



GNSS Services in EPOS' Pilot Operational Phase

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Outline

- Introduction
- Pre-operational GNSS data services
- Pre-operational GNSS product services
- Conclusions

European Plate Observing System (EPOS)

What?

EPOS is the European Research Infrastructure serving Solid Earth science

In Practice

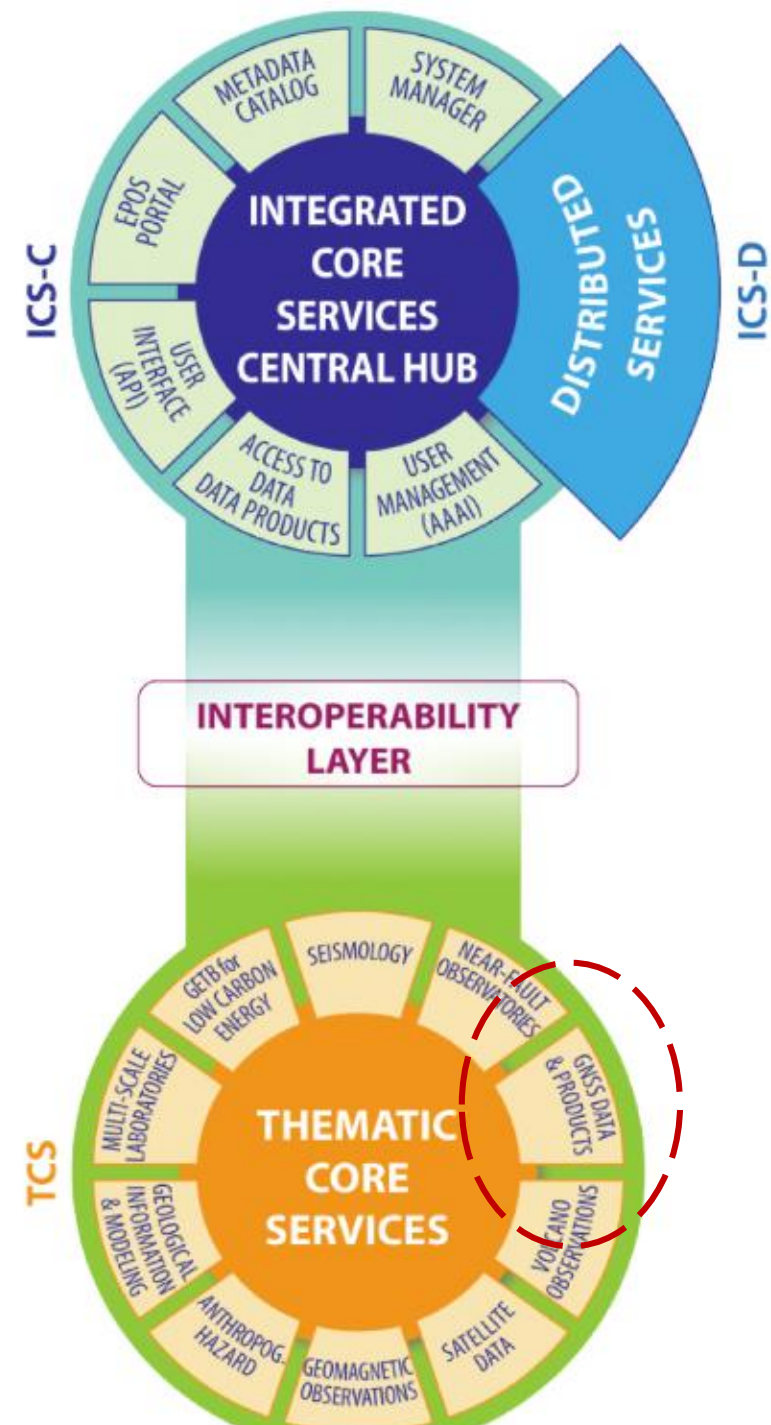
Multidisciplinary research platform to provide access to quality controlled data from diverse Earth science disciplines, together with tools for their use in analysis and modelling

Measure how ground moves

Understand why ground moves



POP aims at enabling Data and Service provision and strengthen their sustainability



Central Hub of EPOS Integrated Core Services

<https://www.ics-c.epos-eu.org/>

ICS services are not yet fully operational and are presently evaluated and improved



Central Hub of EPOS Integrated Core Services

<https://www.ics-c.epos-eu.org/>

The screenshot displays the EPOS ICS web application. On the left, a sidebar shows search results for various categories: Geoelectromagnetism (19), Geology (8), Anthropogenic Hazard Observations (39), Volcano Observations (45), Satellite Observations (8), Geodesy (14), Near Fault Observations (37), and Seismology (55). A blue arrow points from the 'Satellite Observations (8)' category to a detailed view of this category. This view lists several data products: Wrapped Interferograms, Spatial Coherence, Unwrapped Interferograms, Map of LOS Vector, Interferogram, Atmospheric Phase Screen from Global Atmospheric Model, DEM in radar geometry, Lookup table from radar coordinates to ground coordinates, and LOS Displacement Time Series. Each product has icons for download and other actions. The background of the interface shows a map of Europe.

Access to
(meta)data
from different
communities

EPOS Integrated Core Services

<https://www.ics-c.epos-eu.org/>

The screenshot displays the EPOS ICS web interface. On the left, a sidebar shows search results for 225 items, categorized by service: Geoelectromagnetism (19), Geology (8), Anthropogenic Hazard Observations (39), Volcano Observations (45), Satellite Observations (8), Geodesy (14), Near Fault Observations (37), and Seismology (55). The 'Geodesy (14)' category is selected, and a detailed view of its services is shown in a central panel. This panel lists three main data categories: 'Data (3)' and 'Products (11)'. The 'Data' category includes 'GNSS Stations with RINEX Data', 'List RINEX Files search parameters', and 'Download RINEX file Metadata from EPOS Validated Providers'. The 'Products' category is further divided into 'Raw GNSS Position Time Series (1)' and 'Cleaned GNSS Position Time Series (5)'. The 'Raw' series is 'Raw GNSS Position Time Series from WUT-EUREF Distribution'. The 'Cleaned' series include 'Cleaned GNSS Position Time Series from UGACNRS Distribution', 'Cleaned GNSS Position Time Series from INGV Distribution', 'Cleaned GNSS Position Time Series from ROB-EUREF Distribution', 'Cleaned GNSS Position Time Series from LTK Distribution', and 'Cleaned GNSS Position Time Series from LTK-EUREF'. Each item has icons for search, download, and folder management. The background shows a map of Europe with a search bar and a 'Map' button.

EPOS Timeline - GNSS

2011: EPOS reached out to EUREF TWG

EUREF TWG appointed representative to EPOS.

2012: Impossible for EUREF (no legal entity) to formally not contribute to EPOS.
Individual EUREF agencies could **assure EUREF standards are transposed to EPOS.**

2015: EPOS Implementation Phase

Several EUREF agencies helped to shape the future EPOS infrastructure.

2019: EUREF resolution encouraging its members to contribute to EPOS

More and more agencies involved in EUREF started to contribute also to EPOS.

2020: Start of EPOS Pilot Operational Phase

Some of the EPOS-GNSS services are mature enough to be tested by EPOS.

2021: EUREF-EPOS ERIC Memorandum of Understanding under preparation



EPOS goals related to GNSS:

- ✓ Provide access to GNSS data, metadata, and products
- ✓ Promote best practices for GNSS station operation, data quality control and data management
- ✓ Maintain and develop GNSS products for Solid Earth sciences

From as much
as possible
GNSS stations
all over
Europe

Organization of GNSS Services in EPOS



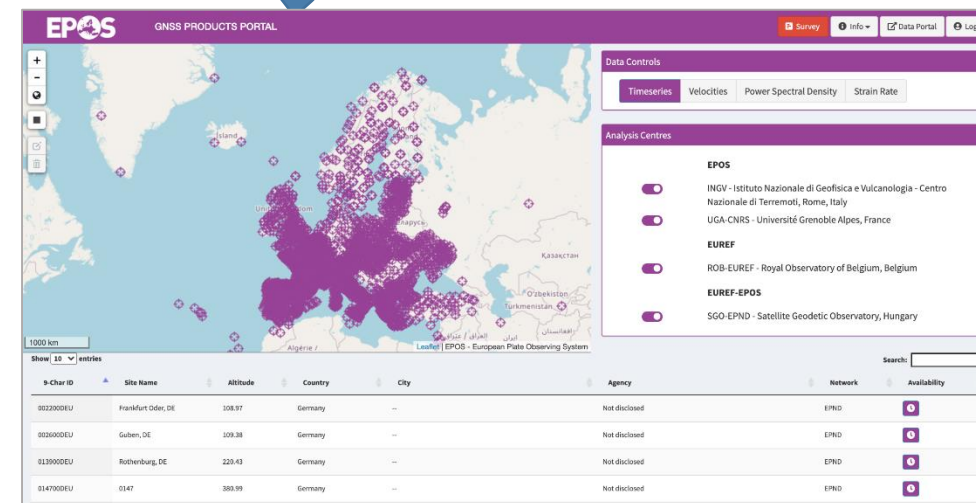
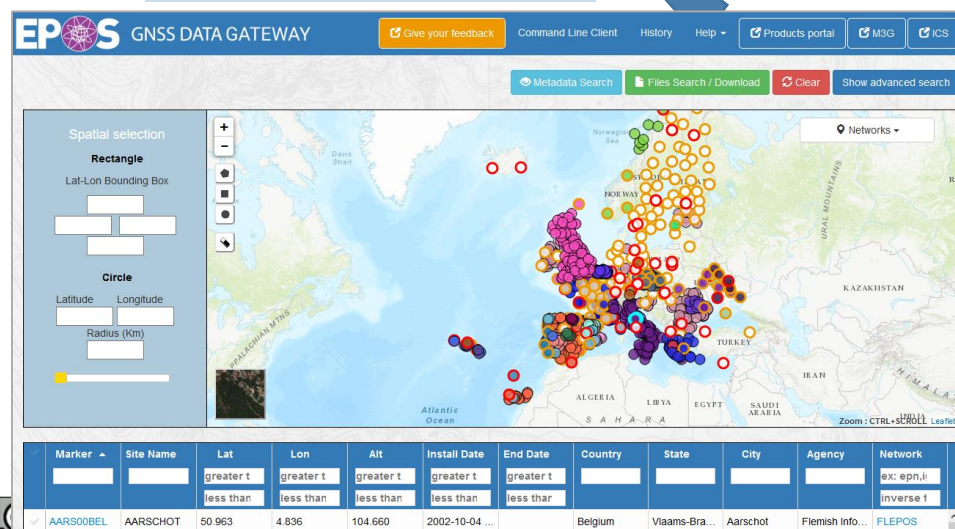
Central Hub of Integrated Core Services
<https://www.ics-c.epos-eu.org/>

Web services

Web services

EPOS-GNSS data portal
<http://gnssdata-epos.oca.eu/>

EPOS-GNSS product portal
<https://gnssproducts.epos.ubi.pt/>



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EPOS-GNSS station network

1. Permanently tracking **GNSS stations**
 - a) Presently active
 - or
 - b) Decommissioned stations that worked for minimally 3 years
2. Maintain station metadata (**site log** + other metadata)
3. Provide **free access** to **daily RINEX** data (v2 or v3)

Agencies providing GNSS data to EPOS need to formalize this through the signature of the EPOS-GNSS data supplier letter

1205 stations

- ✓ 240 EPN stations (66%)
- ✓ 828 EPN densification stations
- ✓ 137 other GNSS stations



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

16 stations from the Netherlands (received on 27/05/2021 are not yet included)

EPOS-GNSS station site logs

<https://gnss-metadata.eu>

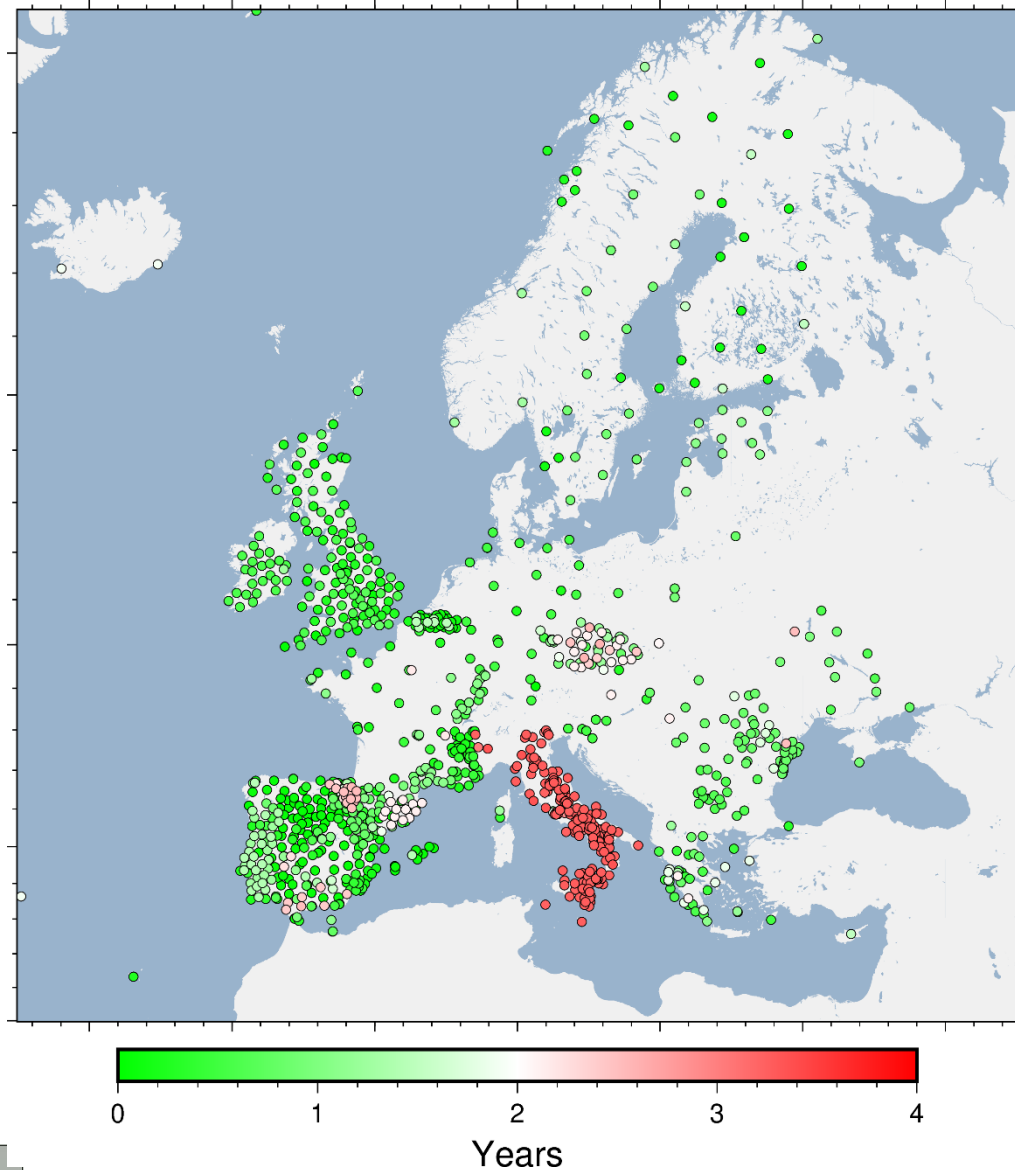
Development of M³G

Full harmonization between EUREF and EPOS

- M³G used to submit/validate site logs of EPN, EPN densification and EPOS stations
- IDENTICAL site logs in EUREF and EPOS for common stations
 - Site log has to be submitted just once

The screenshot shows the M³G website interface. At the top, the logo 'M³G' is displayed next to the text 'Metadata Management and Distribution System for Multiple GNSS Networks'. Below this is a navigation bar with links for Agencies, Stations, Metadata Catalog, EPOS Data Nodes, Networks, Documentation, and About, along with a Login button. A large 'Welcome!' banner is prominently displayed. The main content area is divided into three sections: 'Supported GNSS networks' on the left, a central map of Europe showing '2687 GNSS stations with metadata in M³G', and 'Updates' on the right. The 'Supported GNSS networks' section lists three networks: EUREF Permanent Network (EPN), EPN Densification Network, and European Plate Observing System (EPOS) Network, each with a play button icon. The central map shows a dense distribution of green dots representing GNSS stations across Europe, with a legend indicating 'On' for EPN stations, EPN densification stations, and EPOS stations. The 'Updates' section lists several recent updates, including firmware updates and antenna changes for various stations, with a pagination bar at the bottom showing '1 2'.

EPOS-GNSS station metadata



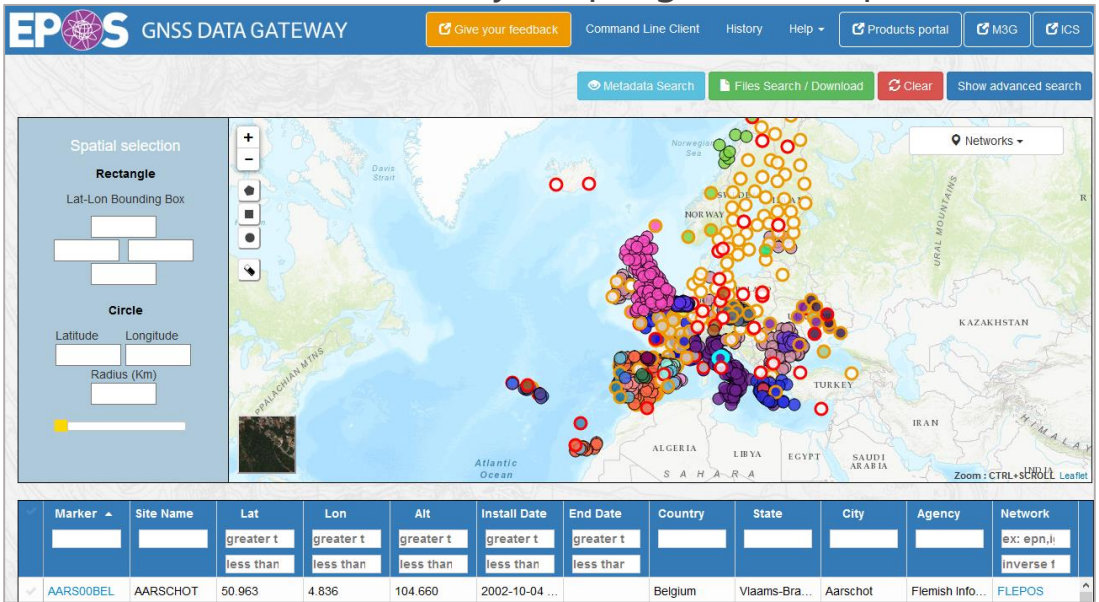
Time since last site log update

- Site log updates are time consuming for agencies operating large amount of stations
- Goal: to automatically trigger site log update in M³G when agency updates site logs in their local data base

One of the issues to be solved during EPOS Pilot Operational Testing

GNSS data availability

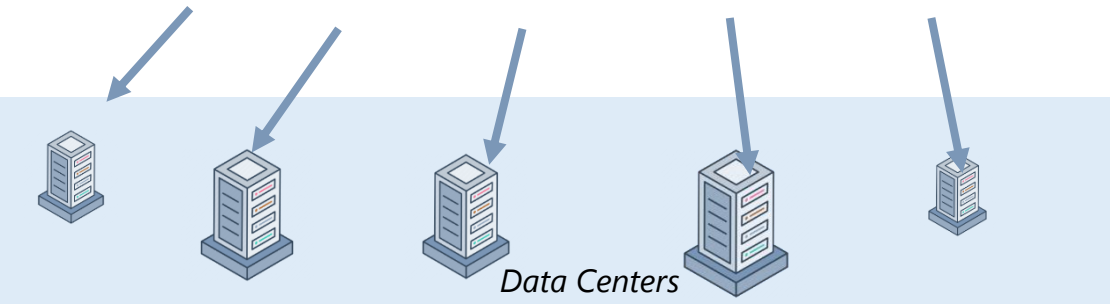
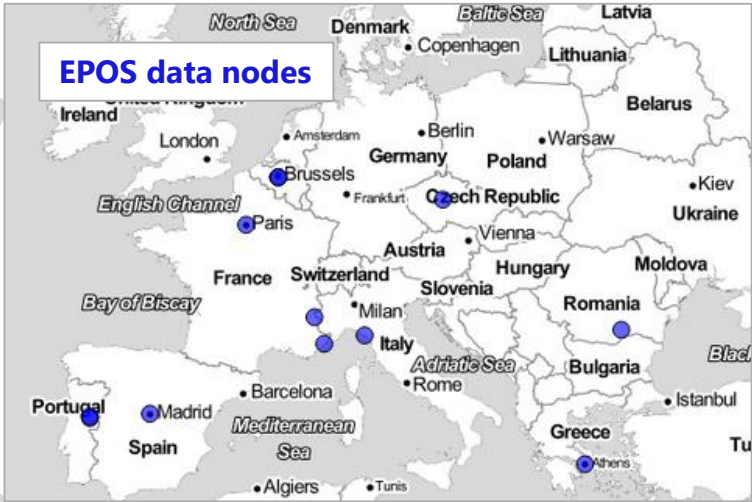
EPOS GNSS Data Gateway: <http://gnssdata-epos.oca.eu>



Centralized access to RINEX data via

- Web interface
- APIs

EPOS data nodes provide access to RINEX data available from underlying data centers **IF they pass quality control**



RINEX data remain at Data Centers

GNSS Data Discoverable from EPOS Data Gateway

Pilot Operational Phase

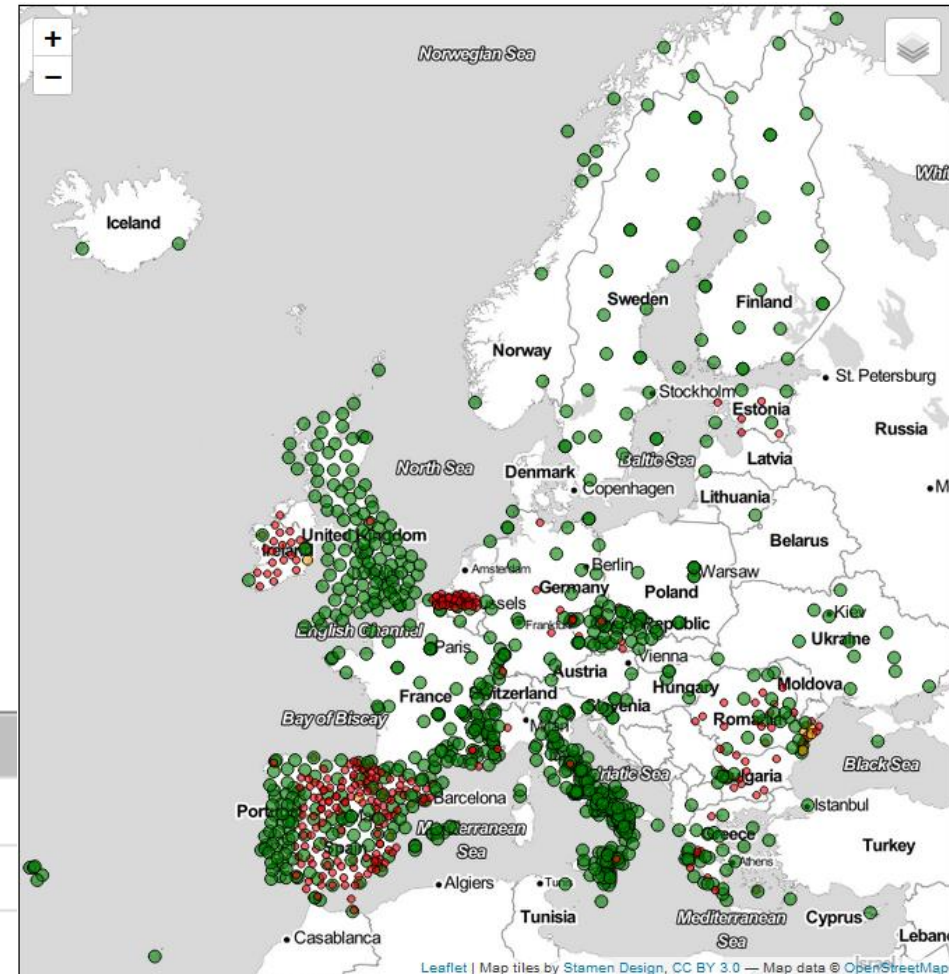
Not all station data are accessible yet from EPOS-GNSS data gateway

- Some nodes still being set up (e.g. Belgian node)
- Some nodes are still being populated
 - Clean up all RINEX data & site logs

Only RINEX data consistent with site log info will be accessible from EPOS-GNSS data gateway

1205 EPOS Stations at DGW

●	833 stations with more than 30 days of RINEX data
●	11 stations with less than 30 days of RINEX data
●	361 stations without RINEX data



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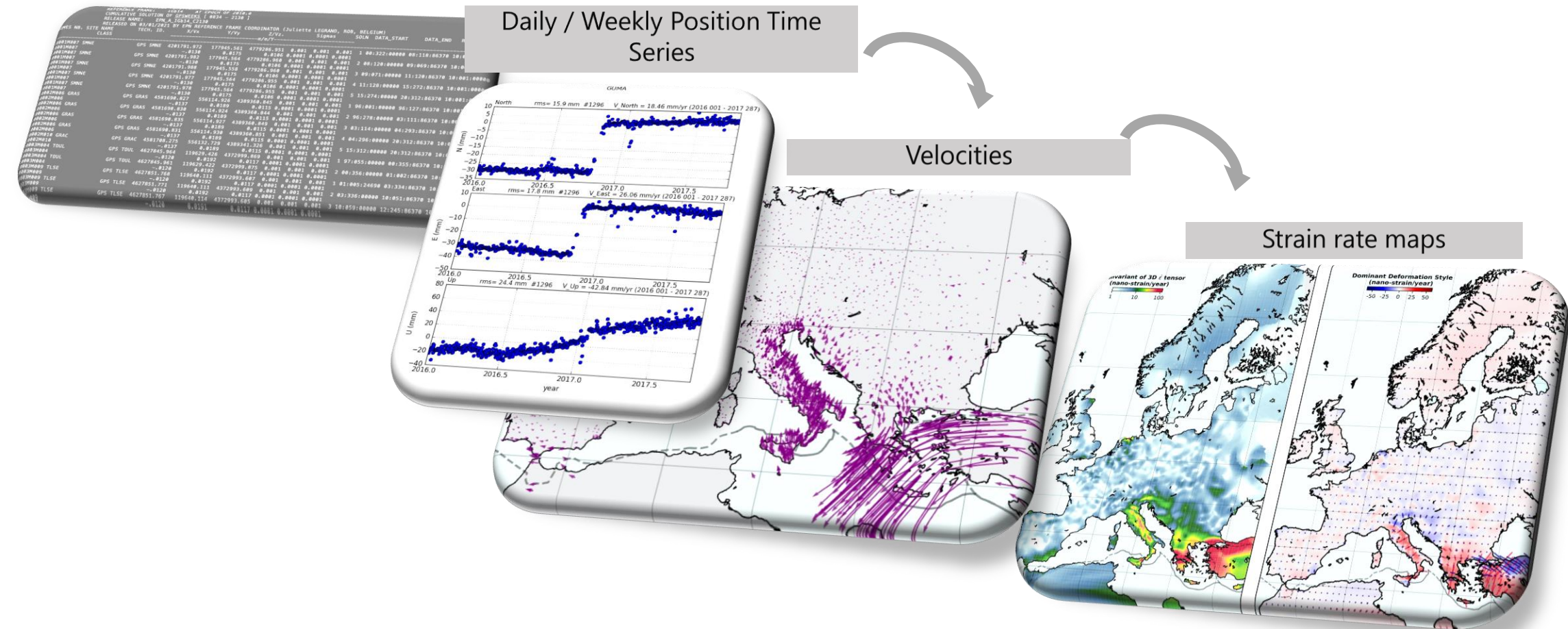
GNSS Products

Daily / Weekly Positions

Daily / Weekly Position Time Series

Velocities

Strain rate maps



GNSS Products

EPOS-GNSS Product Portal: <https://gnssproducts.epos.ubi.pt/>

S-Char ID	Site Name	Altitude	Country	City	Agency	Network	Availability
002200DEU	Frankfurt Oder, DE	108.97	Germany	—	Not disclosed	EPND	
002600DEU	Guben, DE	109.38	Germany	—	Not disclosed	EPND	
013900DEU	Rothenburg, DE	220.43	Germany	—	Not disclosed	EPND	
014700DEU	0147	380.99	Germany	—	Not disclosed	EPND	

Analysis Centers UPLOAD products to product portal

Products can be based on data from EPOS and non-EPOS stations (taking data licenses into account)

EPOS Pilot Operational Testing: EPOS-GNSS Product Portal currently under revision!

Uploaded GNSS Products

- A. EPOS-specific solutions
 1. Double difference
 2. PPP
- B. EUREF solutions
 1. EPN daily combined solution
 2. EPN reference frame solution
 3. EPN densification solution
- C. EUREF-EPOS solutions
 1. Combination of A.1, A.2, B.3
 2. Strain rates

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EPOS' Pre-Operational GNSS Services in a Nutshell

Ambition: Provide information on ground motions based on permanent GNSS stations in Europe

Collaboration between agencies involved in EUREF and geophysicists from all over Europe

Data Services

- Collection of and access to station metadata through M³G
- Centralized access to daily RINEX data through EPOS-GNSS Data Gateway

Contributions from

- EPN station managers
- EPN data centers
- EPN Central Bureau

Product Services

- EPOS-specific GNSS data analysis
- Centralized access to GNSS products through EPOS-GNSS Product Portal
 - EUREF products
 - EPOS-specific products
 - Common EUREF-EPOS products

Contributions from

- EPN analysis coordinator,
- EPN reference frame coordinator
- EPN densification WG
- EPN deformation modeling WG

Linked through **web services (APIs)** to the **EPOS ICS** where GNSS data and products can be combined with other data.