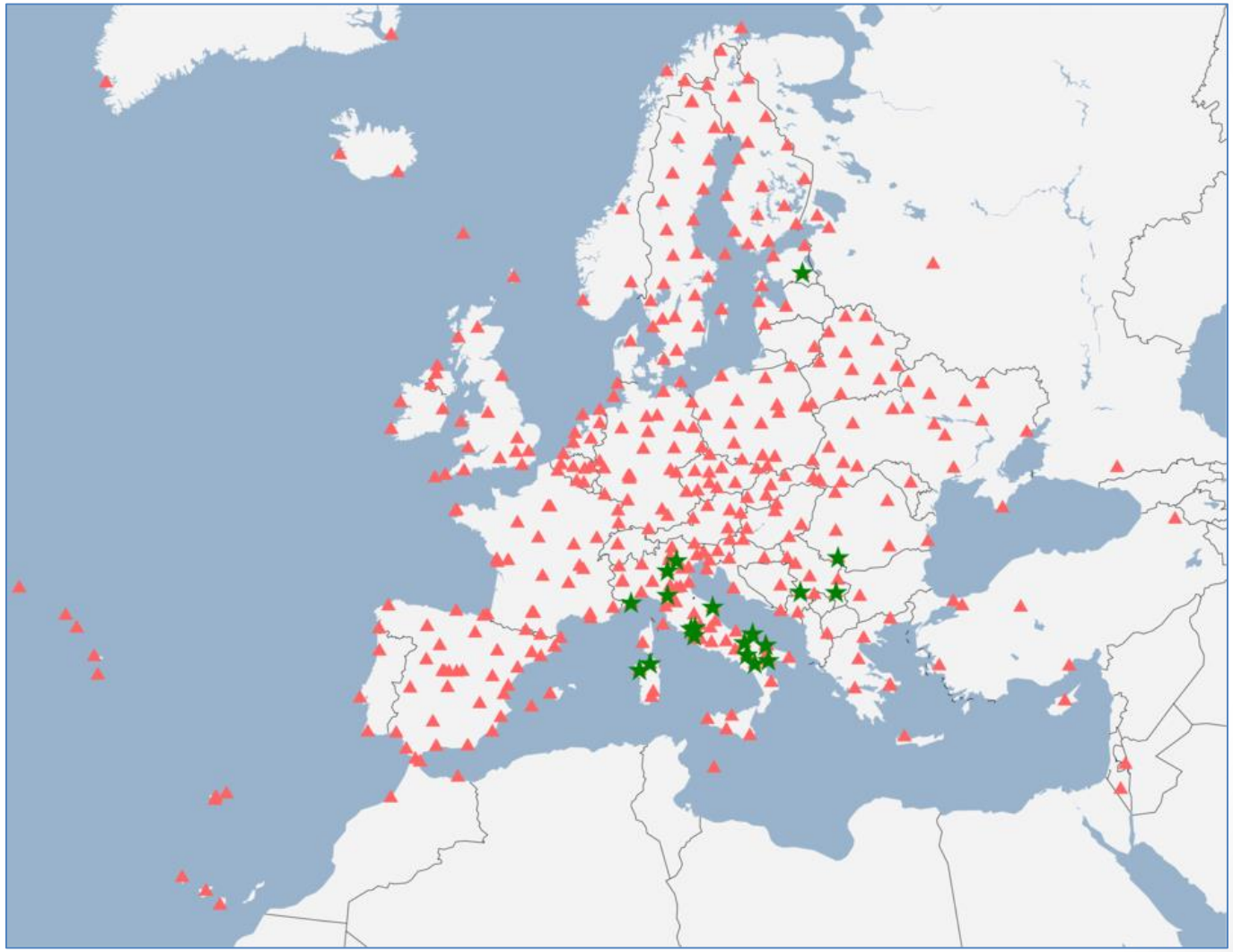
**424 EPN stations**

22 new EPN stations

CIMO00ITA, CMEL00ITA, CUGA00ITA, EKAR00ITA,
JATE00ITA, KLAD00SRB, KLSQ00GRL, LCRA00ITA,
LESK00SRB, MDEU00ITA, MMET00ITA, ORTE00ITA,
PALB00ITA, POPI00ITA, PRIJ00SRB, THU200GRL,
TOPP00ITA, TOR300EST, VIGI00ITA, VIGN00ITA,
VLFR00ITA, VTRB00ITA

Serbia
Italy
Estonia
Greenland

| | 2022 | | 2023 | | 2024 |
|---|---|---|---|---|---|
| GLO: | 97% | → | 97% | → | 97% |
| GAL: | 88% | → | 89% | → | 91% |
| BDS: | 76% | → | 78% | → | 81% |

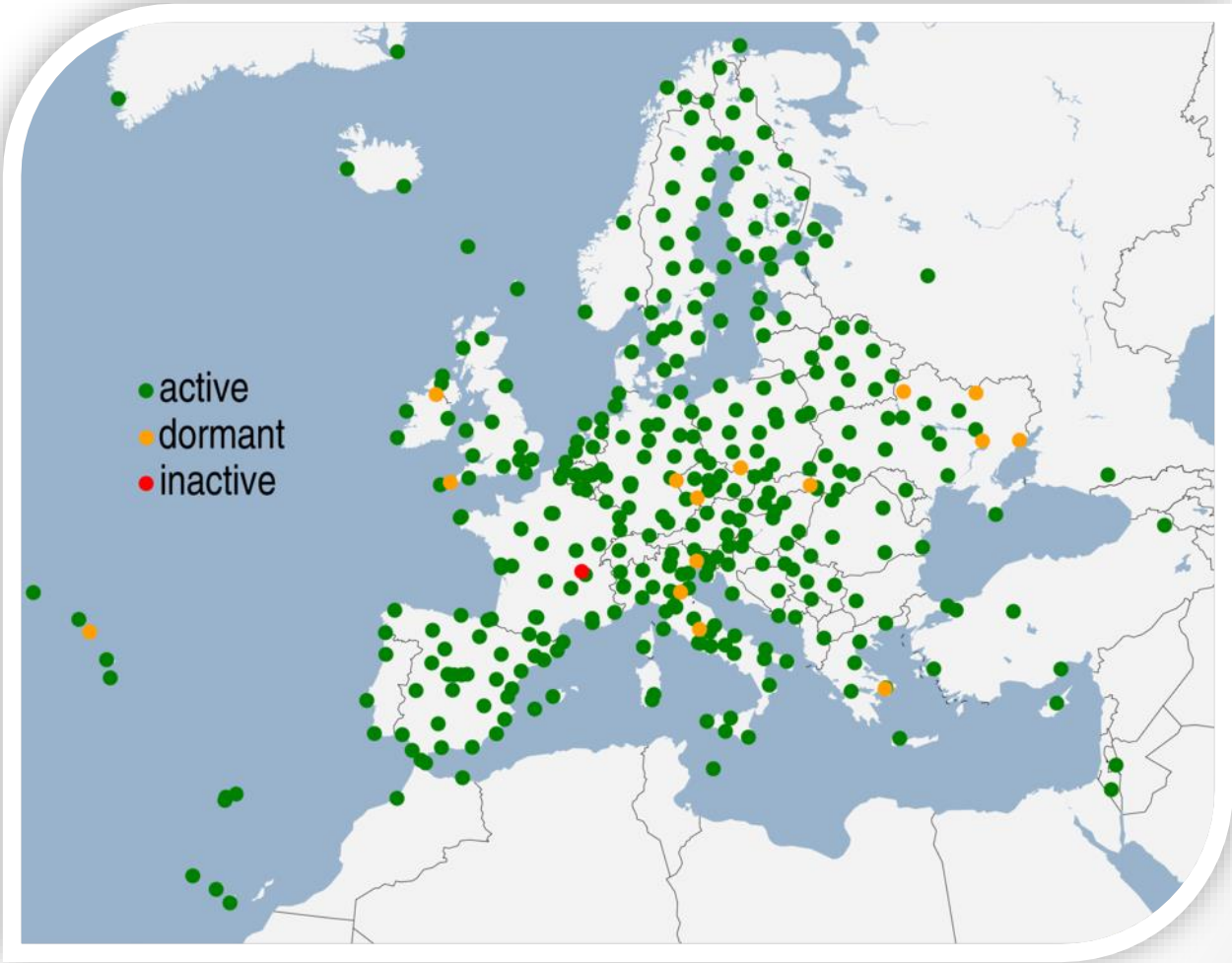


*Status May 24, 2024*

# Station status

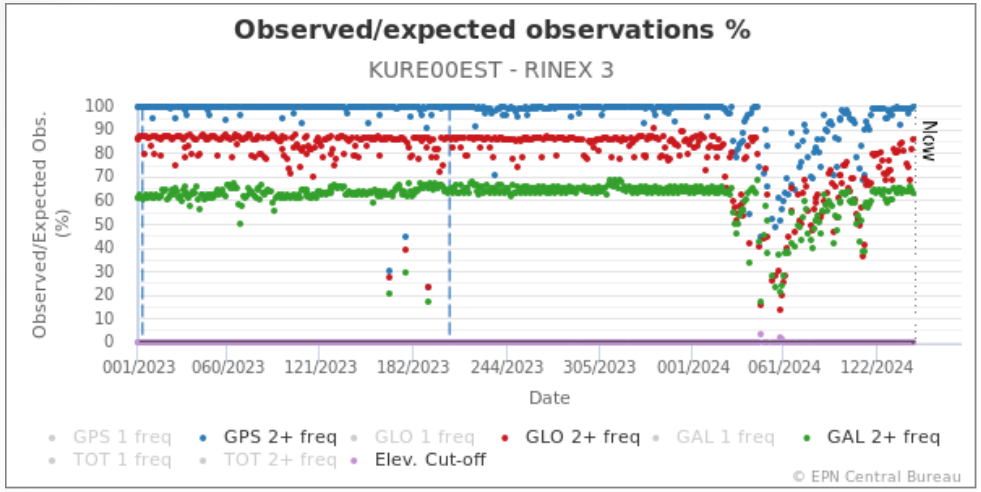
- **424 EPN stations**
  - **Dormant stations** (14)
    - No data in last 3 months
    - Ukraine, no replies to emails, no resources
  - **Inactive stations** (1)
    - no receiver or antenna currently installed
    - SJDV00FRA (construction work)

- 2 additional decommissioned stations:
  - PLND00SRB (antenna mount)
  - VNRS00UKR (operations stopped)

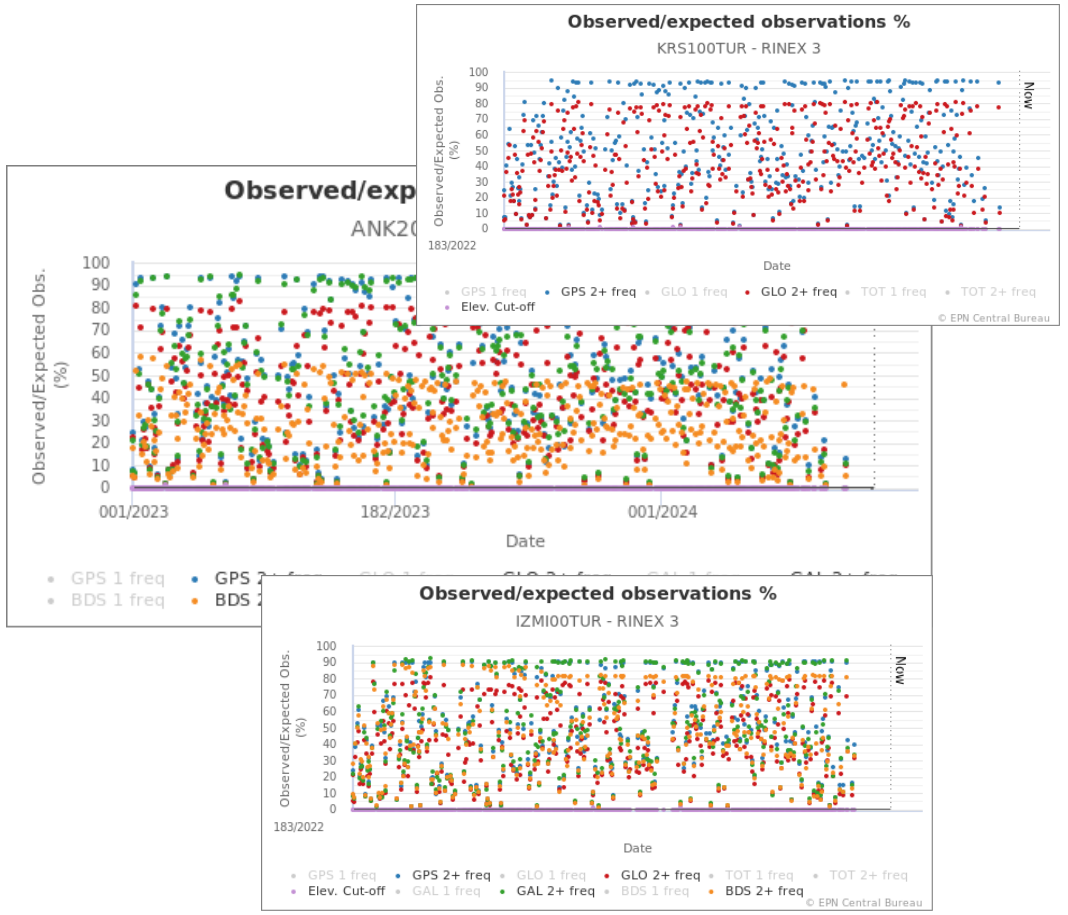



*Status May 24, 2024*

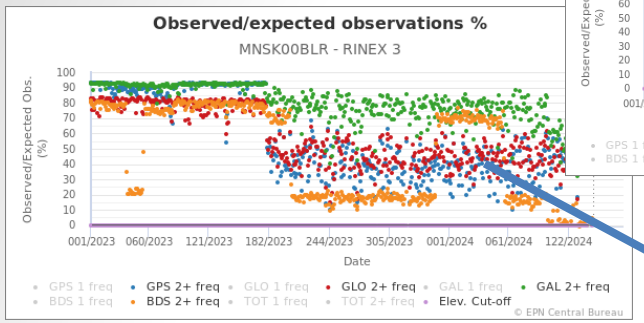
# Few tracking problems

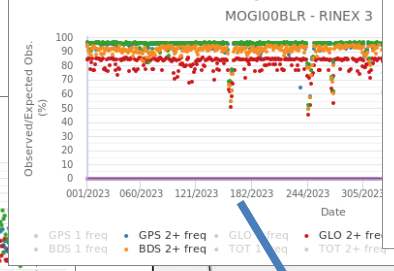


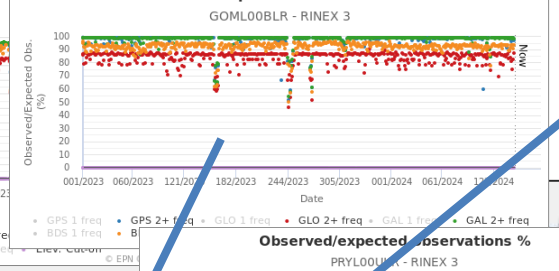

Damaged antenna cable

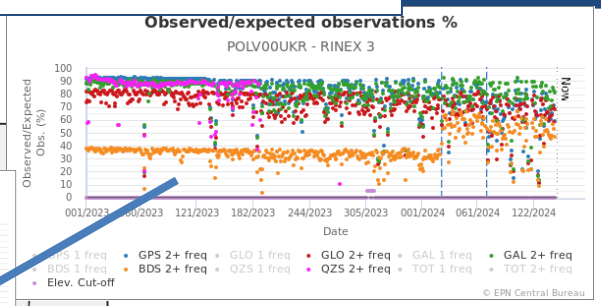


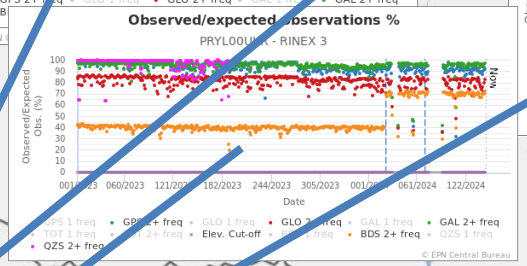
No data since end Feb 2022

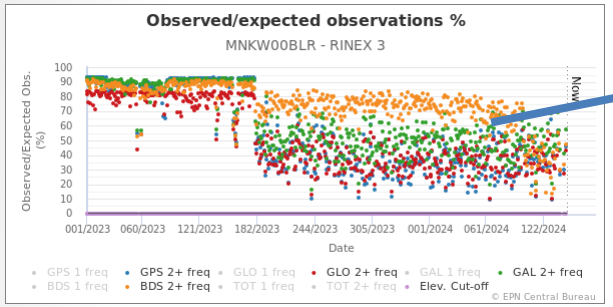


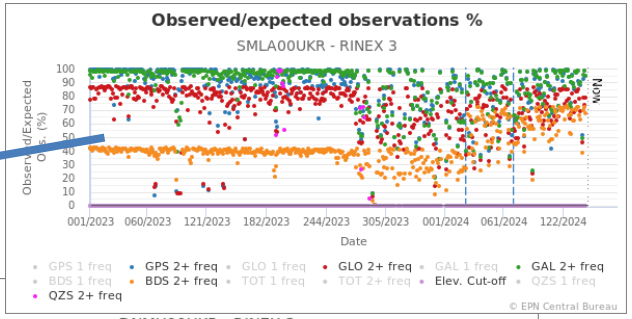



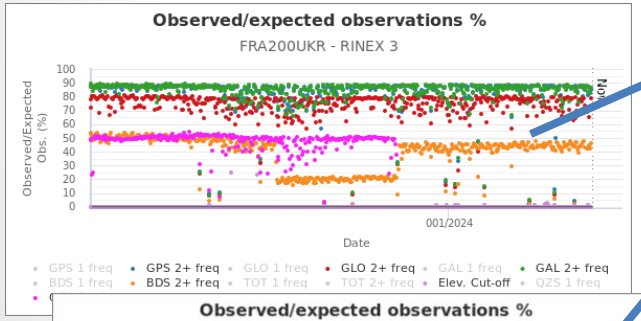



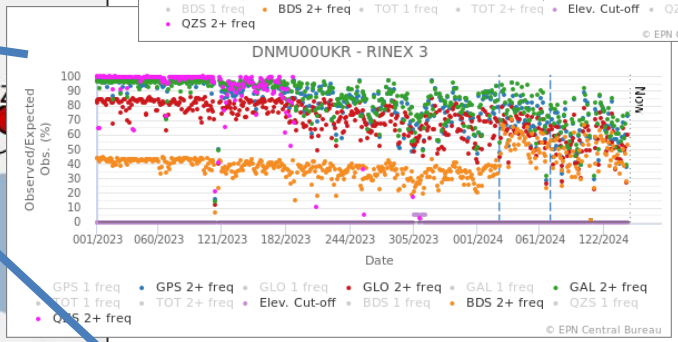



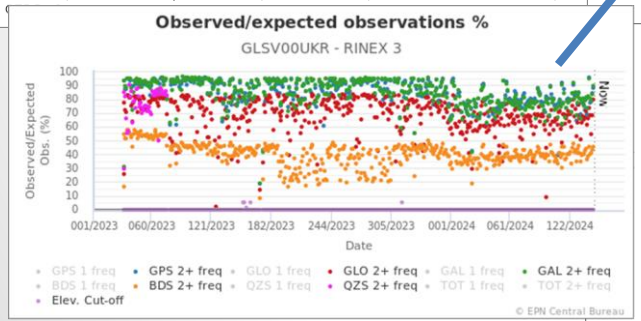



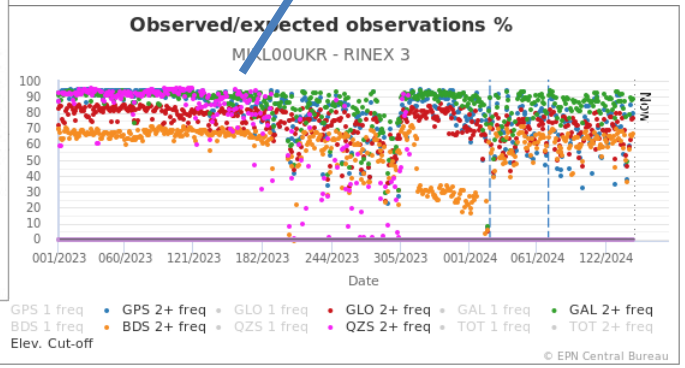



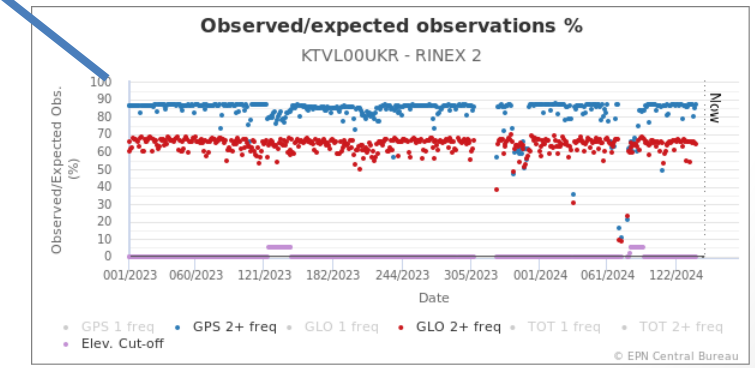







No data since end Feb 2022




ROYAL OBSERVATORY OF BELGIUM

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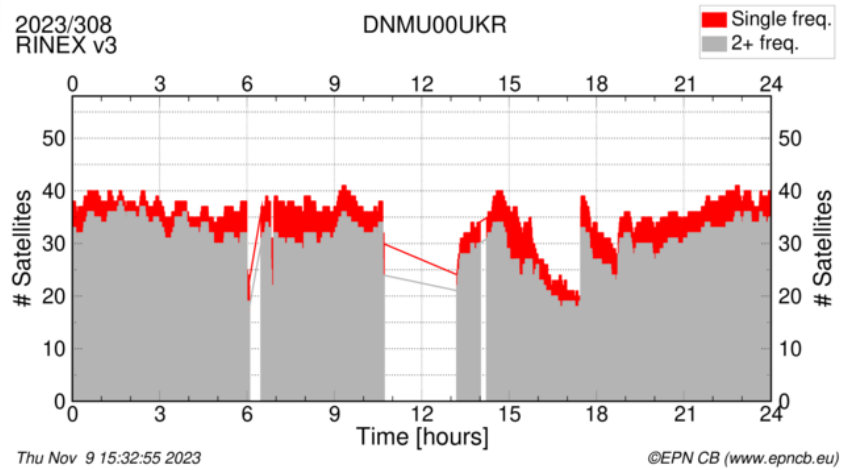
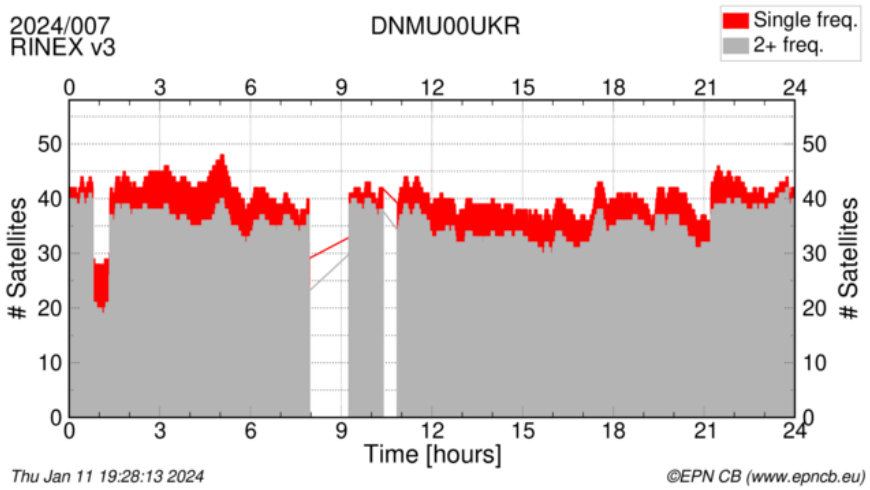
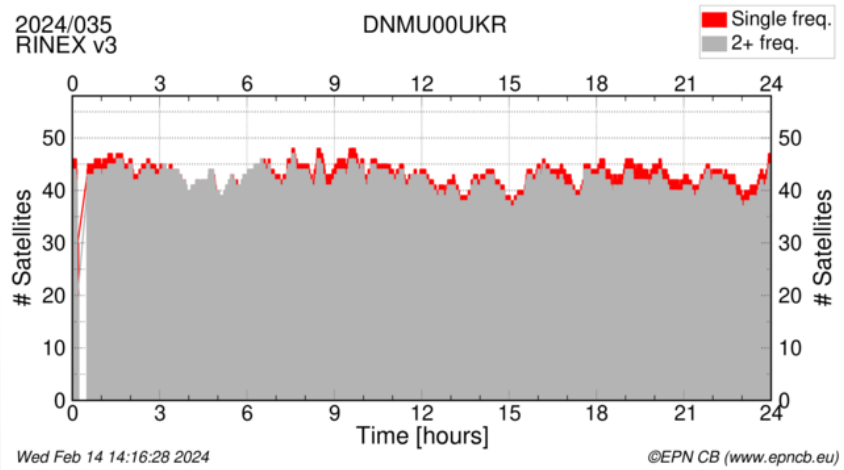
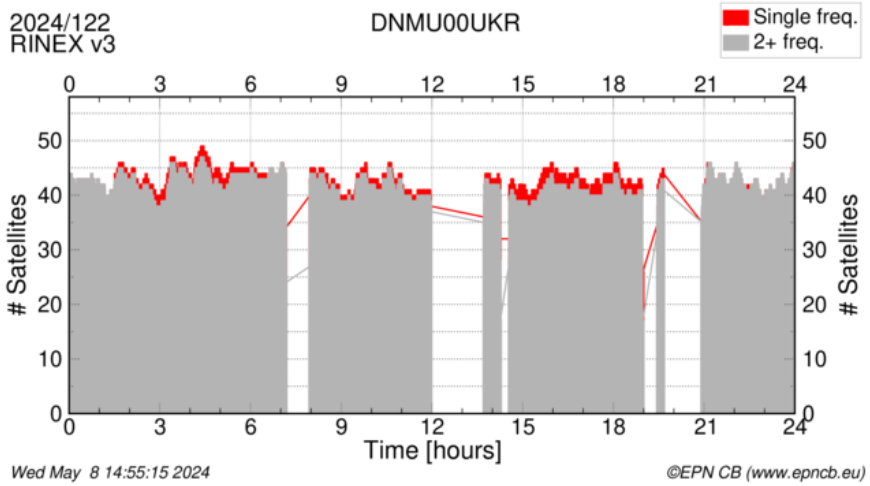
EUREF2024

# Number of observed satellites/epoch



# Outline

- Status of EPN tracking network
- Changes at EPN Central Bureau
- Follow-up on EUREF resolutions
- Summary

# Availability of coordinate and tropospheric products

## Monitoring availability of coordinate products

## Now also of tropospheric products

Taking new long product names into account

https://epncb.oma.be/pub/product/availability/CHECK_DAILY_BKG.SNXX

https://epncb.oma.be/pub/product/availability/CHECK_DAILY_BKG_2024.TROX

```
*********  A  B  B  B  C  G  I  I  L  M  N  R  R  S  S  U  W     E
BKG SNX    S  E  E  K  O  F  G  G  P  U  K  G  O  G  U  P  U     U
*********  I  K  V  G  D  Z  E  N  T  T  G  A  B  O  T  A  T     R
R = RAPID : x = x days
F = FINAL : 0 = 0-6 days; 1 = 7-13 days; 2 = 14-20 days; 3 = 21-27 days.
****************** Last Update : 26-MAY-24 13:40 (DOY 147)
2295-0 -  F2 F2 F2 F1 F1 F2 F3 R0 F2 F5 F2  . F2 F2 F2 F3 F5    F7
2294-6 -  F1 F3 F2 F1 F0 F2 F2 R0 F1 F5 F1  . F1 F1 F1 F2 F4    F5
2294-5 -  F1 F3 F2 F1 F1 F2 F2 R0 F1 F5 F1  . F1 F1 F1 F2 F4    F6
2294-4 -  F1 F3 F2 F1 F1 F2 F2 R0 F1 F5 F1  . F1 F1 F1 F2 F5    F6
2294-3 -  F1 F2 F2 F1 F1 F2 F2 R0 F1 F5 F1  . F1 F1 F1 F2 F5    F6
2294-2 -  F1 F2 F2 F1 F1 F2 F3 R0 F2 F5 F2  . F1 F1 F1 F2 F5    F6
2294-1 -  F2 F2 F3 F2 F1 F3 F3 R0 F2 F6 F2  . F2 F2 F1 F2 F5    F6
2294-0 -  F2 F2 F3 F1 F1 F3 F3 R0 F2 F6 F2  . F2 F2 F2 F3 F5    F6
2293-6 -  F1 F2 F3 F1 F1 F2 F2 R0 F2 F3 F1  . F1 F1 F1 F2 F4    F5
2293-5 -  F1 F2 F3 F1 F1 F2 F2 R0 F2 F3 F1  . F1 F2 F1 F2 F4    F6
2293-4 -  F1 F2 F3 F1 F1 F2 F2 R0 F2 F3 F2  . F2 F2 F1 F2 F4    F6
2293-3 -  F1 F3 F3 F1 F1 F2 F2 R0 F2 F3 F2  . F2 F2 F1 F2 F4    F6
2293-2 -  F2 F3 F4 F2 F1 F3 F3 R0 F3 F3 F2  . F2 F2 F1 F2 F4    F6
2293-1 -  F2 F3 F4 F2 F1 F3 F3 R0 F3 F3 F2  . F2 F2 F1 F2 F4    F6
2293-0 -  F2 F3 F4 F2 F1 F3 F3 R0 F3 F4 F2  . F2 F2 F2 F3 F4    F6
2292-6 -  F2 F3 F5 F2 F1 F3 F3 R0 F1 F2 F2  . F2 F2 F1 F2 F4    F5
2292-5 -  F2 F3 F5 F2 F1 F3 F3 R0 F1 F2 F2  . F2 F3 F1 F2 F5    F6
2292-4 -  F2 F3 F5 F2 F1 F3 F3 R0 F1 F2 F3  . F3 F3 F1 F2 F5    F6
2292-3 -  F2 F3 F5 F2 F1 F3 F3 R0 F2 F2 F3  . F3 F3 F1 F2 F5    F6
2292-2 -  F3 F3 F6 F2 F1 F4 F4 R0 F2 F2 F3  . F3 F3 F1 F2 F5    F6
2292-1 -  F3 F3 F6 F2 F1 F4 F4 R0 F2 F2 F3  . F3 F3 F1 F2 F5    F6
2292-0 -  F3  . F6 F2 F1 F4 F4 R0 F2 F3 F3  . F3 F3 F2 F3 F5    F6
2291-6 -  F1 R* F4 F1 F0 F1 F2 R0 F1 F3 F1  . F3 F1 F1 F5 F1    F5
2291-5 -  F1 R1 F4 F1 F1 F1 F2 R0 F1 F3 F1  . F3 F1 F1 F5 F1    F6
2291-4 -  F1 R0 F4 F1 F1 F1 F3 R0 F1 F3 F1  . F4 F1 F1 F5 F1    F6
```

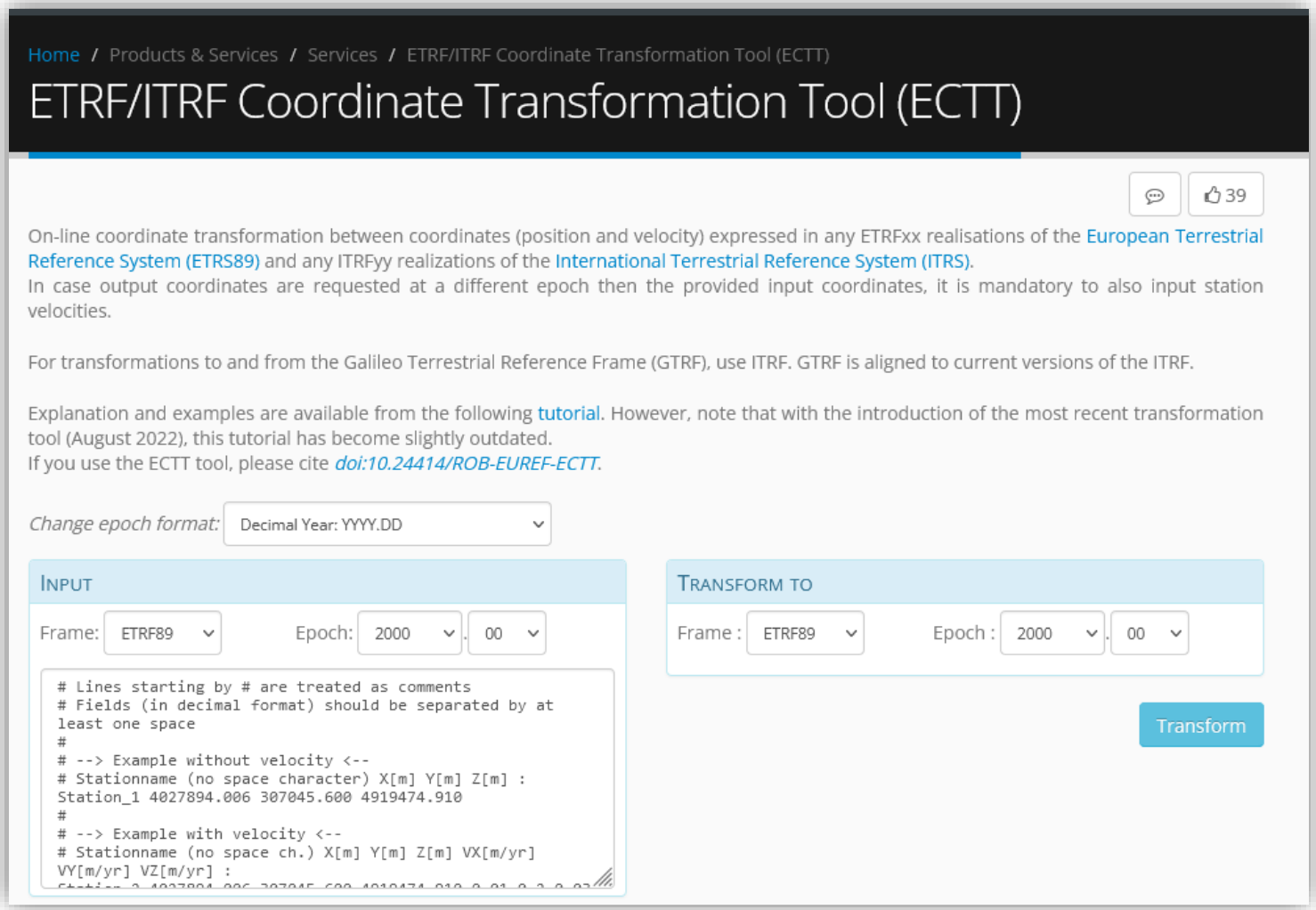
```
*********  A  B  B  B  C  G  I  I
BKG TRO    S  E  E  K  O  F  G  G
*********  I  K  V  G  D  Z  E  N
R = RAPID : x = x days
F = FINAL : 0 = 0-6 days; 1 = 7-13
****************** Last Update :
2315-6 -   .  .  .  .  .  .  .  .
2315-5 -  R0 R0  . R0  .  . R0  .
2315-4 -  R0 R0  . R0  .  . R0  .
2315-3 -  R0 R0  . R0  .  . R0  .
2315-2 -  R0 R0  . R0  .  . R0  .
2315-1 -  R0 R0  . R1  .  . R0  .
2315-0 -  R0 R0  . R2  .  . R0  .
2314-6 -  R0 R0  . R2 F0  . R0  .
2314-5 -  R0 R0  . R4 F1  . R0  .
2314-4 -  R0 R0  . R5 F1  . R0  .
2314-3 -  R0 R0  . R0 F1  . R0  .
2314-2 -  R0 R0  . R0 F1  . R0  .
2314-1 -  R0 R0  . R1 F1  . R0  .
2314-0 -  R0 R0  . R0 F1  . R0  .
2313-6 -  F1  .  . F1 F1 F1  .  .
2313-5 -  F1 R0  . F1 F1 F1 R0  .
2313-4 -  F1 R0  . F1 F1 F1 R0  .
2313-3 -  F1 R0  . F2 F1 F2 R0  .
2313-2 -  F2 R0  . F2 F2 F2  .  .
2313-1 -  F2 R0  . F2 F2 F2 R0  .
2313-0 -  F2 R1  . F2 F2 F2 R0  .
2312-6 -  F1 R0 F1 F1 F0 F2  .  . F1  . F1 F2 F1 F1 R0 R0 R0     .
2312-5 -  F1 R0 F1 F1 F0 F2 R0  . F1  . F2 F2 F1 F1 R0 R0 R0     .
2312-4 -  F1 R0 F1 F1 F1 F2 R0  . F1  . F2 F3 F1 F1 R0 R0 R0     .
2312-3 -  F1 R0 F1 F1 F1 F3 R0  . F1  . F2 F3 F1 F1 R0 R0 R0     .
2312-2 -  F1 R0 F1 F1 F1 F3 R0  . F1  . F2 F3 F1 F1 R0 R0 R0     .
2312-1 -  F2 R0 F2 F1 F1 F3 R0  . F2  . F2 F3 F2 F1 R0 R0 R0     .
```

# ETRF/ITRF Coordinate transformation

https://epncb.oma.be/_productsservices/coord_trans/

**April 2024**:

Inclusion of transformations from and to ETRF2020



# New site log format to be introduced

June 5, 2024

## Index of /pub/station on EPN CB file server

| Name | Last modified | Size | Description |
|---|---|---|---|
| Parent Directory | | - | |
| coord/ | 2019-09-12 06:31 | - | |
| densification/ | 2022-01-18 05:58 | - | |
| frequencies/ | 2024-01-02 05:13 | - | |
| general/ | 2024-05-25 19:32 | - | |
| log/ | 2024-05-24 10:45 | - | |
| log_9char/ | 2024-05-24 10:45 | - | |
| log_9char_R3/ | 2023-07-04 06:59 | - | |
| new/ | 2024-04-11 06:32 | - | |
| new_9char/ | 2024-05-03 05:43 | - | |

Log:

- acor_20240411.log
- adar_20230628.log
- agrn_20240226.log
- ajac_20211215.log

**NO CHANGE**

Log_9char:

- acor00esp_20240411.log
- adar00gbr_20230628.log
- agrn00ita_20240226.log
- ajac00fra_20211215.log

**CHANGE !**

# New site log format to be introduced

**File name:**

acor00esp_20240411.log

adar00gbr_20230628.log

agrn00ita_20240226.log

ajac00fra_20211215.log

**9-character station identifiers** inside **section 1** of the site log:

```
Four Character ID      : (A4)         --> Nine Character ID      : (A9)
Four Character ID      : BRUX         --> Nine Character ID      : BRUX00BEL
```

Substitution of "Country" with "**Country or Region**" in **section 2** of the site log.
Use alphabetical three-character (Alpha-3) **ISO-3166 country/region code**.

```
Country                :              --> Country or Region      : (A3)
Country                : Belgium      --> Country or Region      : BEL
```

Changes announced by EUREF mails on 23/04/2024 and 28/05/2024/

# Site log format – STEP 1 on June 5

**On EPN CB:**

- The site logs in the existing directory https://epncb.oma.be/pub/station/log_9char are changed by the EPN CB to agree with the new site log format.
- The site logs in the directory https://epncb.oma.be/pub/station/log are not changed.

**On M³G:**

- A new directory https://gnss-metadata.eu/data/station/log_9char/ is created to store the site logs in the new format.
- The directory https://gnss-metadata.eu/data/station/log/ is not changed.
- Site logs uploads will be allowed in both the old and new site log format.
- API V1.3.x (https://gnss-metadata.eu/v1) will remain unchanged: site logs in old format
- API V1.4x (https://gnss-metadata.eu/v14): site logs in new format

**DATE OF STEP 2 unknown (to be decided by IGS):** "log_9char" copied into "log" directory

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- Status of EPN tracking network
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# Some EPN-related resolutions

- 2019: EPOS + RINEX 3
- 2021: FAIR data principles + Coordinates in real-time streams
- 2022: GDPR + data submission to both regional EPN data centers
- 2023: $M^3G$

# EUREF 2019 resolutions: EPOS

## Encourage contribution to the European Plate Observing System

*Tallinn, 22-24/05/2019*

**Resolution No. 2.**

The IAG Reference Frame Sub-commission for Europe (EUREF)

*recognising* that that the European Plate Observing System (EPOS) will maintain a sustainable European infrastructure for solid Earth studies from 2020 onwards, including a GNSS infrastructure and related GNSS-based products

*and noting* the efforts of the EUREF community towards the derivation of a European deformation model in order to improve cross-boundary positioning

*and considering* that many European countries active in EUREF are a member (or planning to become a member) of the EPOS European Research Infrastructure Consortium (ERIC)

*encourages* the EUREF community to also contribute to EPOS especially to its GNSS component

EPOS-EUREF MoU signed on 12/09/2022

EUROPEAN PLATE OBSERVING SYSTEM

**Memorandum of Understanding**

**between**

The European Plate Observing System European Research Infrastructures Consortium (hereinafter referred to as "EPOS ERIC"), established by Commission Implementing Decision (EU) 2018/1732 of 30 October 2018 (Official Journal of the European Journal, L288/10), having its headquarter and statutory seat at Via di Vigna Murata, 605 - 00143 Rome, Italy which is represented for the purpose of signature of this Memorandum of Understanding by its Executive Director

on the one hand,

and

The Reference Frame Sub-commissi
(hereinafter referred to as "EUREF"),
of this Memorandum of Understandi

on the other hand.

EPOS ERIC and EUREF (hereinafter re
expressed their mutual desire to co-
implementation of the activities spec
"MoU").

**Date and signatures**

EPOS ERIC
The Executive Director

Firmato digitalmente da Carmela Freda
Data: 2022.07.01 19:31:23 +02'00'

For and on behalf of EPOS ERIC — Date

Dr Martin Lidberg, Chairman of EUREF. Gävle 2022-09-12

For and on behalf of EUREF — Date

# EUREF 2019 resolutions: EPOS

## EPN stations in EPOS

2023 2024

81% → 87 % of EPN stations daily RINEX data are redistributed by EPOS

Why not all?

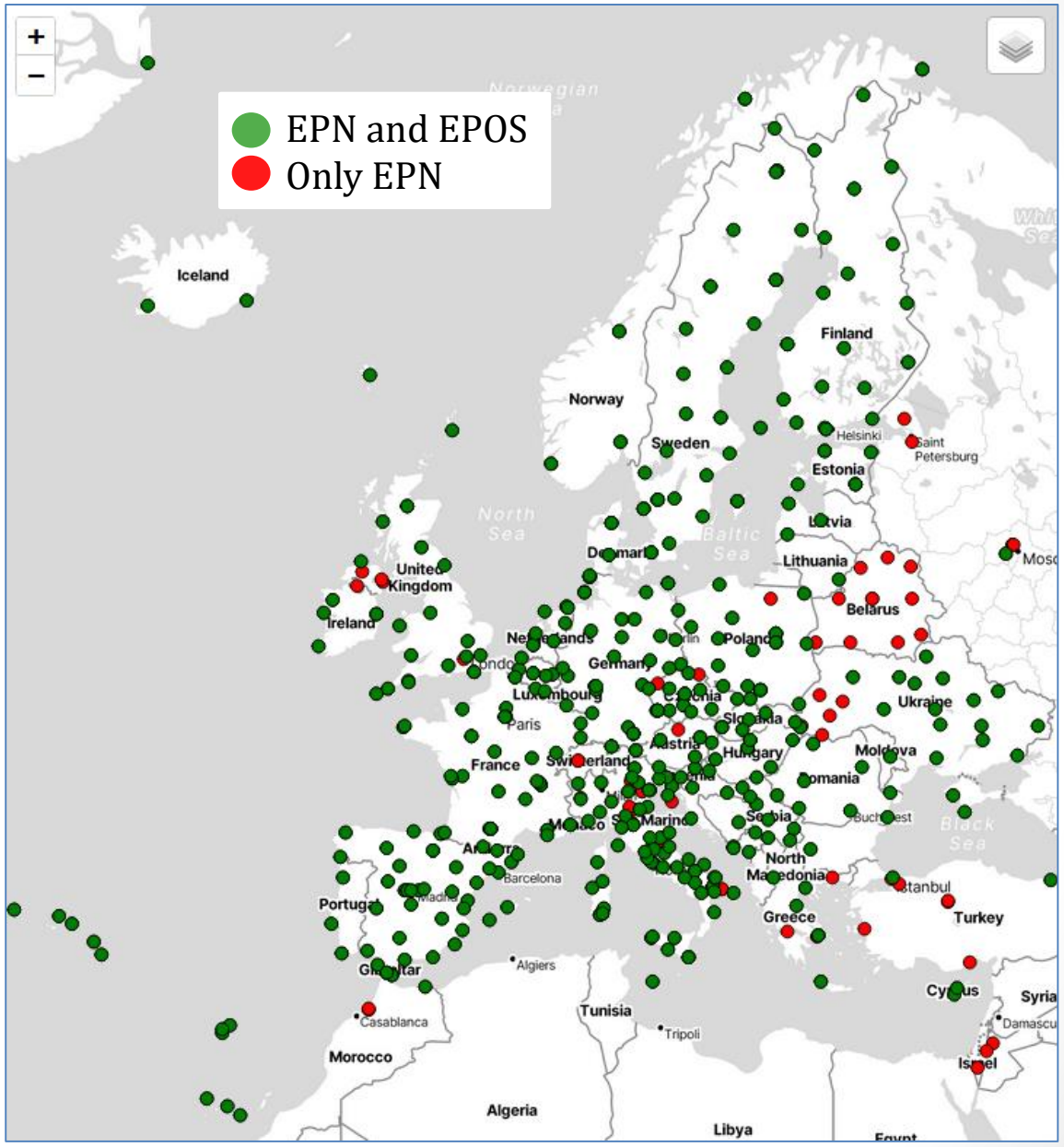
Decommissioned stations:

- Station history too short (3 years required by EPOS)

No contact with station manager

All new EPN stations agree that EPOS redistributes their data !

*Status May 26, 2024*



# EUREF 2021 resolutions: FAIR

## Encourage adoption of FAIR data principles

*Ljubljana, 26-28/05/2021*

**Resolution No. 2.**

The IAG Reference Frame Sub-commission for Europe (EUREF)

*considering* that major funding bodies, including the European Commission, promote and require the implementation of FAIR (Findable, Accessible, Interoperable, and Reusable) data principles

*and recognising* that FAIR data principles increase the value and the reuse of digital resources, by humans as well as machines

*encourages* the EUREF community to adopt these principles in all aspects of data management

# EUREF 2021 resolutions: FAIR

## Encourage adoption of FAIR data principles

**Steps towards FAIR**

A. Attach rich and standardized metadata to the GNSS data

B. Make GNSS (meta)data available through API

C. Attach a Persistent Identifier to the GNSS data

First: Collection of rich metadata to be associated with RINEX data files

- **100% site log info**
- **100% data quality information**
- **97%** of the EPN stations have assigned a **data license** to the RINEX data they distribute through EUREF

```
Missing:
DRAG00ISR MDVJ00RUS PADO00ITA PAT000GRC PULK00RUS RABT00MAR RAMO00ISR
ROVE00ITA SVTL00RUS TUBI00TUR UPAD00ITA YLDZ00TUR ZECK00RUS ZIM200CHE
ZIMM00CHE
```

# EUREF 2021 resolutions: FAIR

## Encourage adoption of FAIR data principles

**Steps towards FAIR**

A. Attach rich and standardized metadata to the GNSS data

B. Make GNSS (meta)data available through API

C. Attach a Persistent Identifier to the GNSS data

Standardization of metadata :

GNSS-DCAT-AP

*See*

*Presentation* ***"Application of FAIR data principles on the EPN Historical Data Centre"***

*on Thursday morning*

# EUREF 2021 resolutions: FAIR

## Encourage adoption of FAIR data principles

**Steps towards FAIR**

A. Attach rich and standardized metadata to the GNSS data

B. Make GNSS (meta)data available through API

C. Attach a Persistent Identifier to the GNSS data

*See*

*Presentation* ***"Application of FAIR data principles on the EPN Historical Data Centre"***

*on Thursday morning*

# EUREF 2021 resolutions: FAIR

## Encourage adoption of FAIR data principles


*Committee on DOI for geodetic datasets*

**Steps towards FAIR**

A. Attach rich and standardized metadata to the GNSS data

B. Make GNSS (meta)data available through API

C. Attach a Persistent Identifier to the GNSS data

DOI (Digital Object Identifier) for GNSS data

- EUREF is working in collaboration with GGOS

$M^3G$ New EPN CB service for EPN stations

- Assign DOI to the RINEX data originating from an EPN station and stored in the EPN HDC
- Take advantage of information that the station managers already inserted in $M^3G$
- **63 EPN stations with DOI in $M^3G$, contact me!**

# EUREF 2021 resolutions: Coordinates in real-time streams

*Ljubljana, 26-28/05/2021*

**Resolution No. 4.**

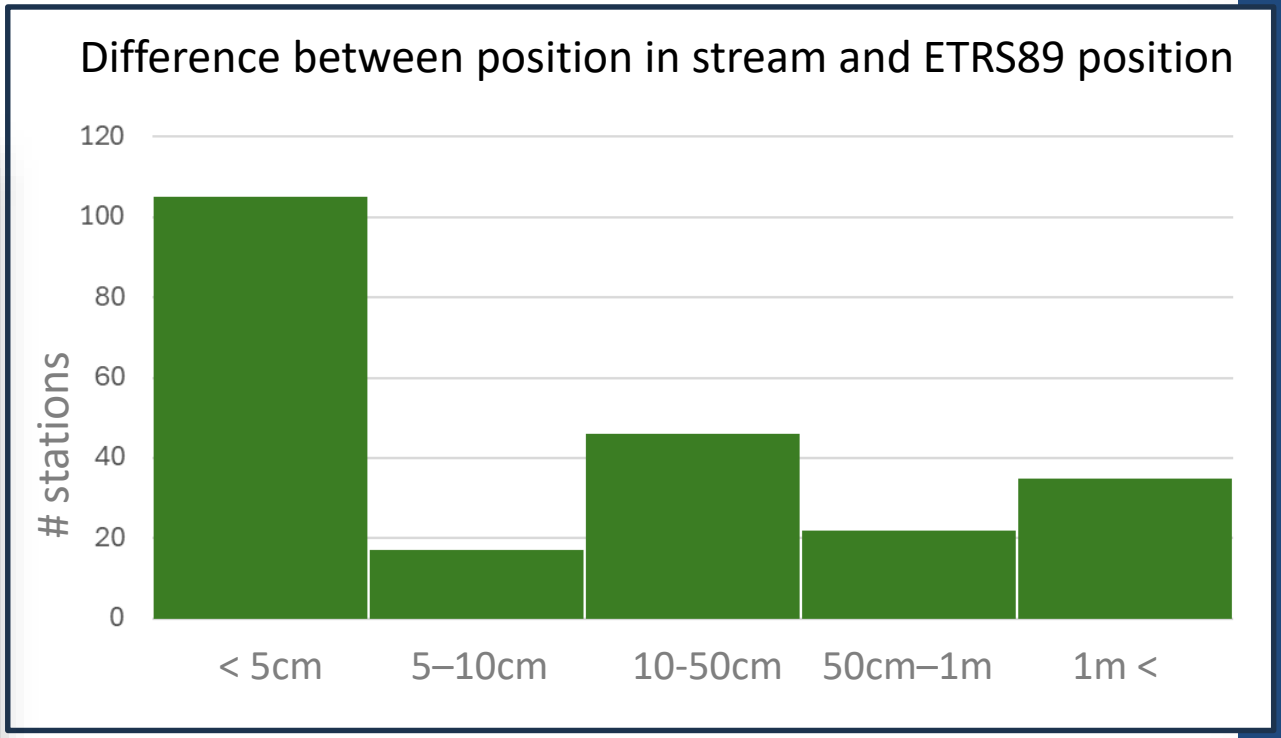
The IAG Reference Frame Sub-commission for Europe (EUREF)

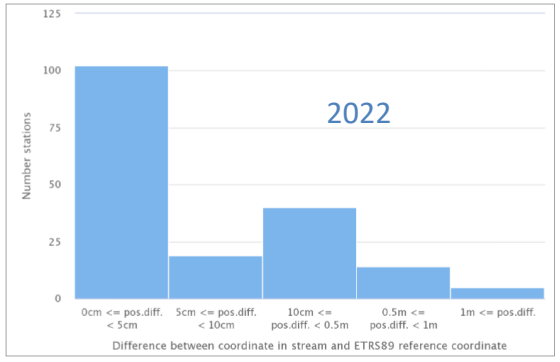
*considering* the increased use of the EPN real-time observation data streams for surveying activities

*and noting* that, for some stations, the differences between the coordinates contained within the real-time streams and the official ETRS89 coordinates exceed acceptable limits

*encourages* the managers of EPN stations, located within the geographical scope of ETRS89 and distributed through the EUREF real-time broadcasters, to insert up to date ETRS89 coordinates in the real-time observation data streams

2024



# EUREF 2022 resolutions: GDPR

*Ljubljana, 26-28/05/2021*

**Resolution No. 3.**

The IAG Reference Frame Sub-commission for Europe (EUREF)

*considering* that the EU General Data Protection Regulation (GDPR) imposes limitations on the use of personal data

and noting the need to ensure sustainable contact information of all EPN components

urges all contributors to the EUREF Permanent GNSS Network to use neutral, non personally-identifiable contact details in all metadata, data, and products submitted to EUREF that are intended for public distribution

# EUREF 2022 resolutions: GDPR

In use since March 2023:

- Site Log Section 0 → no personal contact information allowed
- Site Log Section 11, 12 → primary contact: no personal contact information allowed
- Not only because of GDPR, but also because contact info is easier to maintain

*Possible to register multiple central personal contacts*

Impossible to update site logs if your agency has not set up at least one public central email

June 2023: Still 179 EPN site logs that are not OK!

June 2024: Still 86 EPN site logs that are not OK

```
 BRUX00BEL Site Information Form (site log)
     International GNSS Service
     See Instructions at:

https://files.igscb.org/pub/station/general/sitelog_instr.txt

0.   Form

     Prepared by (full name)  : GNSS team (gnss@oma.be)
     Date Prepared            : 2022-04-05
     Report Type              : UPDATE
     If Update:
      Previous Site Log       : brux00bel_20210420.log
      Modified/Added Sections : 6.11, 6.12, 11
```

```
11.  On-Site, Point of Contact Agency Information

     Agency                   : Royal Observatory of Belgium
     Preferred Abbreviation   : ROB
     Mailing Address          : Av. Circulaire 3
                              : 1180 Brussels
                              : Belgium
     Primary Contact
       Contact Name           : GNSSatROB
       Telephone (primary)    :
       Telephone (secondary)  :
       Fax                    :
       E-mail                 : gnss@oma.be
```

# EUREF 2023 resolutions: M³G

**Resolution No. 4.**

The IAG Reference Frame Sub-commission for Europe (EUREF)

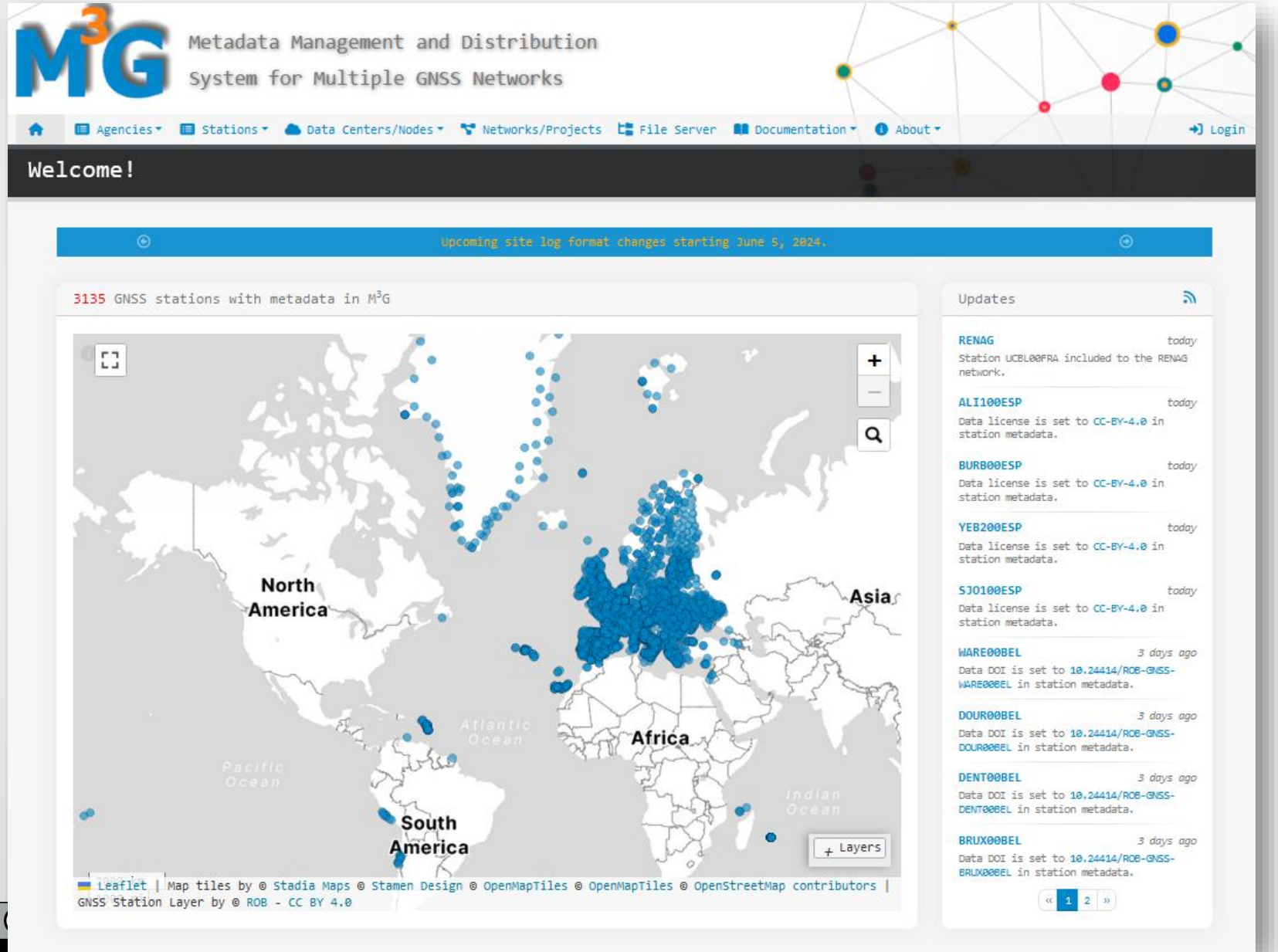
*recognising* the importance of having, up to date and complete EPN Reference Frame and troposphere products

*and also recognising* the importance that the corresponding site metadata is accurate and up to date

*encourages* any EPN station managers who have RINEX data, that has not yet been provided to the EPN Historical Data Centre, to submit this data by the end of June 2023 in order to make it available to the EPN Analysis Centers participating in the EPN-Repro3 campaign

*and further requests* all site owners and station managers to take full advantage of the tools provided by the M3G facility to check their site metadata and to keep site logs fully up to date with all site changes

# EUREF 2023 resolutions: M³G

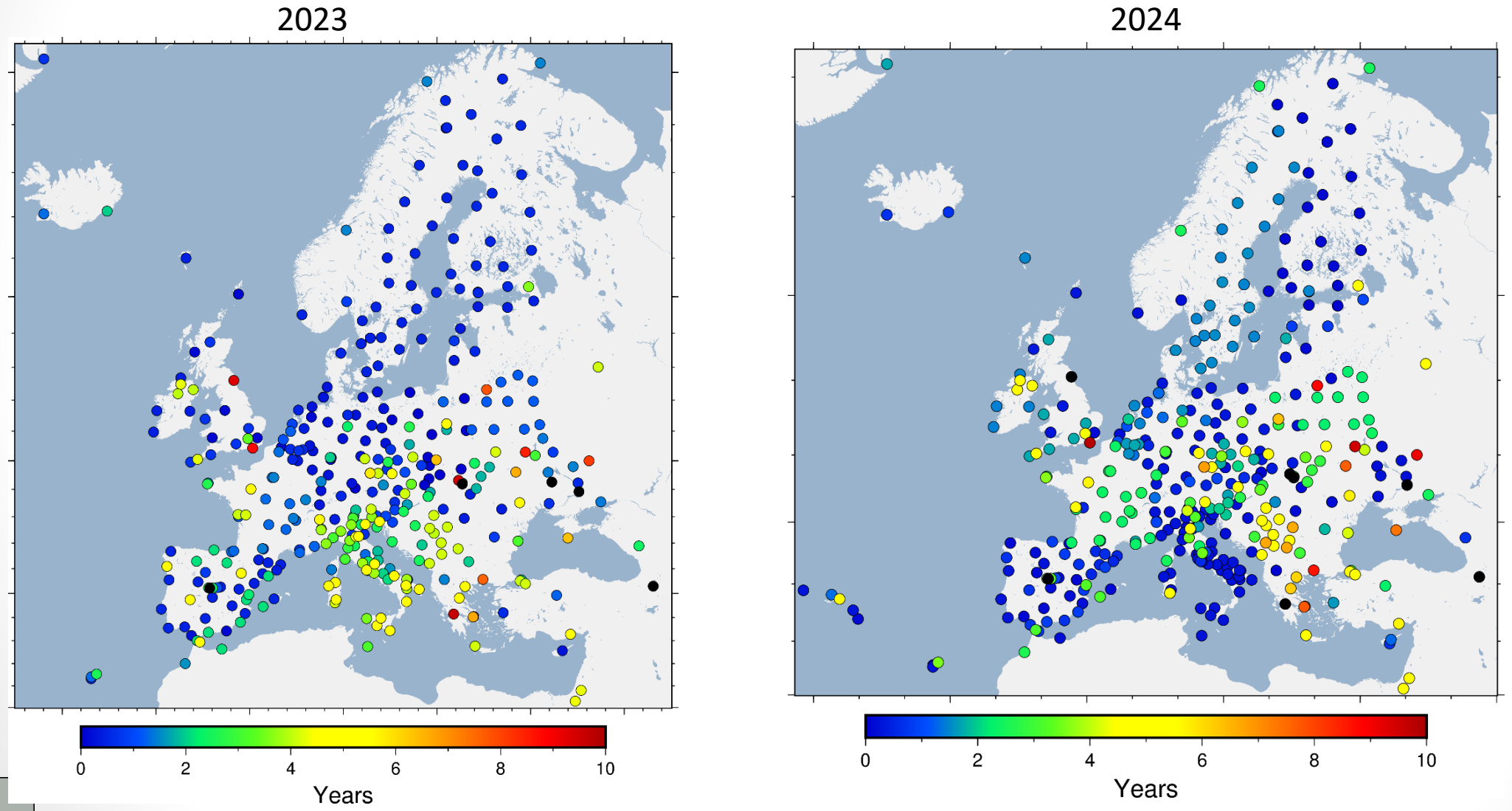



Today:
3136 stations in M³G

Site logs for ~1400 EPN densification stations

# EUREF 2023 resolutions: M³G

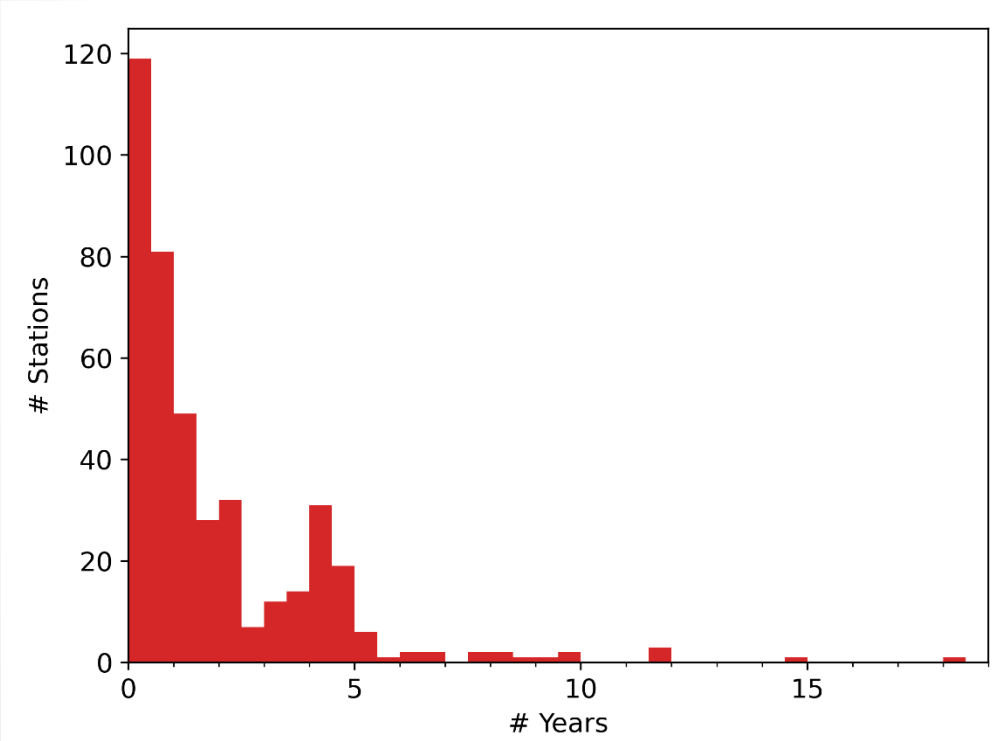
## Number of years since last firmware/receiver update



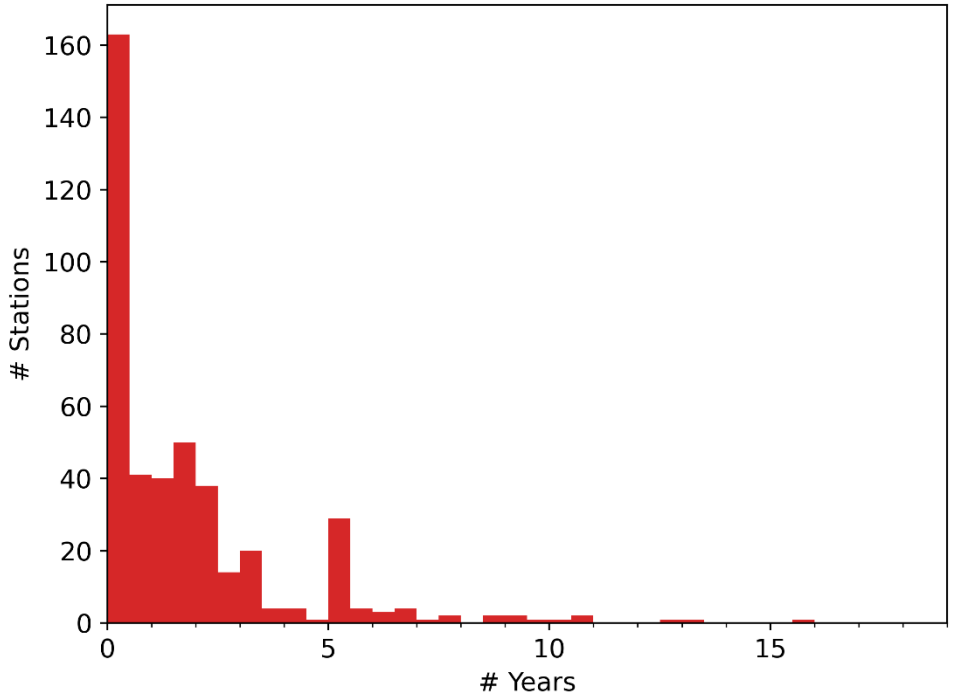
# EUREF 2023 resolutions: M³G

## Number of years since last firmware/receiver update

2023




2024



# Summary

- ✓ 22 new EPN stations → 424 EPN stations (2 decommissioned stations)
- ✓ 15 EPN stations not providing data since several months (years)
- ✓ In general, few GNSS data quality issues
- ✓ Be prepared for change of site log format
- ✓ Good Progress:
  - ✓ 87% of EPN stations also distributing data through EPOS
  - ✓ 97% of EPN stations with data license for their daily RINEX data
  - ✓ 83% (65% in 2023) of EPN stations have site log that is GDPR-compliant
  - ✓ Improvement in usage of M$^3$G and in site log updating
  - ✓ New EPN CB service to mint DOI (or help minting DOI) for EPN stations
- ✓ Step backwards:
  - ✓ More coordinates in real-time stream that are not in-line with ETRS89

**Contact**
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EPN Central Bureau
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BELGIUM

# Thank you for your attention

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