



# Update on the GNSS component of the European Plate Observing System

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# Outline

- Introduction
- Extension of the network
- Data dissemination concept
- New network monitoring
- Conclusions

# GNSS component of EPOS

... To provide, through the European Plate Observing System (EPOS), access to GNSS data, meta-data, and products in support of the Solid Earth Sciences → From thousands of GNSS stations

## EUREF 2019 Resolution No2

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**

# Memorandum of Understanding

EPOS and EUREF are close to sign MoU

- collaboration on [standards and guidelines](#)
- [develop common components](#)
- [inform](#) each other on progress, projects or initiatives
- [raise awareness of the complementarity](#) of the two initiatives in each of the two communities

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# EPOS-GNSS station network

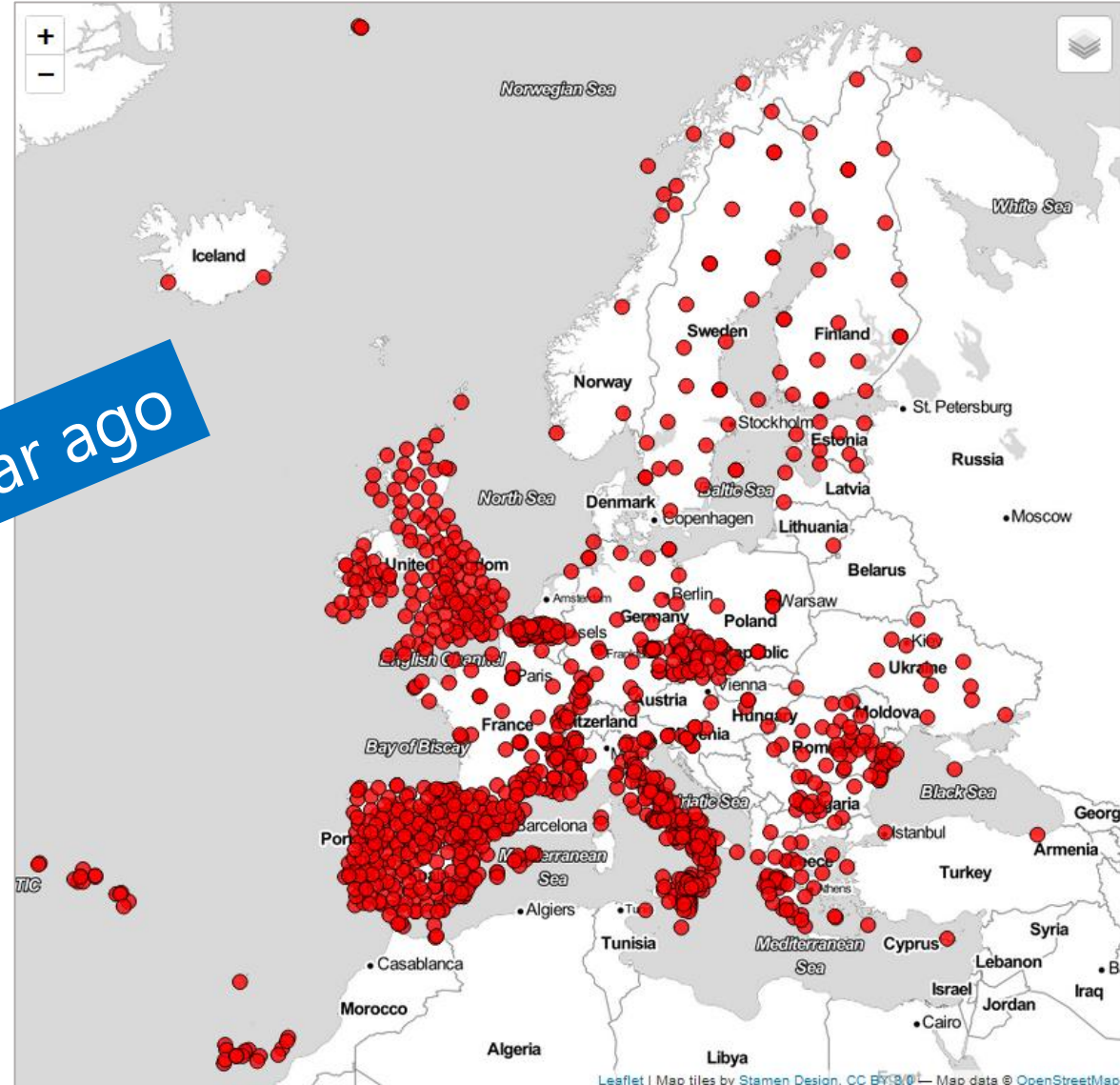
1205 EPOS-GNSS stations

✓240 EPN stations

✓828 EPN densification stations

✓137 other GNSS stations

One year ago



# EPOS-GNSS station network

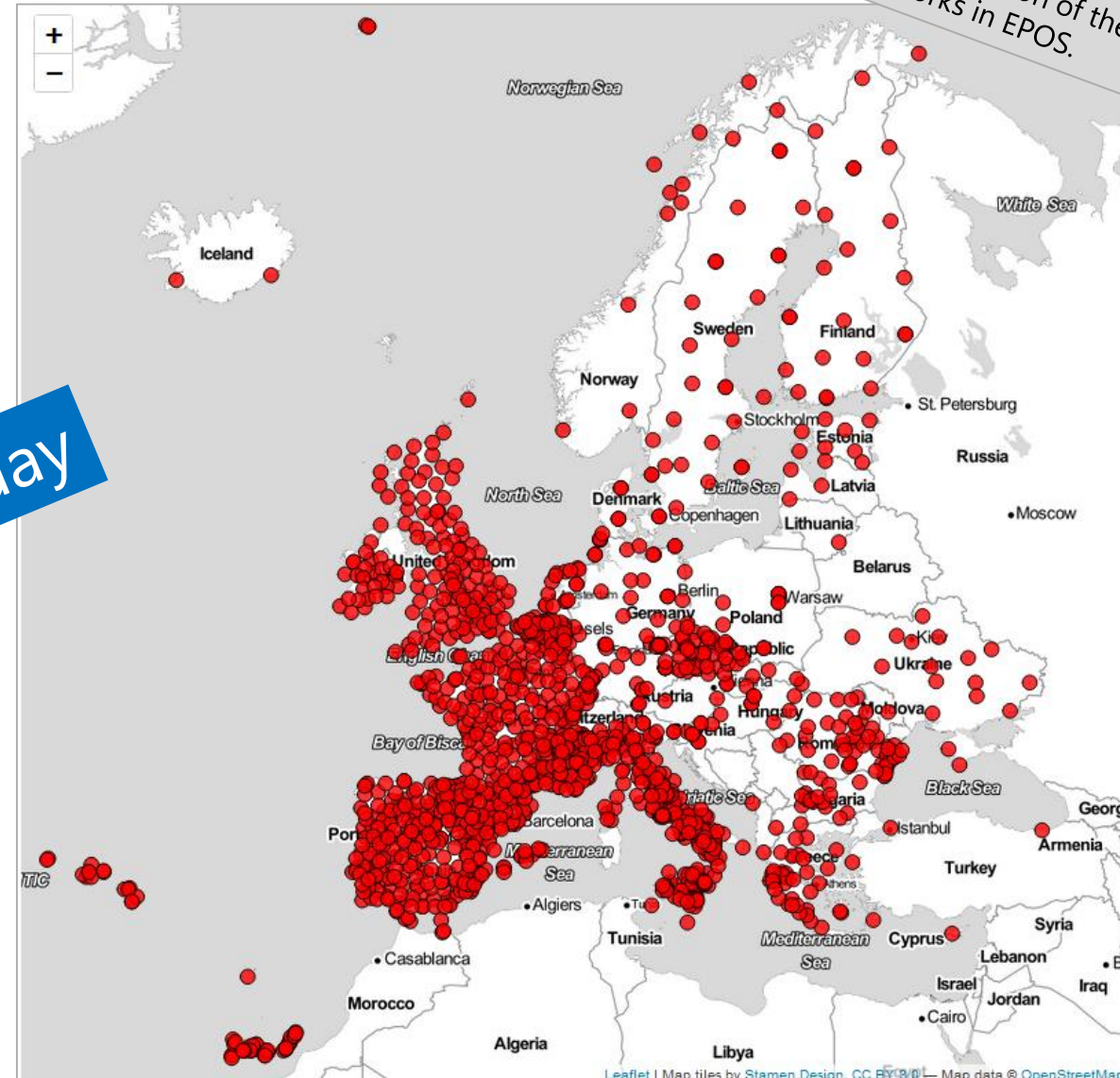
1567 EPOS-GNSS stations (+362)

✓315 EPN stations

✓966 EPN densification stations

✓286 other GNSS stations

Today



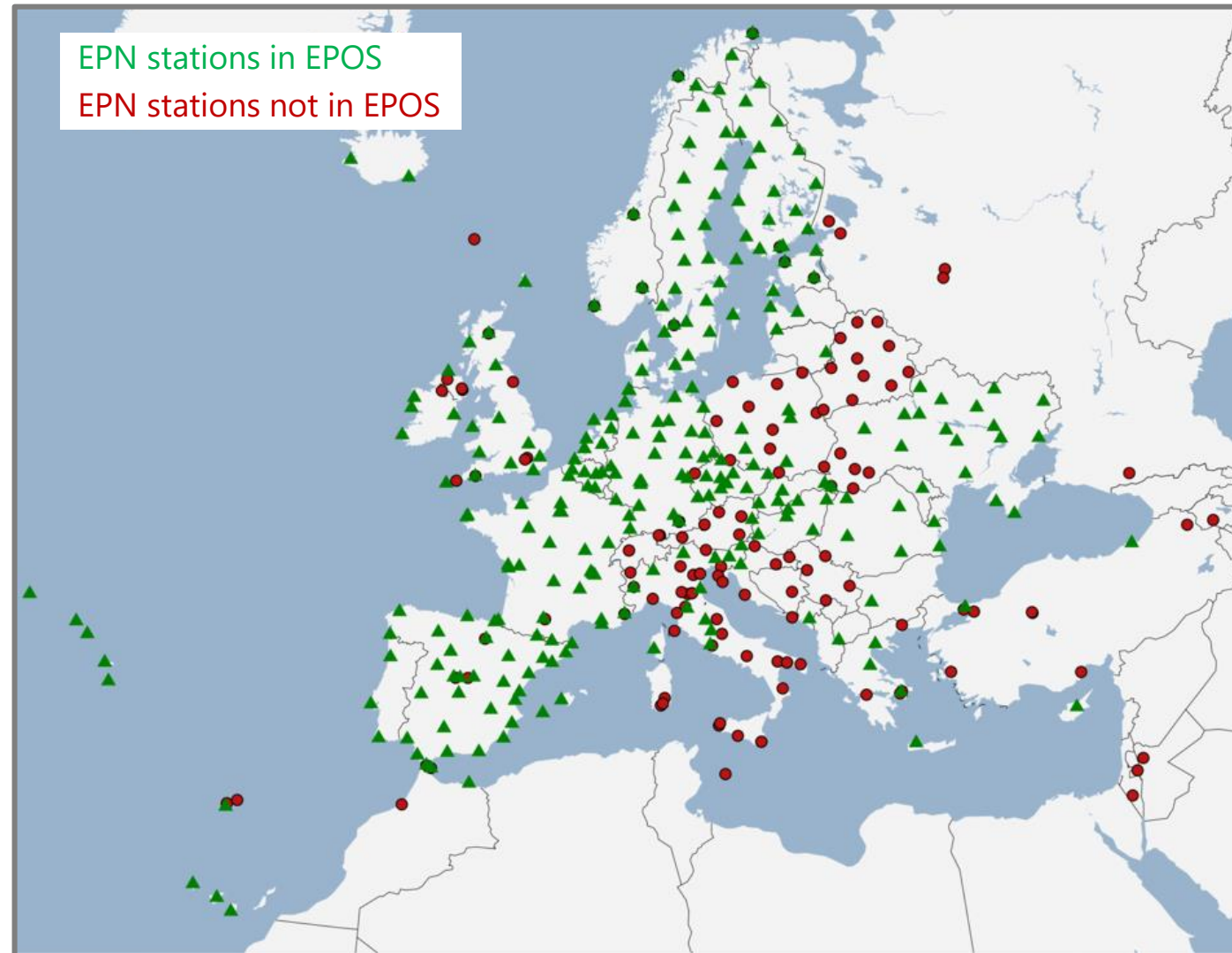
Several countries are preparing the integration of their dense networks in EPOS.



# EPN stations integrated in EPOS

## 2022

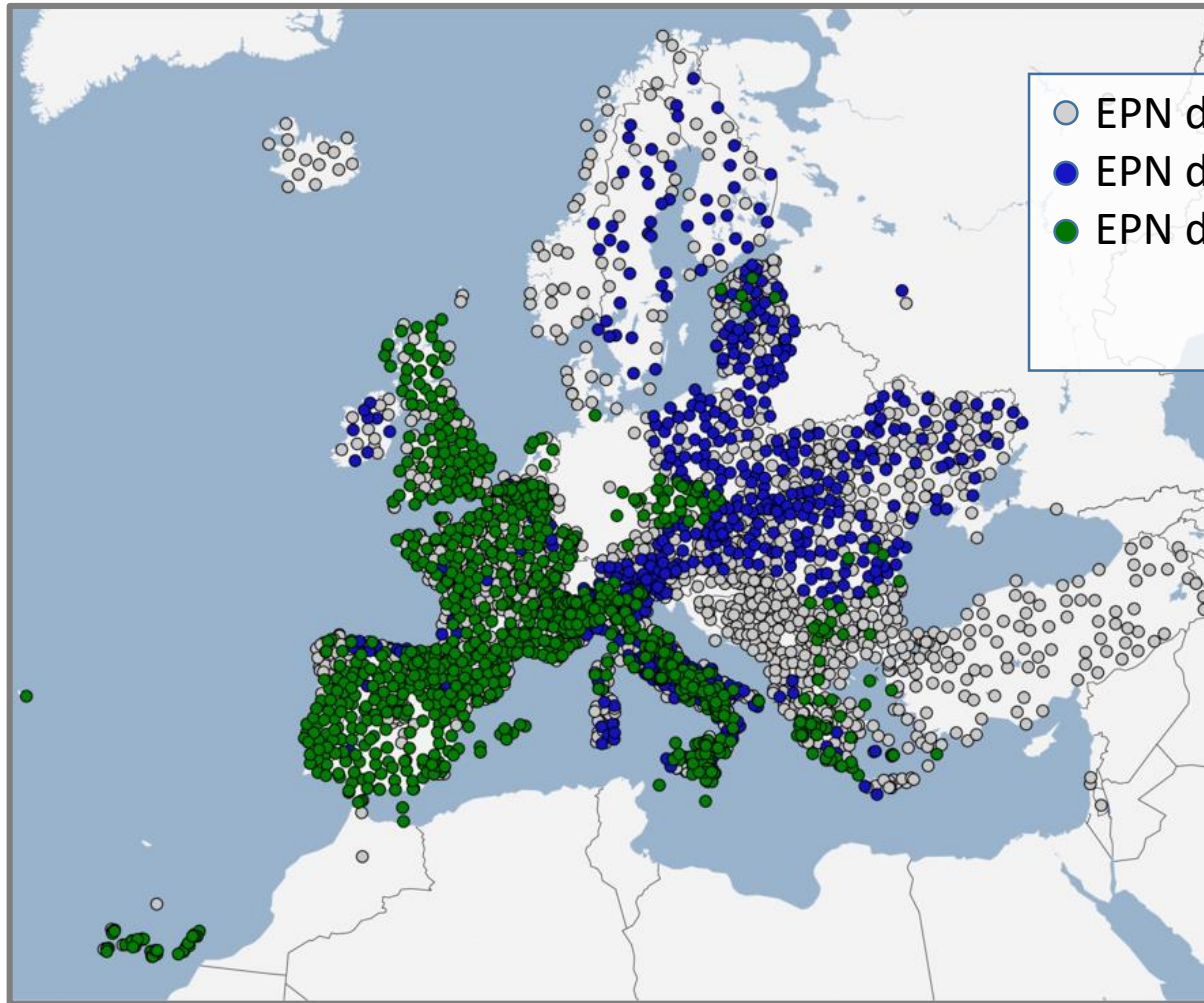
77% of EPN stations that have not been decommissioned agreed to share data with EPOS





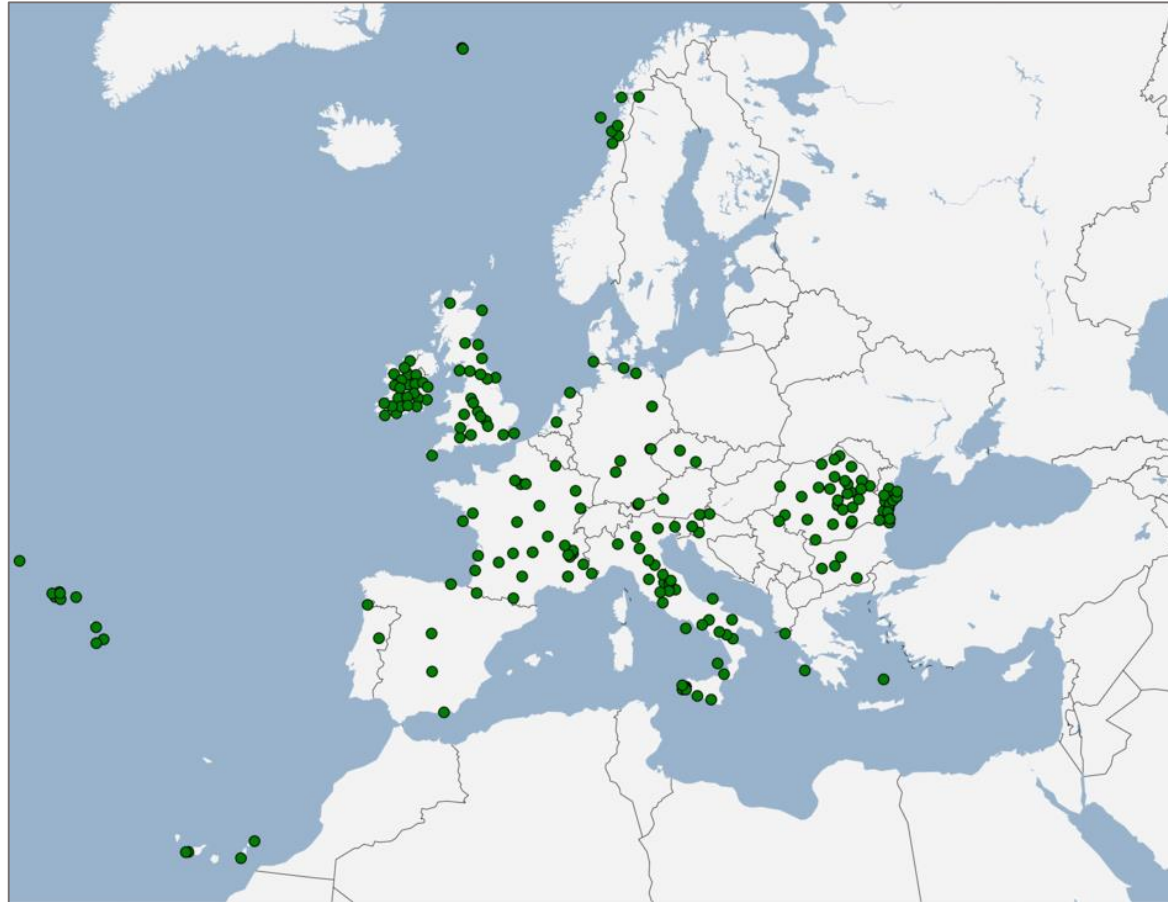
# EPN densification stations integrated in EPOS

## 2022



- EPN densification station
- EPN densification station with site log in M<sup>3</sup>G
- EPN densification station in EPOS with site log in M<sup>3</sup>G (966)
  - *verification RINEX header vs. site log*
  - *quality of derived products*

# EPOS stations not included in EPN densification 2022



- 287 EPOS stations (213 in Europe) which are not included in EPN nor EPN densification

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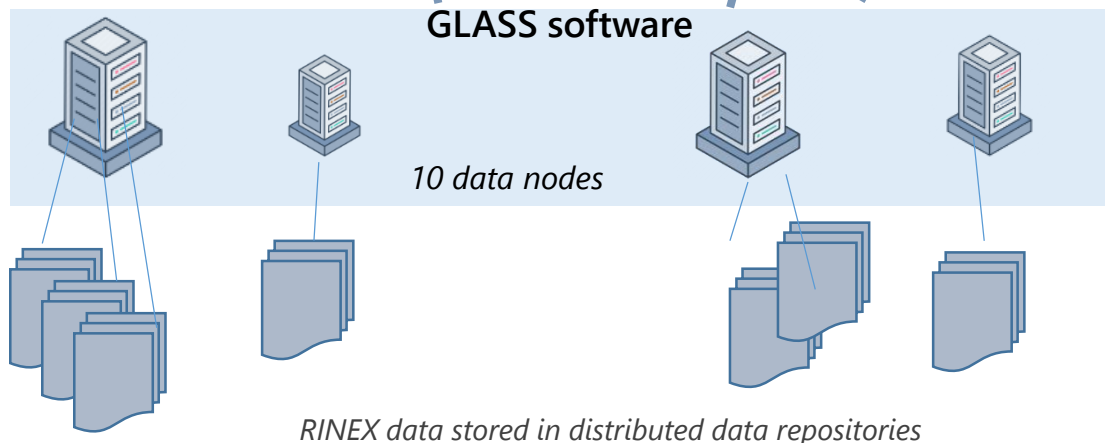
# EPOS-GNSS data dissemination

- Suitable to distribute data from 1000's of GNSS stations
  - Centralized access through one portal
  - But, RINEX data stay distributed at several local nodes (who can then still monitor data usage) → distribute load
- Learn from previous experiences
  - No central access to RINEX data files with 'significant' metadata errors
  - Possibility to identify 'heavily' degraded daily RINEX data before download

# EPOS-GNSS data dissemination concept (1)

EPOS GNSS Data Gateway: <http://gnssdata-epos.oca.eu>

Marker	Site Name	Lat	Lon	Alt	Install Date	End Date	Country	State	City	Agency	Network
AAR300BEL	AARSCHOT	greater t less than	greater t less than	greater t less than	greater t less than	greater t less than	Belgium	Vlaams-Bra.	Aarschot	Flemish Info.	FLEPOS



## Distributed Data Flow:

Station operators upload their GNSS observation data to a data repository.

To make these RINEX data visible to EPOS:

The GLASS software (developed by GNSS group in EPOS) is used to index the RINEX observation files in the repository

Nodes send `https://...` (or `ftp://...`) location of the RINEX data in the repository to the EPOS-GNSS Data Gateway

When users connect to Data Gateway, they will be redirected to nodes → data repositories

Data Gateway offers centralized access to RINEX data via

- Web interface
- APIs

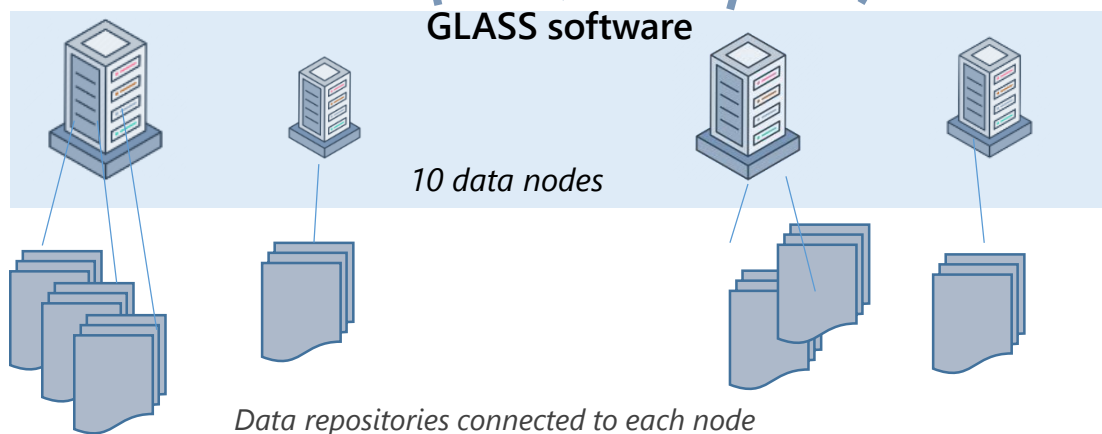
Weak point: majority of EPOS-GNSS stations are offering data to 1 node only → single point of failure



# EPOS-GNSS data dissemination concept (2)

EPOS GNSS Data Gateway: <http://gnssdata-epos.oca.eu>

Marker	Site Name	Lat	Lon	Alt	Install Date	End Date	Country	State	City	Agency	Network
AARS00BEL	AARSCHOT	50.963	4.836	104.660	2002-10-04		Belgium	Vlaams-Bra.	Aarschot	Flemish Info.	FLEPOS



## GLASS software ensures harmonization:

All nodes perform same 'processing' on RINEX data

- A. Crosscheck of site log (source: M<sup>3</sup>G) and RINEX headers
- B. Check data quality of RINEX observation files (G-nut/Anubis)
- C. Decide what to do with RINEX
  - If 'critical' RINEX header error, do not inform Data Gateway of new data
  - If RINEX header OK, inform Data Gateway of new data + provide info on data quality



# EUREF interface with EPOS: ROB-EUREF data node

- EPN Historical Data Center operated by ROB
- GLASS software running on top of data center
- Makes visible to EPOS all daily RINEX data from EPN station managers that agreed to share data with EPOS
  - No need to separately upload data to EPOS
- Site logs: common EPOS / EUREF through M<sup>3</sup>G system

# Outline

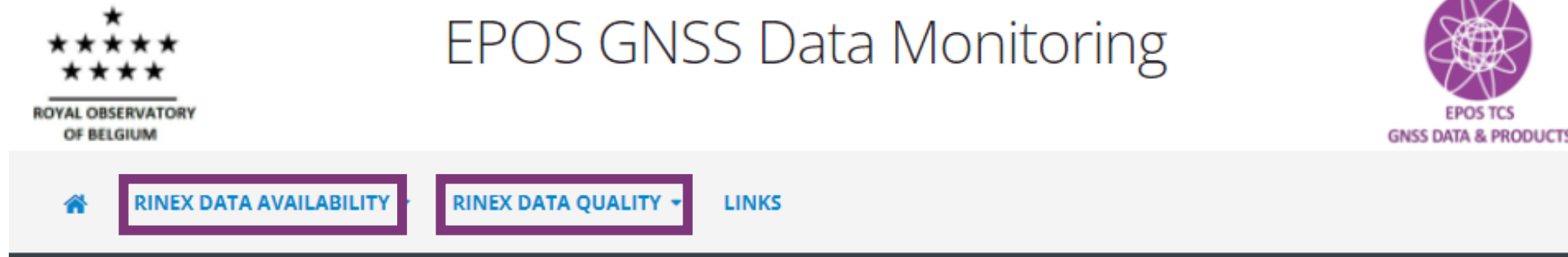
- Introduction
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- **New network monitoring**
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# Development of EPOS-GNSS network monitoring

- Development started at ROB mid 2021
- Initial goal:
  - To map RINEX data available from nodes and Data Gateway
  - Identify issues related to smoothness of the data flow (and generation of data quality checks)
  - To be used as input
    - For software developers to improve GLASS software
    - For nodes to improve 'processing of RINEX data'
- Ultimate goal:
  - Send notifications to station managers / nodes when problems occur with data latency/data quality

# Monitoring of EPOS-GNSS RINEX data availability

<https://gnssquality-epos.oma.be>



The screenshot shows the website header for 'EPOS GNSS Data Monitoring'. On the left is the logo of the Royal Observatory of Belgium. On the right is the logo for EPOS TCS GNSS DATA & PRODUCTS. Below the title is a navigation bar with a home icon, a button for 'RINEX DATA AVAILABILITY' (highlighted with a purple border), a button for 'RINEX DATA QUALITY' (also highlighted with a purple border), and a 'LINKS' link.

Under development using feedback from nodes

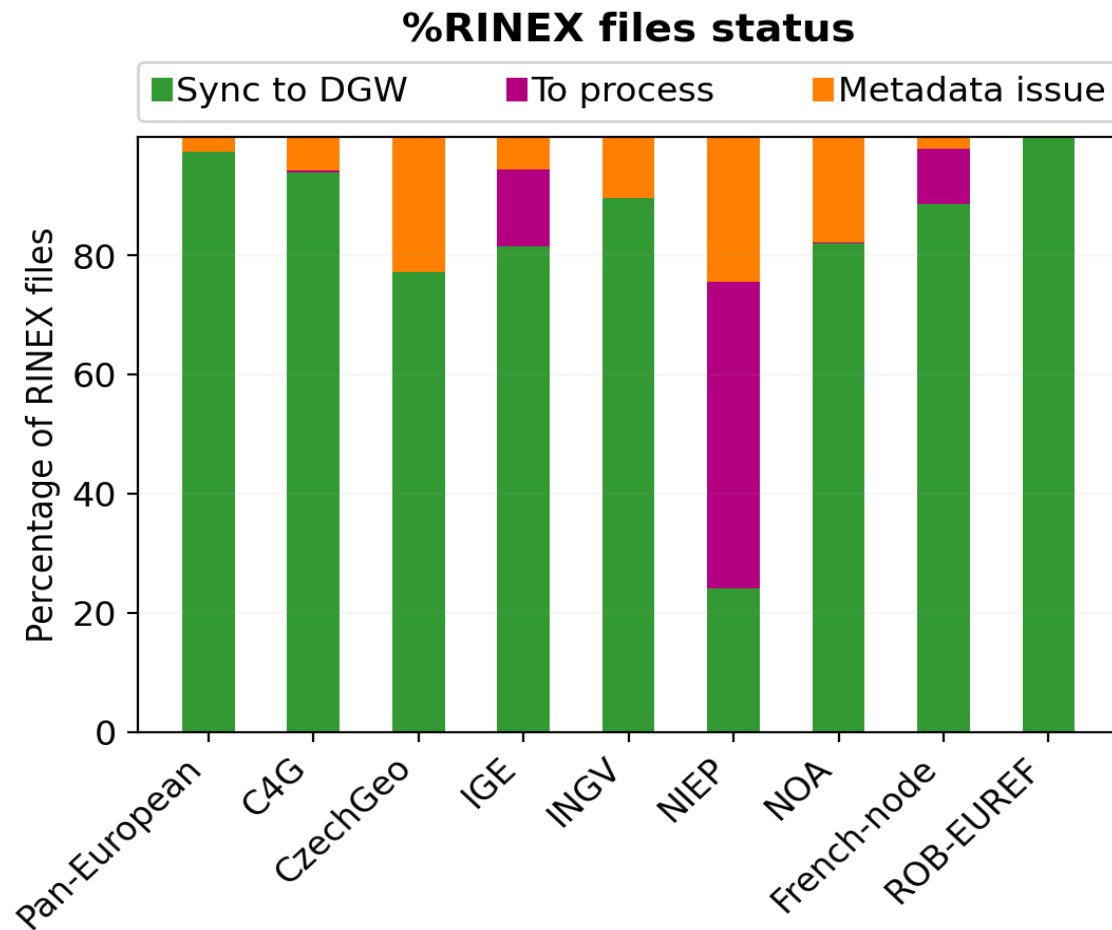
To provide the right tools for nodes to verify if GLASS software is running properly at their node

# RINEX data availability at EPOS-GNSS data gateway

Comparison of daily RINEX data available from nodes with daily RINEX data available from EPOS-GNSS data gateway

Reasons why data not available at data gateway:

- Data not yet processed at node
- Inconsistency RINEX header vs. site log
  - Data not yet re-processed after site log update



# Monitoring GNSS data quality

*in EPN: EPN CB (ROB) has to download all RINEX data to do the GNSS data quality check computations...*

In EPOS:

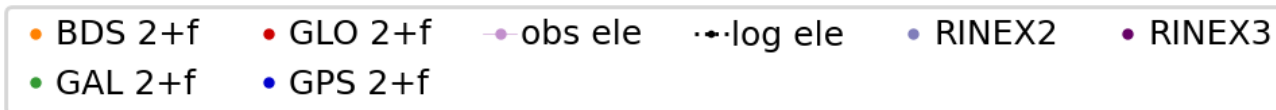
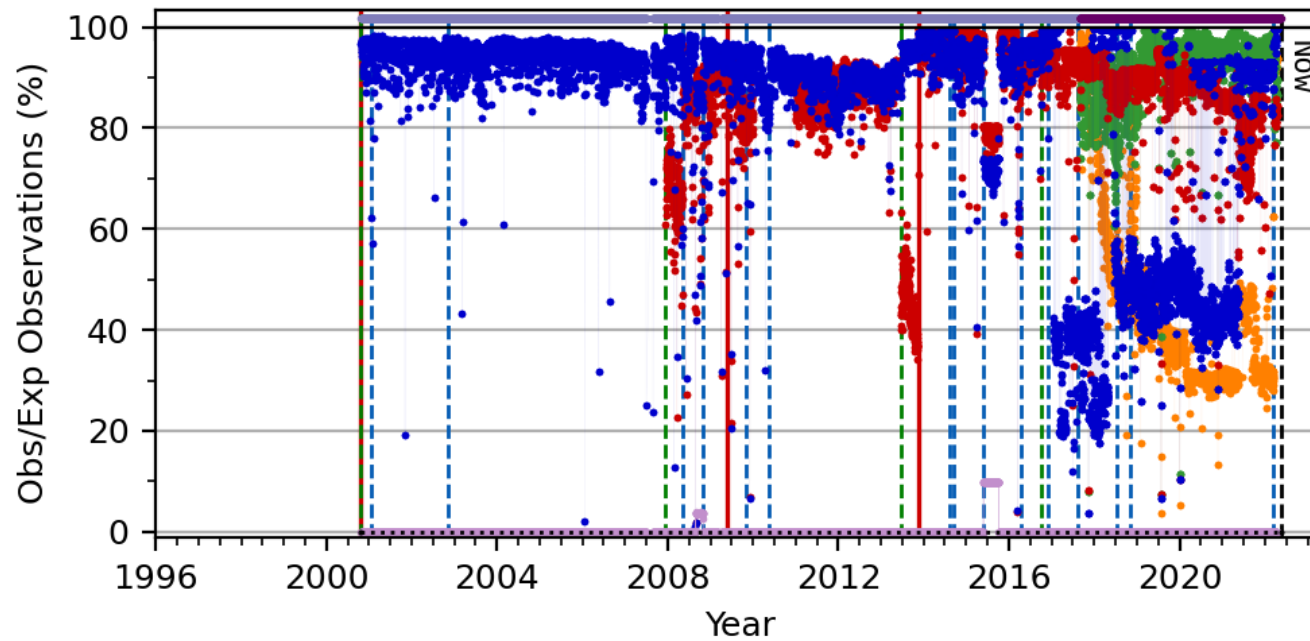
- Distributed computation of data quality metrics; done at node/data repository level
- Data quality metrics are then retrieved by ROB from the different nodes (using web services) to enable centralized plotting and monitoring



# Data quality plots

## Observed/Expected Observations

APEL00NLD - Pan-European data node



Tue May 17 12:30:22 2022

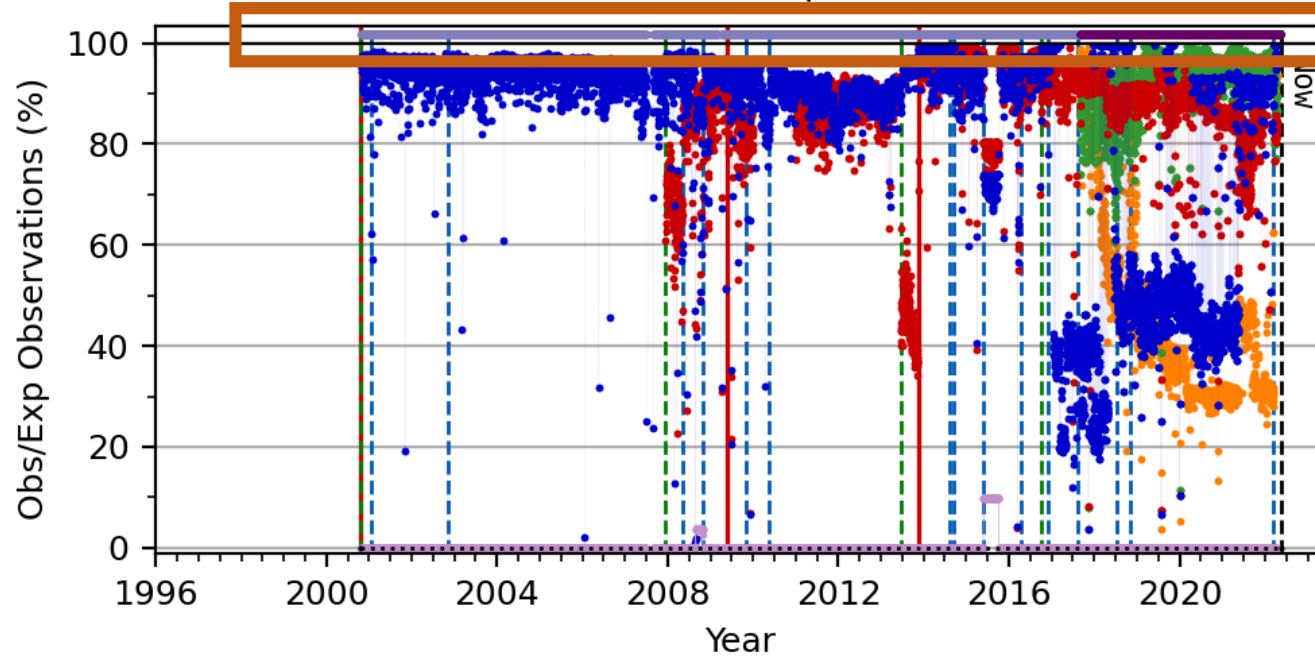
©GNSS@ROB

EPN densification station

# Data quality plots

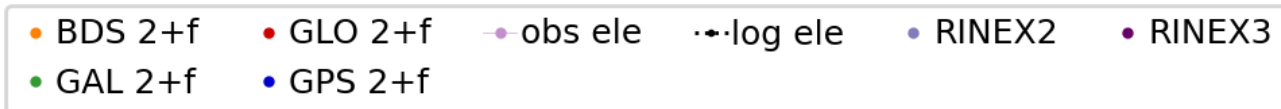
## Observed/Expected Observations

APEL00NLD - Pan-European data node



RINEX 2 and RINEX 3

EPN densification station



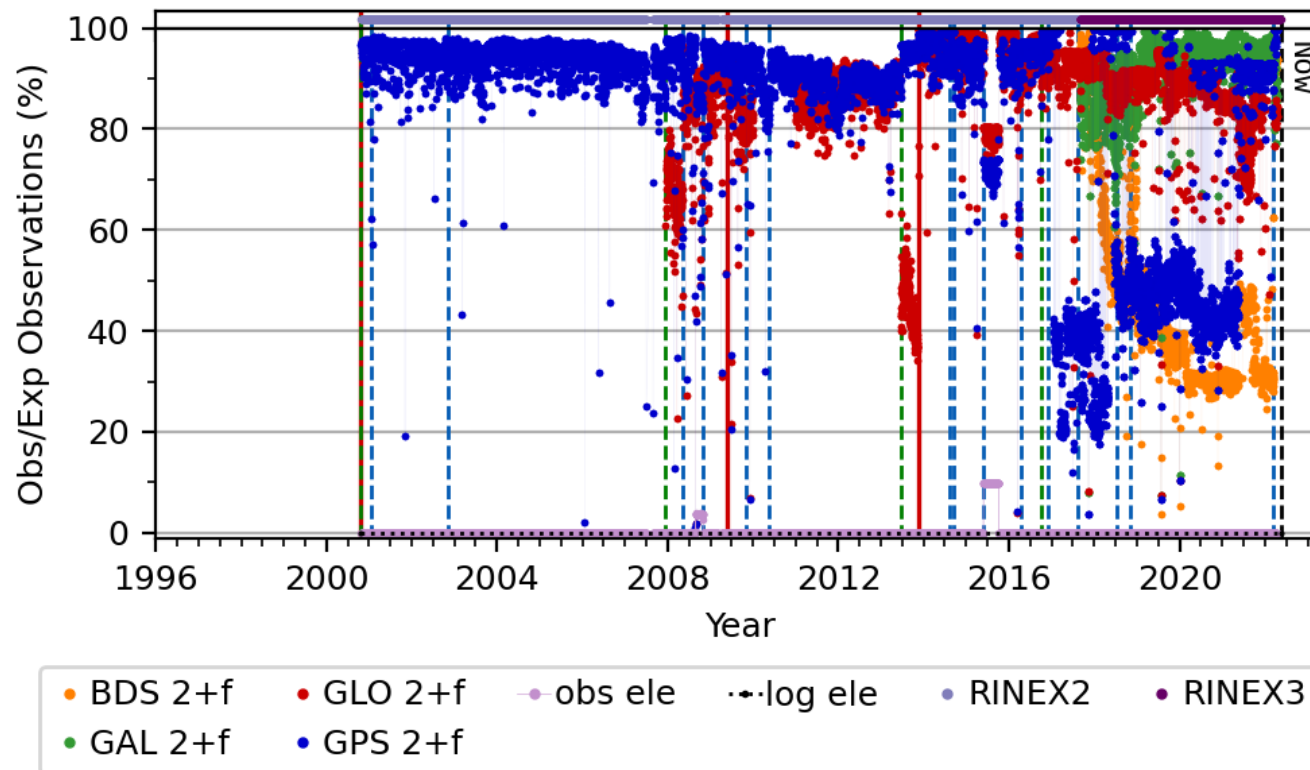
Tue May 17 12:30:22 2022

©GNSS@ROB

# Data quality plots

## Observed/Expected Observations

APEL00NLD - Pan-European data node



Process of validating the data quality metrics is presently ongoing!

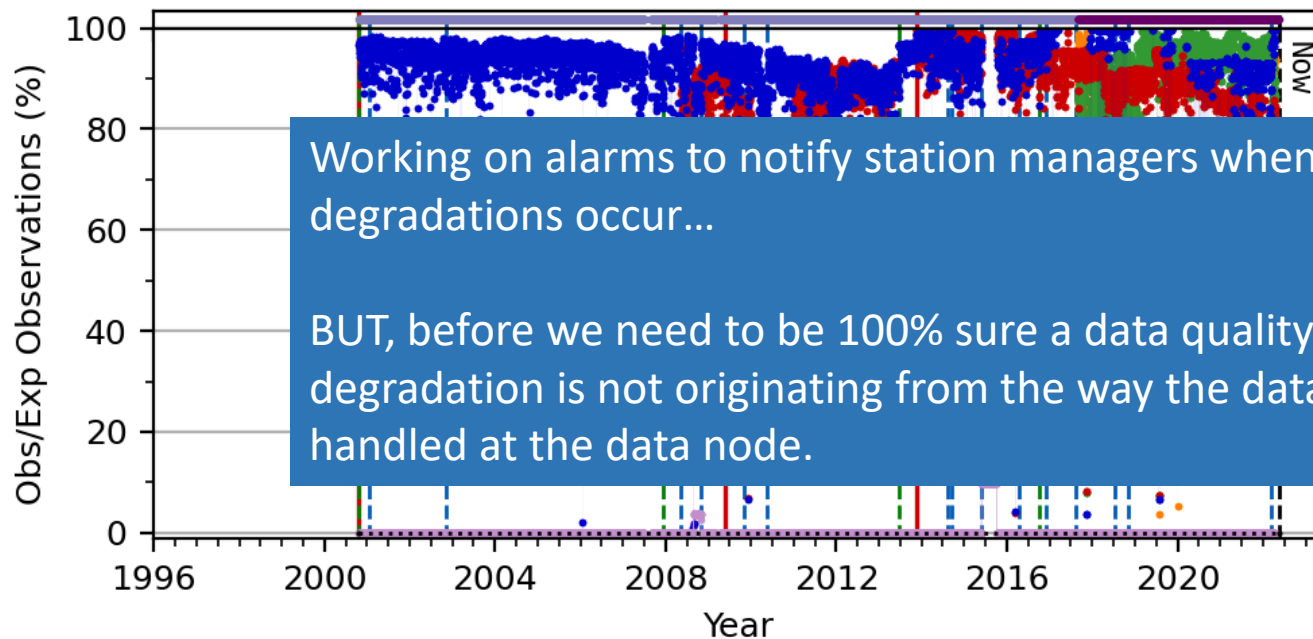
Tue May 17 12:30:22 2022

©GNSS@ROB

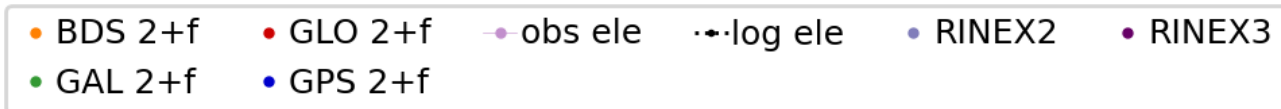
# Data quality plots

## Observed/Expected Observations

APEL00NLD - Pan-European data node



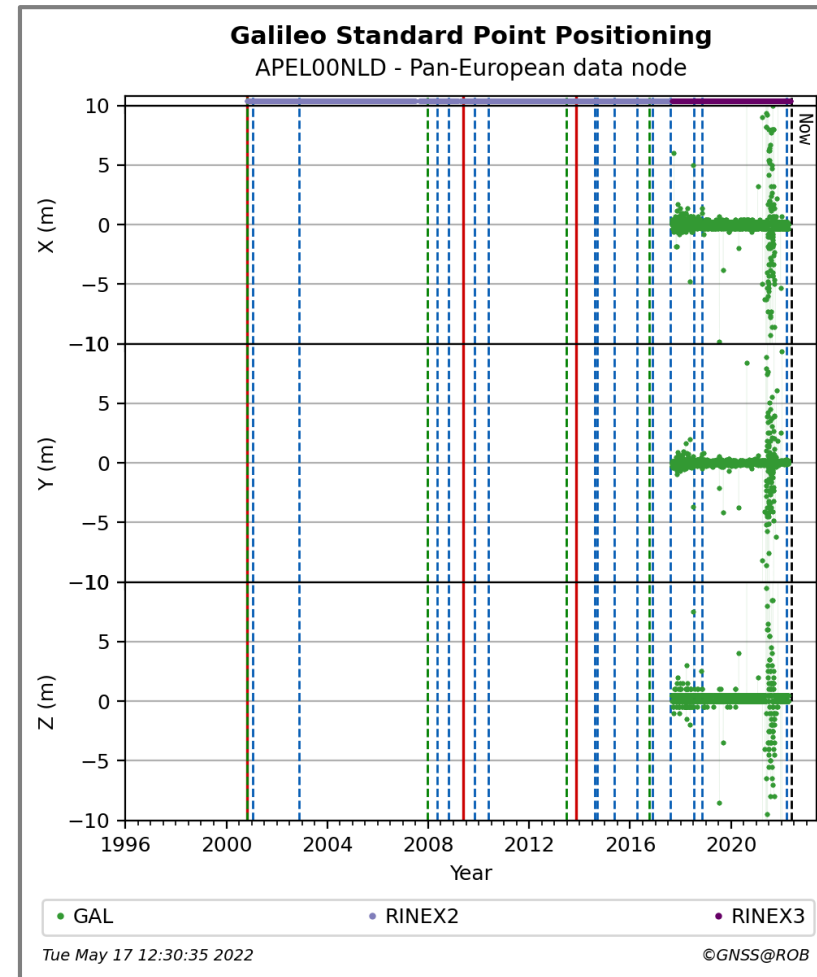
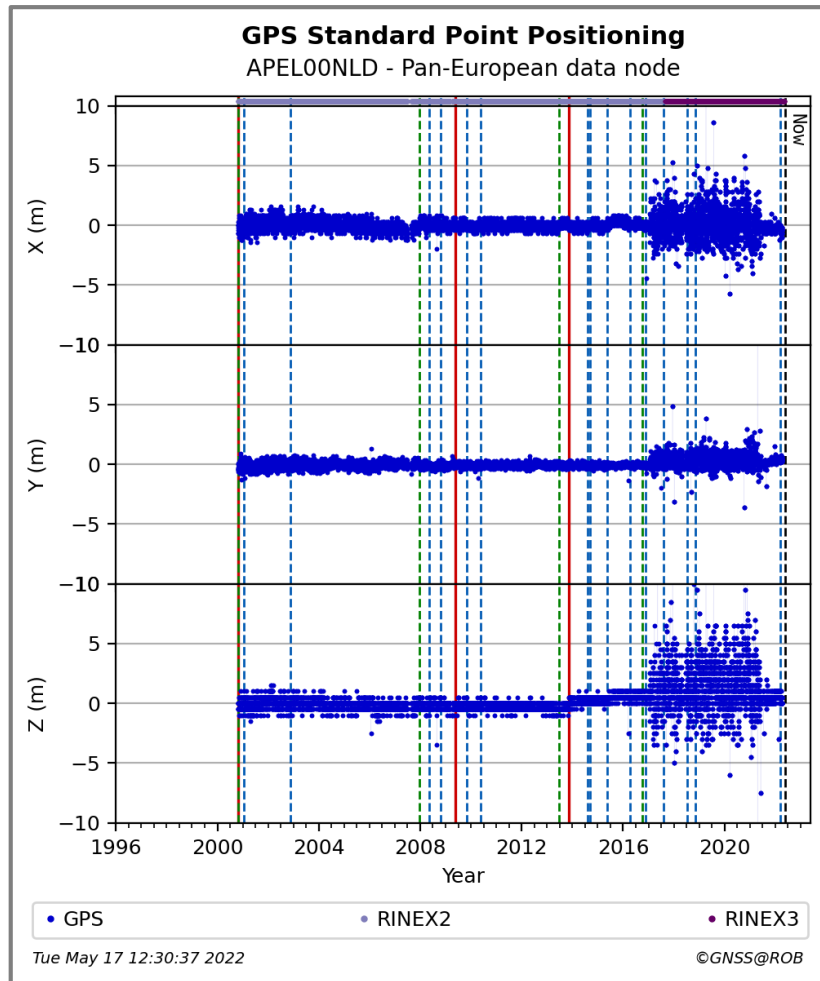
Process of validating the data quality metrics is presently ongoing!



Tue May 17 12:30:22 2022

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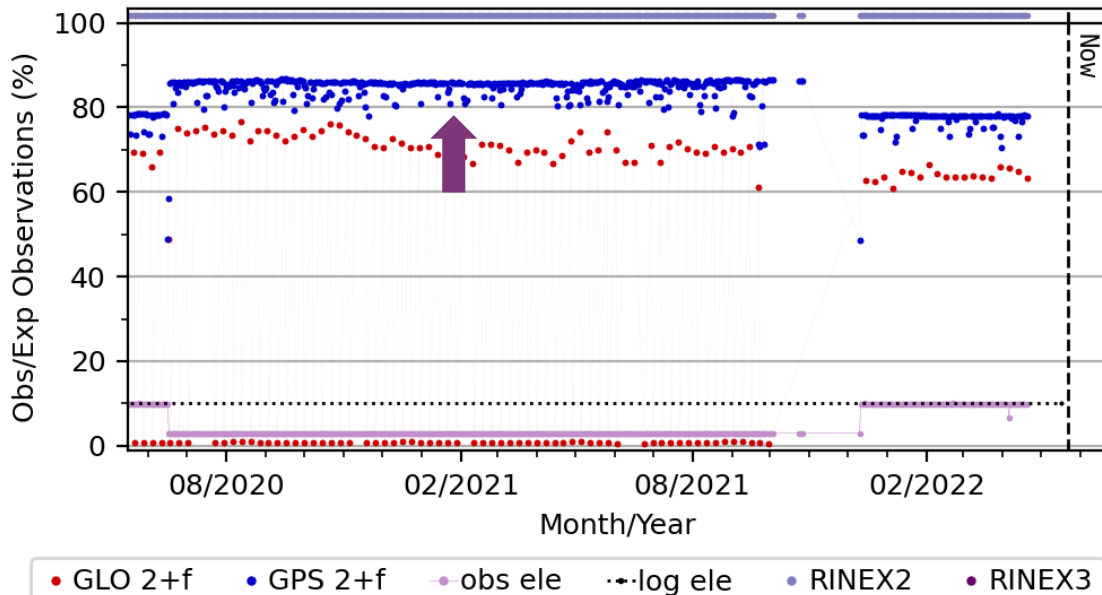
# Data quality plots



# Comparison of data quality plots from two nodes

## Observed/Expected Observations

ZNTE00GRC - INGV data node

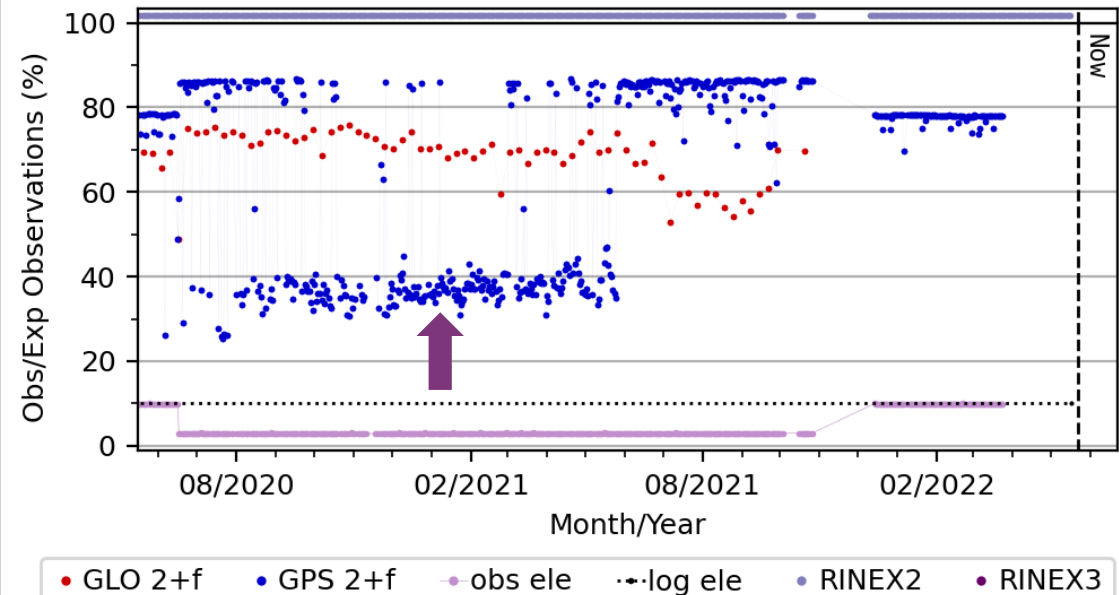


Tue May 17 13:45:41 2022

©GNSS@ROB

## Observed/Expected Observations

ZNTE00GRC - NOA data node



Tue May 17 12:08:13 2022

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# Conclusions & Outlook

- EPOS-GNSS network continues to extend
  - Good contribution from EPN
  - EPN densification stations in EPOS → site log is maintained + EPOS does RINEX header check & data quality plots
  - EPOS provides new GNSS stations not yet contributing to EPN densification
- Distributed data dissemination
  - EPOS-GNSS data nodes all use GLASS software to ensure harmonization of RINEX data handling and quality checks
- New EPOS-GNSS network monitoring has been started at ROB (but still under development!)
  - Like in EPN, when you start monitoring, you start to see problems ....
- EPOS-GNSS technical workshop (May 5-6, 2022)
  - Set priorities for improving GLASS software
  - Increase feedback to nodes and station managers
- Future
  - Integrate European GNSS stations at tide gauges in EPOS (ULR – SONEl)

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