



**GNSS DATA AND
PRODUCTS**

TCS GNSS DATA AND PRODUCTS

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Chair Executive Board
Royal Observatory of Belgium

EPOS-BE Webinar Nov. 24, 2023



Based on the work done by the whole EPOS-GNSS team



ROYAL OBSERVATORY
OF BELGIUM



GNSS data in a nutshell

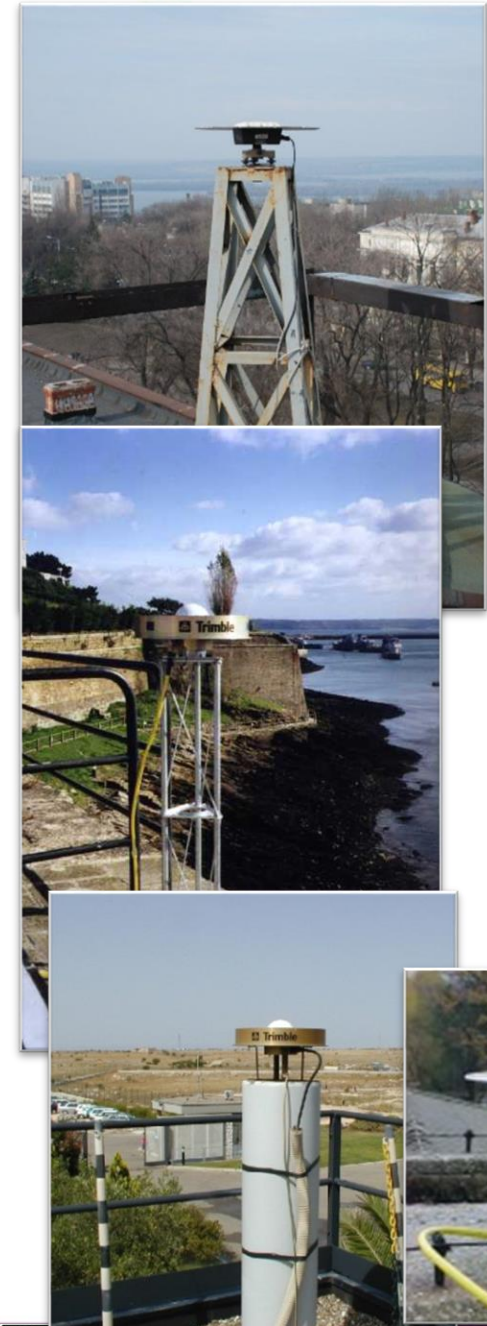


- Global Navigation Satellite Systems, e.g. GPS, Galileo, GLONASS, BeiDou
- GNSS satellites emit radio signals captured by **GNSS stations** installed at fixed locations on the Earth
- GNSS stations are equipped with **high-precision GNSS instruments**
- GNSS data used for **multi-disciplinary applications**: maintenance of coordinate reference systems, monitoring of ground deformations, ionosphere, troposphere, ...

GNSS TCS Mission

- Make openly available data from as many as possible GNSS stations
- Generate and distribute GNSS data products tuned to the needs of EPOS users

through EPOS data portal





GNSS DATA AND
PRODUCTS

The challenge when we got started

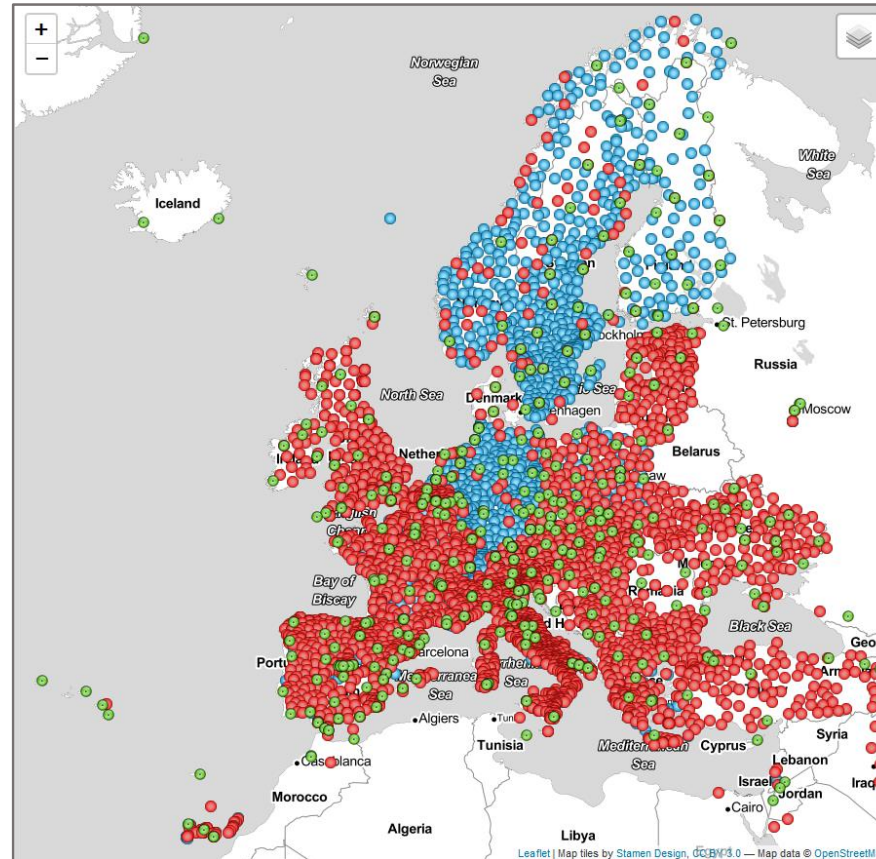
~5000 existing GNSS stations with data operationally analyzed for high-precision applications

→ Huge potential for integration in EPOS RI

GNSS data used for multi-disciplinary applications

- Reference frames (EUREF)
- Surveying
- Ground movements and strain rates
- Space weather
- Numerical weather prediction
- Sea-level monitoring
- Soil moisture
- Ice and snow thickness
- ...

EUROPEAN PLANETARY OBSERVING SYSTEM



- Diverse communities, not necessarily talking to each other
- Different modus operandi and objectives
- Only small part of GNSS data discoverable in an organized way (EUREF stations < 400 – in green in map)



GNSS DATA AND
PRODUCTS

From 2015 on ...



Bring diverse GNSS communities together using an inclusive approach and **construct new GNSS infrastructure** inspired by the existing EUREF network

- ✓ Set up governance framework with representatives from data providers and users
- ✓ Design and implement the necessary procedures and building blocks to provide operational services ensuring
 - Discoverability of quality-checked GNSS data and station metadata
 - Generation and discoverability of GNSS products
- ✓ Using international community-agreed standards

RELIABLE PRODUCTION CHAIN FOR PROVISION OF THE GNSS SERVICES



GNSS DATA AND PRODUCTS

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

TCS community portals

EPOS data portal

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

Access to multi-disciplinary data & products

Live demonstration of data portal after coffee break



EPOS
EUROPEAN PLATE OBSERVING SYSTEM

MENU

Community Portals

Home

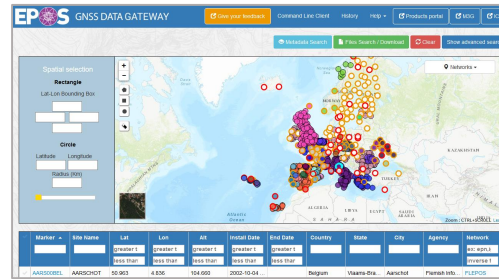
Within EPOS' framework, each Thematic Core Service (TCS) provides where users can find a wide variety of data and other resources

- ▼ **Seismology**
- ▼ **Near-Fault Observations**
- ▼ **GNSS Data and Products**
- ▼ **Volcano Observations**
- ▼ **Satellite Data**
- ▼ **Geomagnetic Observations**
- ▼ **Anthropogenic Hazards**
- ▼ **Geological Information and Modeling**
- ▼ **Multiscale Laboratories**



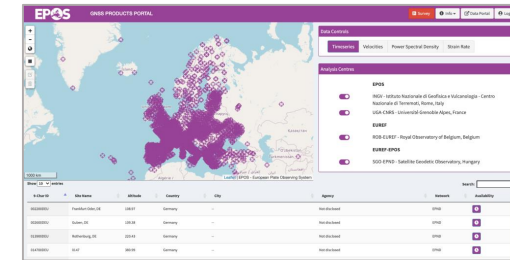
4 GNSS TCS Community Portals

GNSS data portal



France

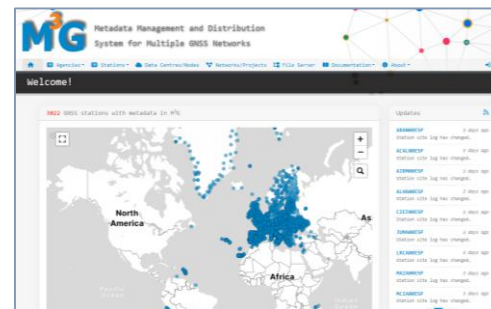
GNSS products portal



Portugal

Portals specifically created/operated for EPOS

GNSS station metadata portal



Belgium

GNSS data quality monitoring portal



Belgium



GNSS data and products

EPOS data portal

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

Web services



EPOS-GNSS data gateway

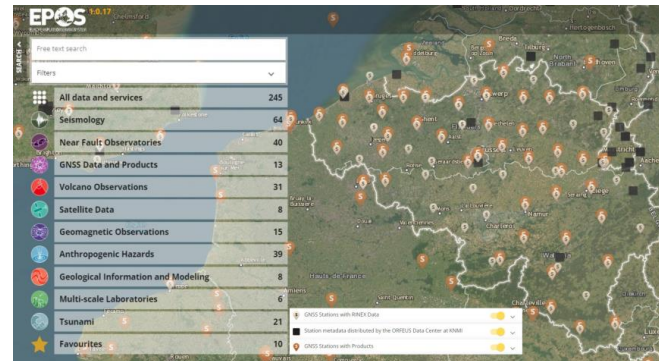
<http://gnssdata-epos.oca.eu/>

Web services



EPOS-GNSS product portal

<https://gnssproducts.epos.ubi.pt/>



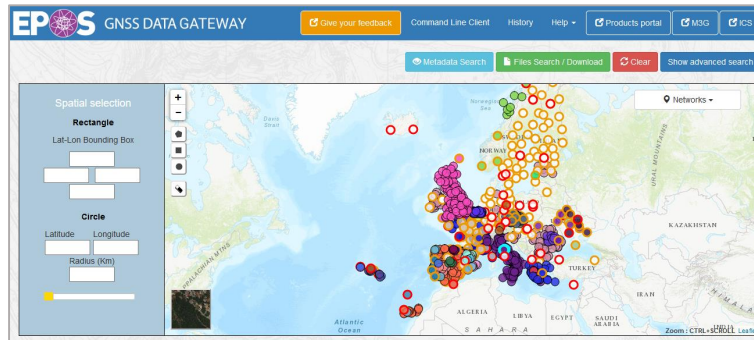
The screenshot shows the EPOS-GNSS data gateway interface. It features a map of Europe with various colored markers representing different data points. On the left, there is a 'Spatial selection' panel with options for 'Rectangle' (Lat-Lon Bounding Box) and 'Circle' (Latitude, Longitude, Radius (km)). Below the map is a search table with columns: Marker, Site Name, Lat, Lon, Alt, Install Date, End Date, Country, State, City, Agency, and Network. The table contains several rows of data, including AARS00BEL, AARSCHOT, and others.

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	Viaams-Bra...	Aarschot	Flemish info...	FLEPOS

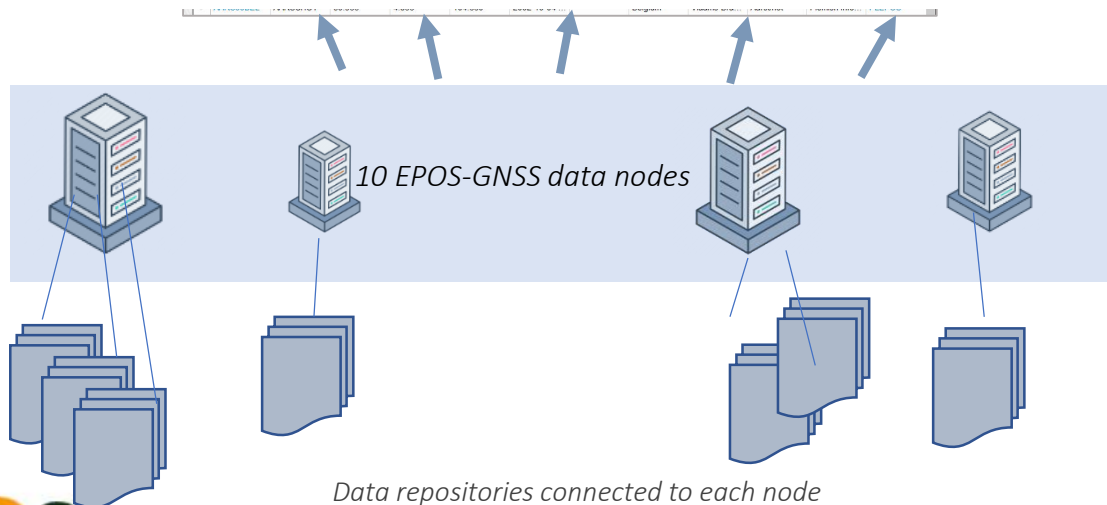
The screenshot shows the EPOS-GNSS product portal interface. It features a map of Europe with various colored markers representing different data points. On the right, there is a 'Data Controls' panel with options for 'Timeseries', 'Velocities', 'Power Spectral Density', and 'Strain Rate'. Below the map is a table of 'Analysis Centres' with columns: 9-Char ID, Site Name, Altitude, Country, City, Agency, Network, and Availability. The table contains several rows of data, including 002200DEU, 002600DEU, 013900DEU, and 014700DEU.

9-Char ID	Site Name	Altitude	Country	City	Agency	Network	Availability
002200DEU	Frankfurt Oder, DE	108.97	Germany	--	Not disclosed	EPND	<input type="checkbox"/>
002600DEU	Guben, DE	109.38	Germany	--	Not disclosed	EPND	<input type="checkbox"/>
013900DEU	Rothenburg, DE	220.43	Germany	--	Not disclosed	EPND	<input type="checkbox"/>
014700DEU	0147	380.99	Germany	--	Not disclosed	EPND	<input type="checkbox"/>

EPOS-GNSS data dissemination concept



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



Distributed Data Access:

Station operators upload their GNSS observation data (daily RINEX 30s) to a data repository (or data center).

Data node

1. Performs quality control
2. Makes GNSS data visible to EPOS-GNSS data gateway

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

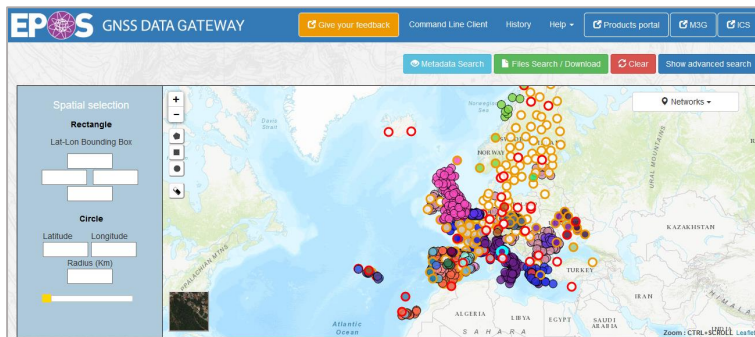
Data Gateway offers centralized access to GNSS (meta)data in all repositories via

- Web interface
- APIs

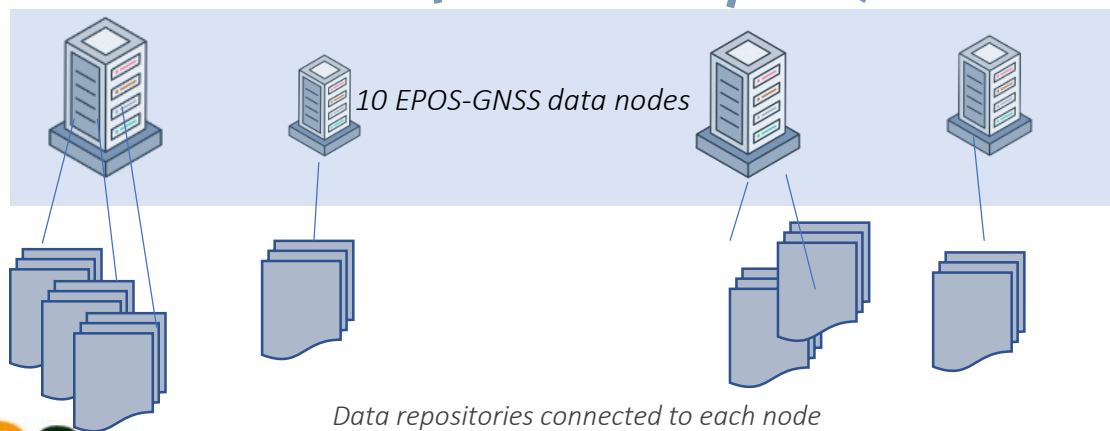


GNSS DATA AND PRODUCTS

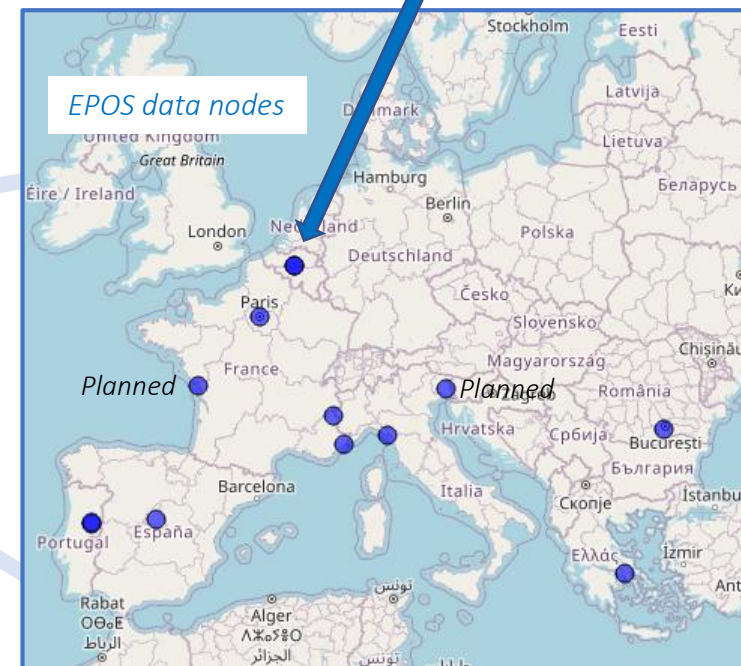
EPOS-GNSS data dissemination concept



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



2 EPOS-GNSS data nodes at Royal Observatory of Belgium

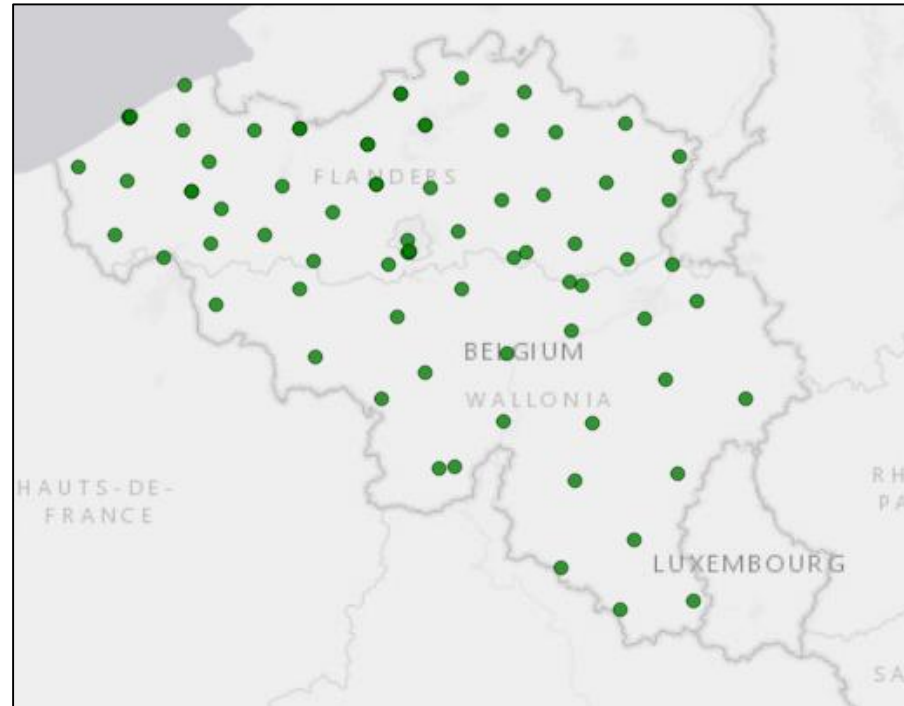




GNSS DATA AND
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Two GNSS data nodes in Belgium

Belgian national data node



Data from

- Royal Observatory of Belgium
- Digitaal Vlaanderen
- Service Public de Wallonie
- Centre Spatial de Liège
- Nationaal Geografisch Instituut

more permanently tracking GNSS stations are welcome!

- # files: 450k
- # stations: 78
- 1996 - today

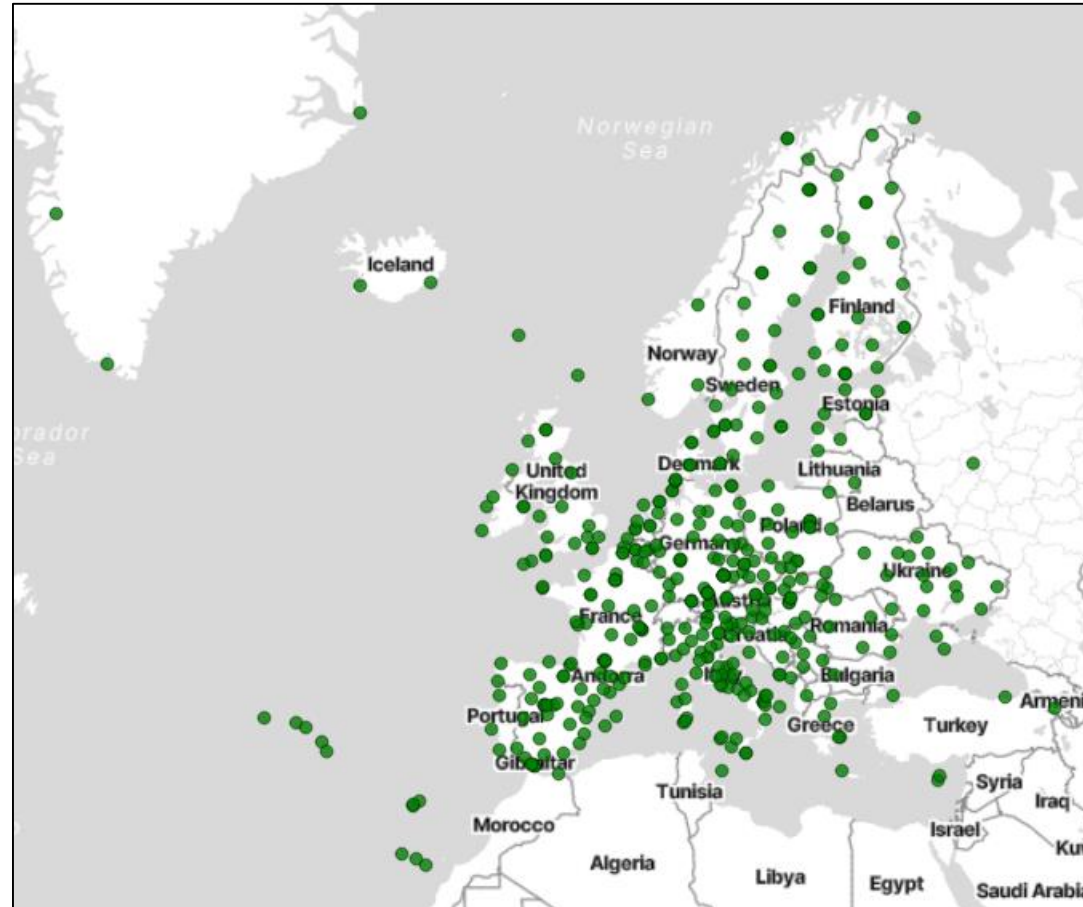
Daily RINEX data available through EPOS-GNSS data gateway or EPOS data portal



GNSS DATA AND
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Two GNSS data nodes in Belgium

EUREF data node



GNSS data from

- 100+ different agencies
- # files: 2,3M
- # stations: 429
- 1996 - today

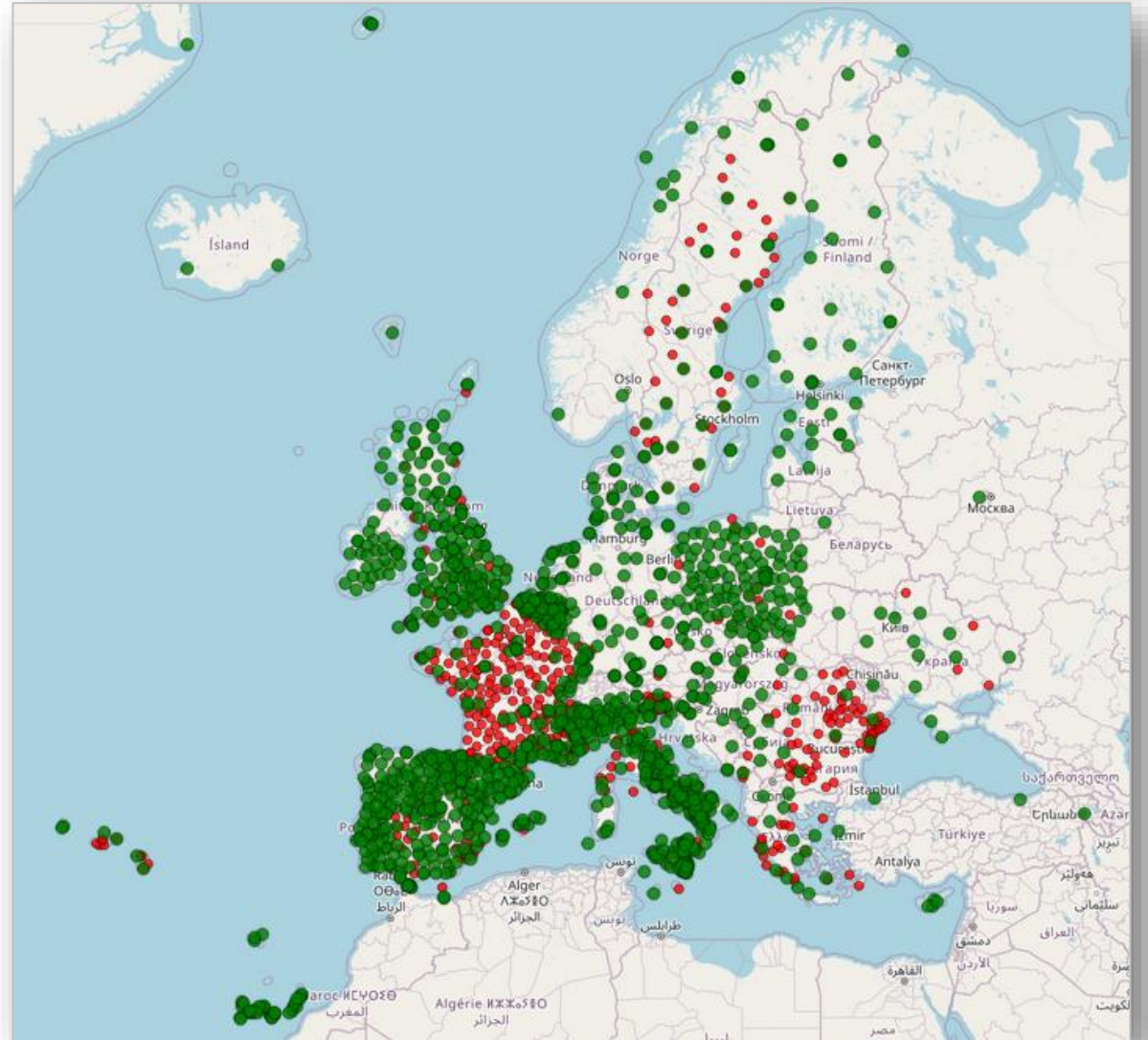
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GNSS DATA AND
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Present EPOS-GNSS network

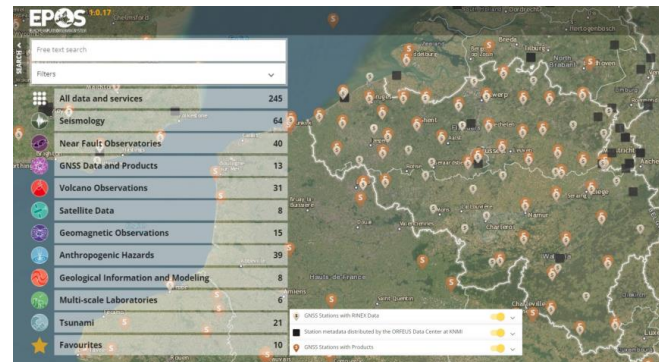
- 583 GNSS stations with data sets to be integrated
- 1363 GNSS stations with integrated data sets





GNSS data and products

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



Web services

Web services

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

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Origin of GNSS products

- 2 dedicated GNSS analysis centers (Italy, France) processing the data of all EPOS-GNSS stations
- EUREF analysis/combination centers (Belgium, Poland, Hungary)
 - Building on contributions from agencies all over Europe
 - Includes contributions from ROB, NGI in Belgium
- Strain rates (Sweden)





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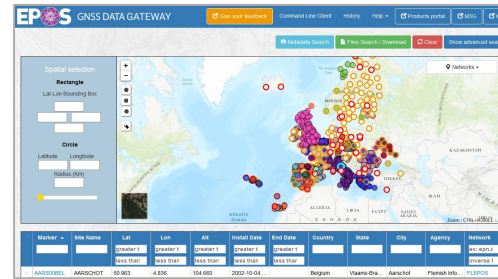
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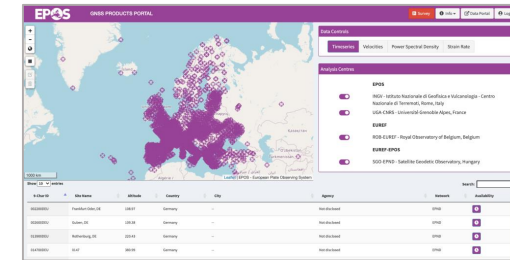
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GNSS data portal



France

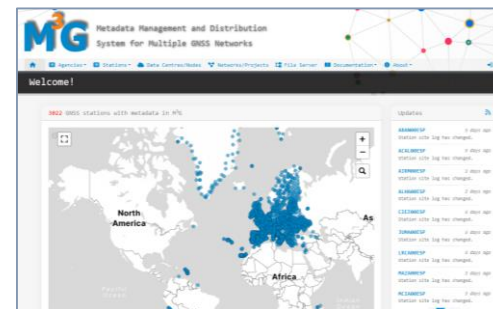
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GNSS station metadata portal



Belgium

GNSS data quality monitoring portal



Belgium



GNSS DATA AND
PRODUCTS

Added-value of EPOS-GNSS

Provision of

- **Station metadata**
 - Site logs: e.g. equipment changes that can influence the estimated station position
 - DOI, data license
- GNSS data quality information
 - e.g. that allows to evidence when GNSS data quality can provide unreliable station position estimates

<https://gnss-metadata.eu>

MG³ Metadata Management and Distribution
System for Multiple GNSS Networks

Welcome!

3014 GNSS stations with metadata in MG³

Updates

- VOLC** Station CBEZ00GLP proposed to the VOLC network. yesterday
- VOLC** Station AB0Z00GLP proposed to the VOLC network. yesterday
- GL** Station CBEZ00GLP proposed to the GL network. yesterday
- GL** Station AB0Z00GLP proposed to the GL network. yesterday
- CBEZ00GLP** Antenna changed to AERAT1675_120 SPKE (SN:5513) yesterday
- HOUZ00GLP** Data license is set to CC-BY-4.0 in station metadata. yesterday
- AB0Z00GLP** Data license is set to CC-BY-4.0 in station metadata. yesterday
- CBEZ00GLP** Data license is set to CC-BY-4.0 in station metadata. yesterday
- AB0Z00GLP** Antenna changed to AERAT1675_120 SPKE (SN:5504) yesterday

Belgian services provided by the Royal Observatory of Belgium



Added-value of EPOS-GNSS

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- Station metadata
 - Site logs: e.g. equipment changes that can influence the estimated station position
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- GNSS data quality information
 - e.g. that allows to evidence when GNSS data quality can cause unreliable station position estimates

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

The screenshot displays the EPOS-GNSS Data Quality Monitoring Portal. The page title is "EPOS-GNSS Data Quality Monitoring Portal" and it is hosted by the "ROYAL OBSERVATORY OF BELGIUM". The main content area shows a map of Europe with numerous station locations marked by colored dots. The map is filtered to show "Data gateway" stations. The legend indicates that there are 1933 EPOS Stations at DGW, with 243 stations having data within the last 2 days and 784 stations having data within the last 25 days. The page also includes navigation links for "RINEX DATA AVAILABILITY", "RINEX DATA QUALITY", "NODE MONITORING", and "LINKS AND DOCUMENTATION".

Belgian services provided by the Royal Observatory of Belgium

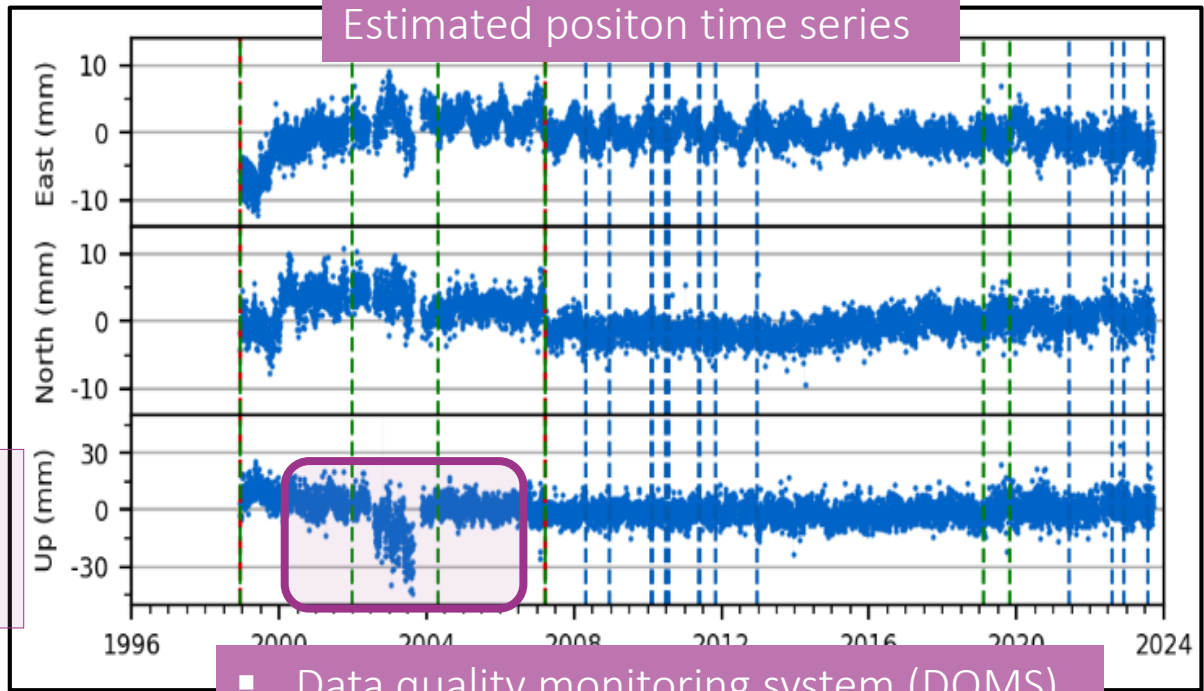


M³G & DQMS provide valuable information to help identifying if a computed change in the position of a GNSS station is caused by a real ground movement or not

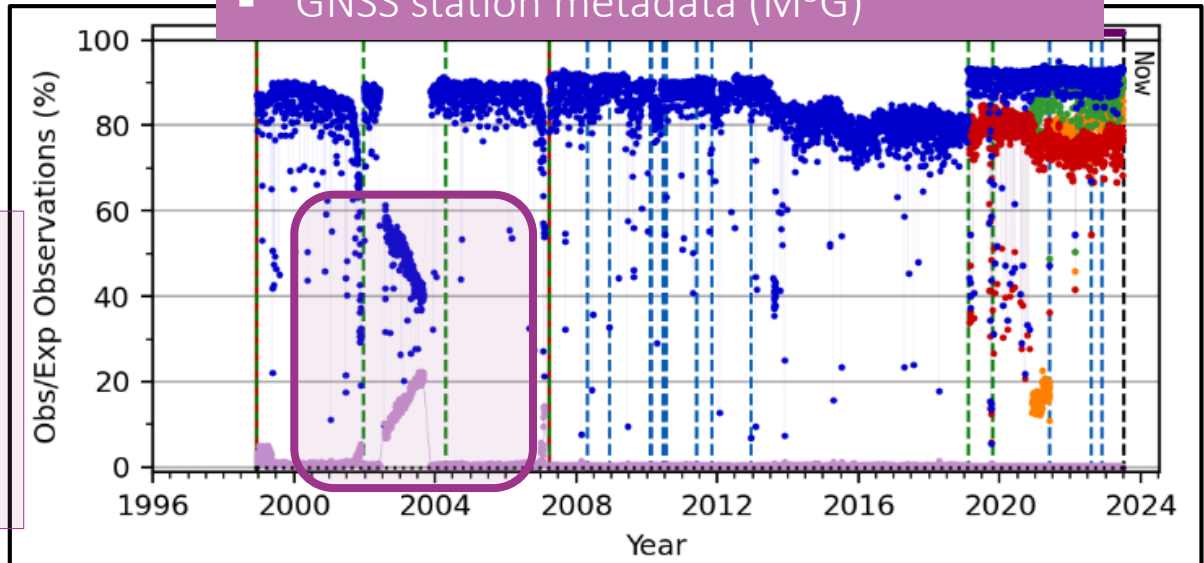
Subsidence of the station of about 3 cm

Computed subsidence is not “real” but caused by degraded data quality

Estimated position time series



- Data quality monitoring system (DQMS)
- GNSS station metadata (M³G)



- BDS 2+f
- GAL 2+f
- GLO 2+f
- GPS 2+f
- obs ele
- log ele
- RINEX2
- RINEX3



GNSS DATA AND
PRODUCTS

Conclusions

- New GNSS e-infrastructure providing data and data products of 1000's of GNSS stations to EPOS
- 4 TCS GNSS community portals: Data gateway, Product gateway, M³G, DQMS
- E-infrastructure is operational, but not yet 'finished'
 - Optimize the chain of operational services
 - Add new GNSS datasets and new data nodes
 - Improve GNSS node software
 - Improve and extend GNSS products

Challenges:

- *Fill geographical gaps, GNSS stations at tide gauges*
- *High-rate data*
- *Real-time data*



**GNSS DATA AND
PRODUCTS**

Contact

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M³G
<https://gnss-metadata.eu>
m3g@oma.be

Data Quality Monitoring Service (DQMS)
<https://gnssquality-epos.oma.be/>
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the European union's Horizon 2020 research and innovation programme under grant agreements No 871121 and 101058518



the European Plate Observing System Research Infrastructure Consortium



the Solar-terrestrial Centre of Excellence

