On the Future High-Precision European GNSS CORS Infrastructure

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Agenzia Spaziale Italiana

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EUREF2019

Motivation

Europe covered by dense networks of permanent GNSS tracking stations

- Geodetic-quality? Long term ? Monumentation?
- Suitable for maintenance of reference frames, monitoring of deformations, or atmosphere
- Who owns the stations? Data access conditions? Who preserves the data?

Information available today / Gaps / Steps for the future

Pan-European Initiatives Dealing with GNSS Networks

EUREF Permanent Network (EPN) **1996**

IAG EUREF sub-commission

Goal: Reference frame maintenance

Products: Positions, velocities, time series, tropospheric parameters

~400 stations ~18 analysis centers

E-GVAP **2005**

European National Meteorological Services (**EUMETNET**)

Goal: Operational meteorology

Products: Near real-time tropospheric parameters

~2700 stations ~27 analysis centers

EPN Densification **2010**

IAG EUREF sub-commission

Goal: Dense European velocity field

Products: Positions, velocities, time series

~3500+ stations ~26 analysis centers

EPOS-GNSS **2020**

GNSS component of European Plate Observing System

Goal: Ground deformations

Products: Positions, velocities, time series, strain rates

~770 stations 2 analysis centers

Comparison of the Networks

		EPN	EPN DENS	E-GVAP	EPOS
RINEX DATA					
	OPEN	MANDATORY	UNKNOWN	UNKNOWN	MANDATORY
	EMBARGO TIME	NOT ALLOWED	UNKNOWN	UNLIKELY	DISCOURAGED
	DATA LICENSE	UNKNOWN	UNKNOWN	UNKNOWN	CC:BY
	ARCHIVING	AT DATA CENTERS	UNKNOWN	UNKNOWN	ENCOURAGED
	CENTRALISED ACCESS	YES	NO	NO	YES
METADATA					
	SITE LOG	MANDATORY	ENCOURAGED	NO	MANDATORY
DATA ANALYSIS					
	STATIONS				

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DATA ANALYSIS					
	STATIONS	TOP DOWN			TOP DOWN

Centralized registration with site log submission

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	STATIONS	TOP DOWN	BOTTUM UP	BOTTUM UP	TOP DOWN

Station is included in network when products for that station are submitted by the analysis center

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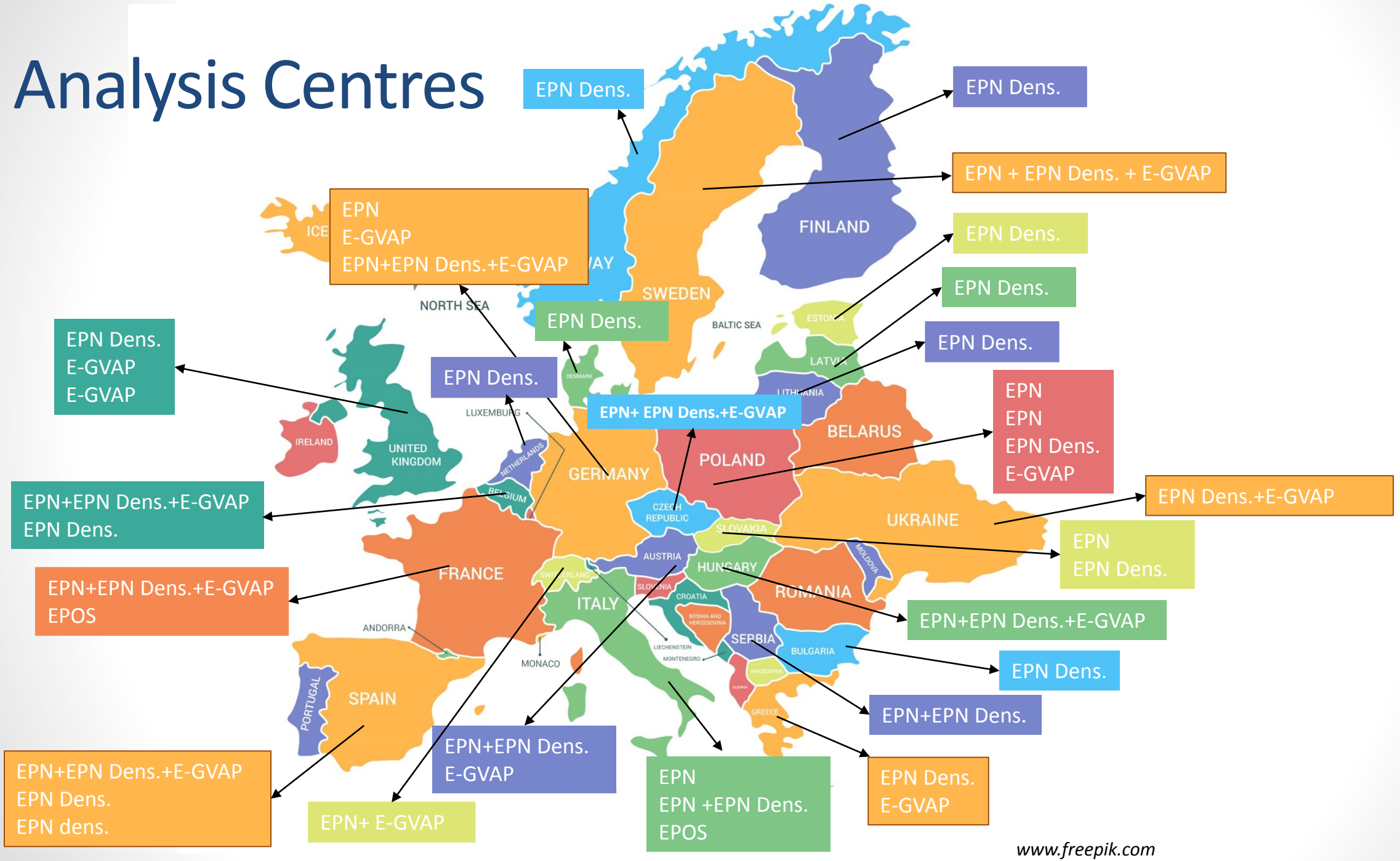
Information about stations must be acquired through the analysis centers

Station is included in network when products for that station are submitted by the analysis center

Analysis Centres



www.freepik.com

Questionnaire sent to EPN Densification and E-GVAP AC

- Simple and short to get ‘first idea’ on future priorities
- High interest of ACs

  38 analysis centers have been asked to complete the questionnaire

  33 responses within less than one week!

  40% E-GVAP / 60% EPN Densification

No questionnaire sent to EPN and EPOS AC because all station information is already available

Results of the Questionnaire

- Large majority of AC uses daily RINEX data

  → consider centralized European data archive beneficial

- Large majority of AC uses a priori metadata for data analysis. If no site log, metadata reconstructed from RINEX headers

  → consider centralized European metadata archive beneficial (100% for E-GVAP AC)

- Data usage by third parties
  - 8% of networks with data not freely available
  - 30% of networks: unknown
  - Rest available to third parties (free or with agreement)

  → A lot of missing information

- Data archived for 90% of networks (mostly by ACs) → Few GNSS data potentially lost

Long-term Vision for the Future

Ensure preservation of and access to European GNSS data

relevant for

reference frame maintenance, monitoring of tectonic deformations, monitoring of sea-level variations, long-term climate monitoring, …

Improve “access” by making data FAIR

FINDABLE **A**CCESSIBLE **I**NTEROPERABLE **R**EUSABLE

(Wilkinson et al., Scientific Data, 2016)

More information on FAIR data principles

- https://www.go-fair.org/fair-principles/
- EGU, AGU sessions
- EC : Nov. 2018. “Turning FAIR into reality”, Final report and action plan from the European Commission expert group on FAIR

FAIR data are easier to discover, share and re-use for research projects, across disciplines, institutions and country borders

→ metadata

Digital Object Identifiers (DOI)

- Unique way to refer to publications, but also to data
- Requested by journal editor (papers) or data center (data)
- Globally centralized database with all DOI → discoverability!

For example, the GNSS data from the ROB network have a DOI:

RINEX header:

```
ROB GNSS Network Data, https://doi.org/10.24414/FST8-P256    COMMENT
BRUX                                                         MARKER NAME
13101M010                                                    MARKER NUMBER
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DOI landing page

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ROB GNSS Network Data

DOI Landing page

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Authors:	C. Bruyninx, P. Defraigne
Contributors:	N. Bergeot, B. Bertrand, J. Legrand, D. Mesmaker, A. Moyaert, E. Pottiaux
Published:	2018
Publisher:	Royal Observatory of Belgium (ROB)
Description:	Observations and metadata from continuously observing GNSS tracking stations operated by the Royal Observatory of Belgium
Date Range:	01/1996 - open
Spatial Coverage:	Belgium
Data Citation:	Bruyninx C., Defraigne P. (2018): ROB Network GNSS Data. Available from Royal Observatory of Belgium. Observation Data. doi: 10.24414/FST8-P256
Resource Type:	Dataset (file-based RINEX data, real-time RTCM data)
Data Availability:	RINEX data: last year on-line. Historical data available on request; RTCM data: only available in real-time and by request.
Data Access:	http://gnss.be/ROB_Network/data.php
License:	CC BY 4.0, https://creativecommons.org/licenses/by/4.0/

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Creative Commons Data Licenses

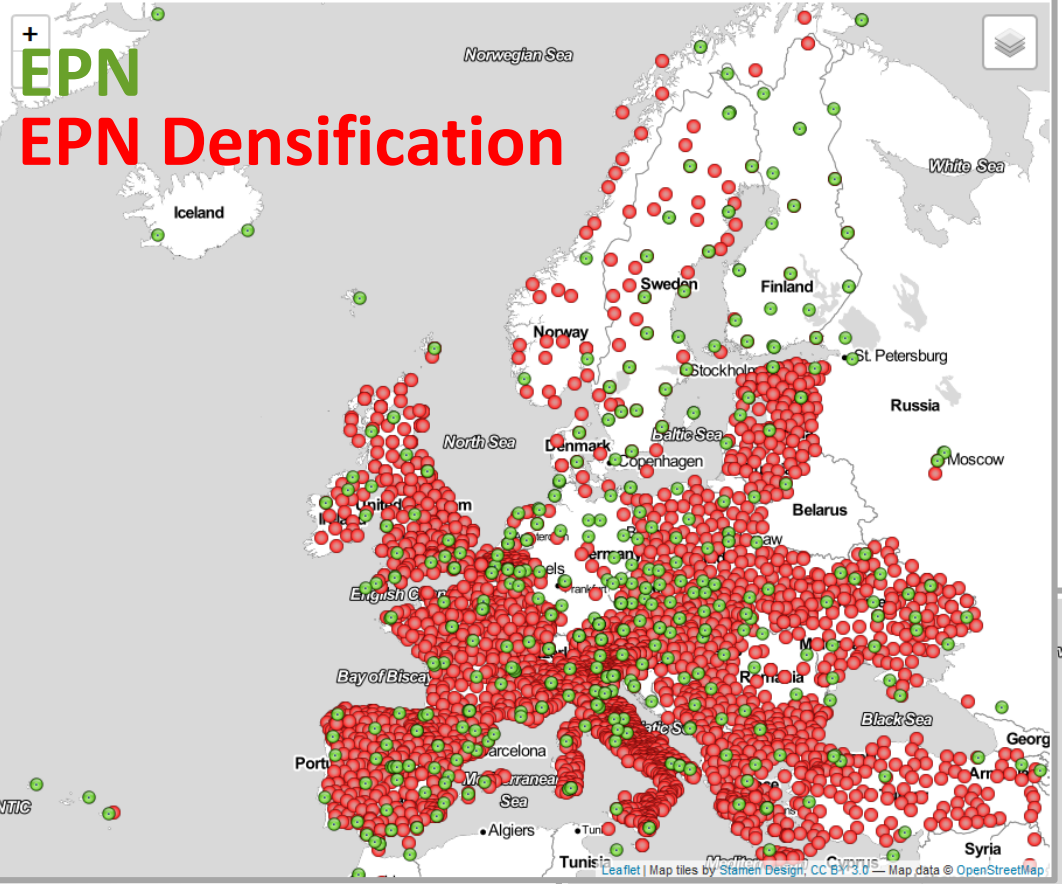
https://creativecommons.org/

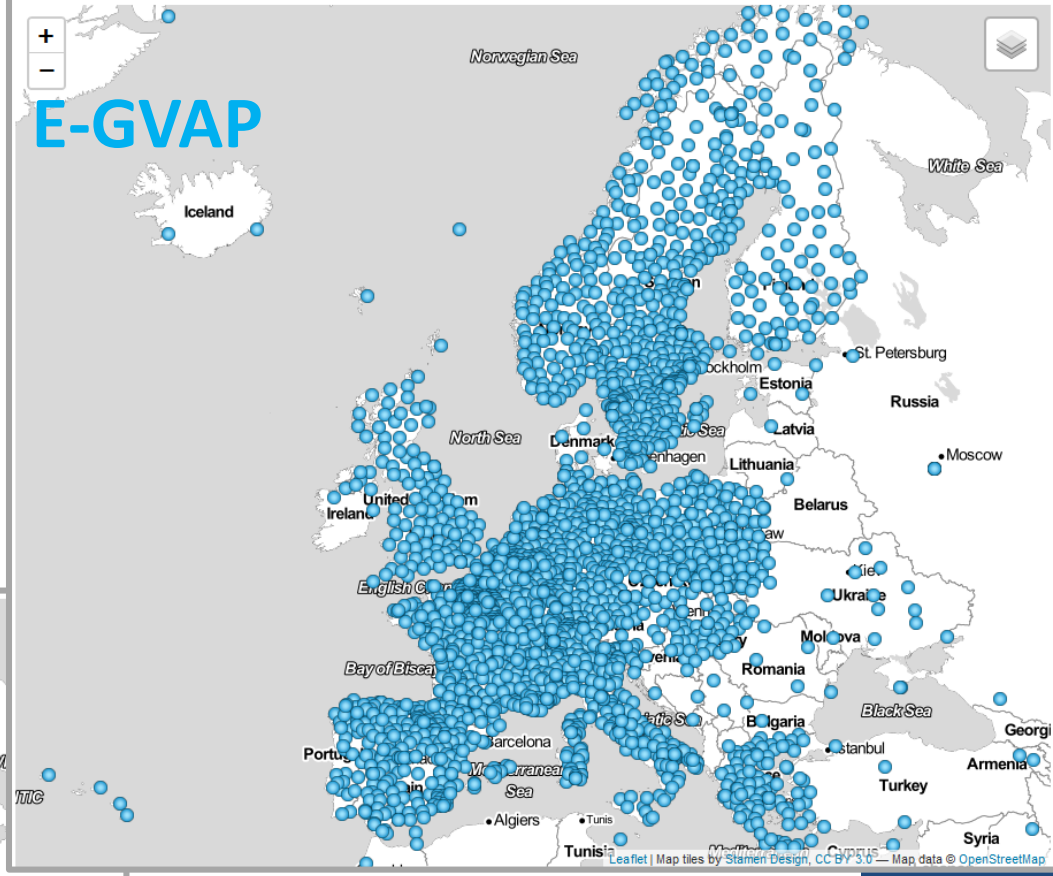
0	Public domain
BY	Allowed to distribute/change data and derived products. Need to acknowledge data provider
NC	No commercial: Allowed to distribute/change data and derived products, but not for commercial applications
ND	No derivative works: Allowed to distribute data, not allowed to change it
SA	Share alike: distribution of derived products only allowed under same license as original work

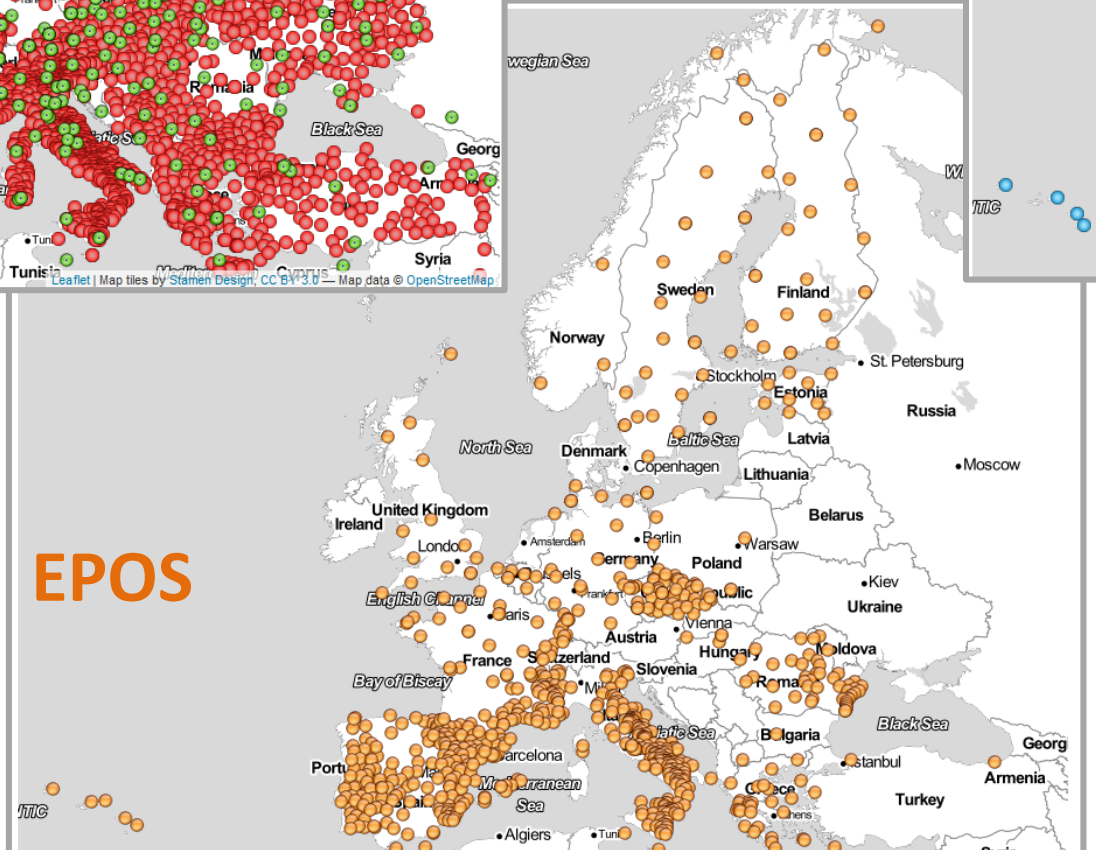
What metadata do we already have?

- EPN, EPOS : list of stations + locations + all site logs
- EPN densification: list of stations + locations + some site logs
- E-GVAP: list of stations + locations

(thanks to Owen Lewis et Gemma Bennit, UK MetOffice)







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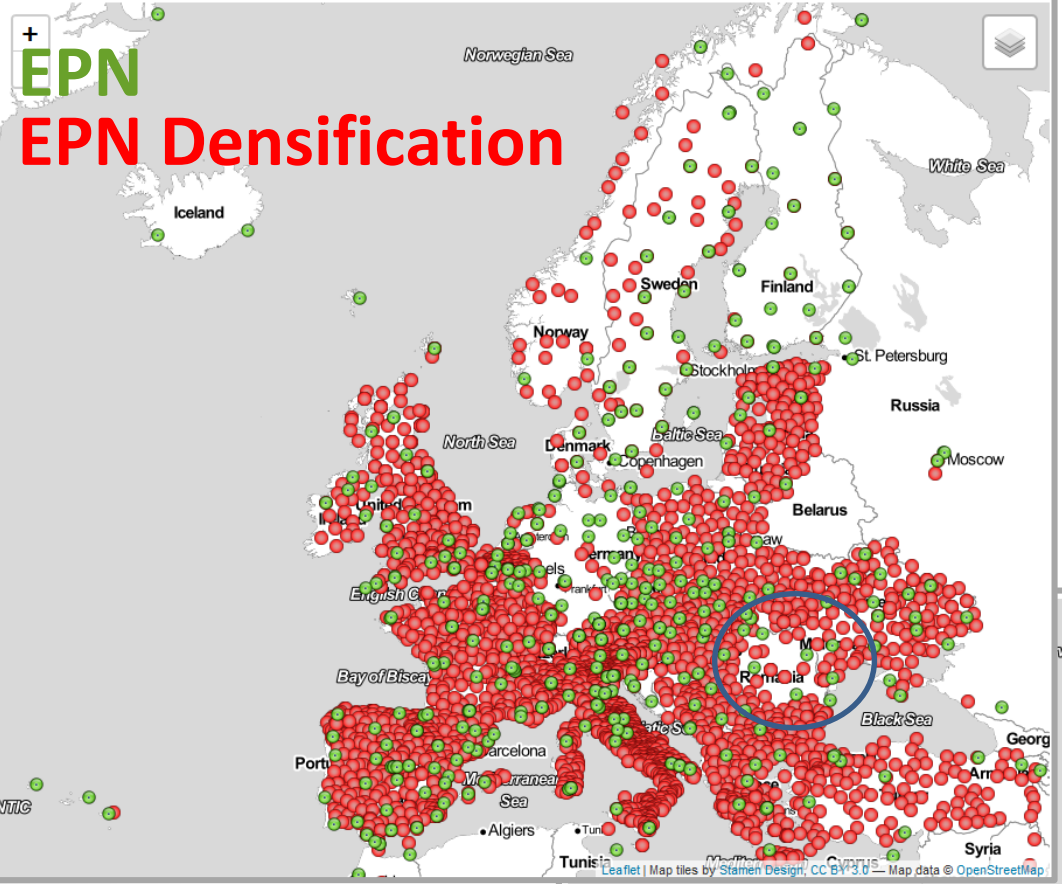
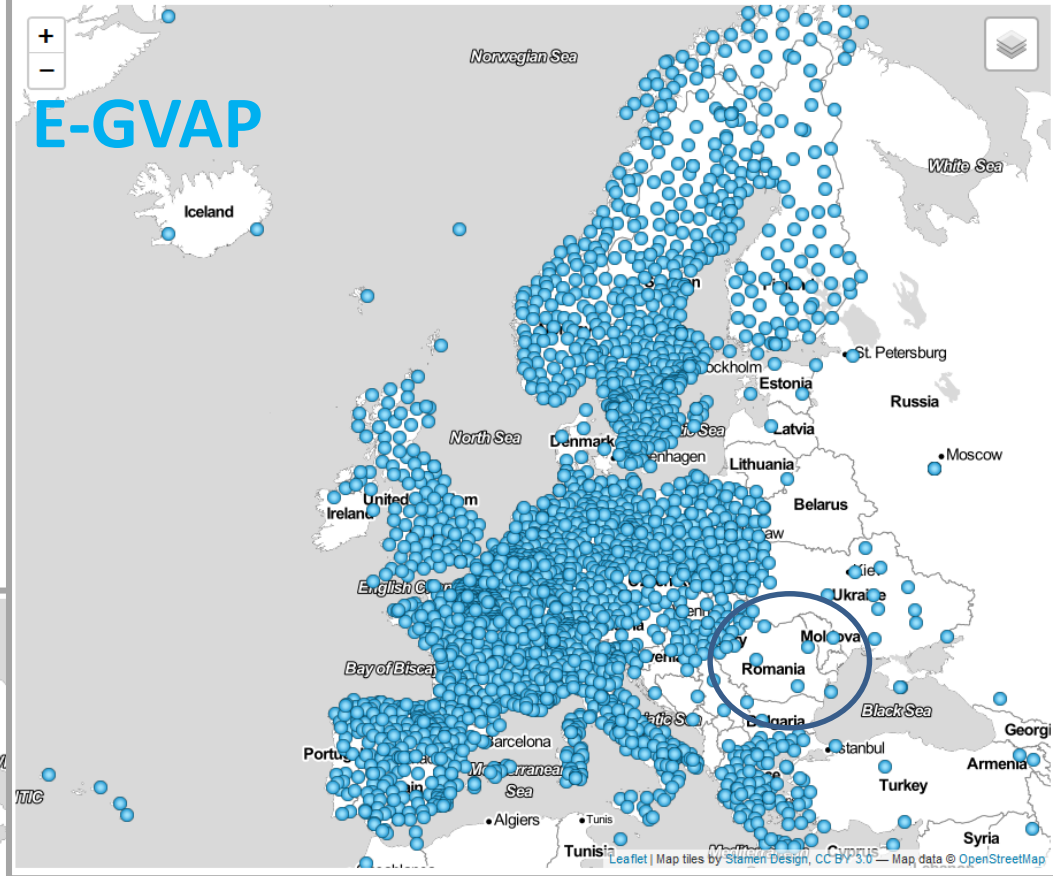
EPN

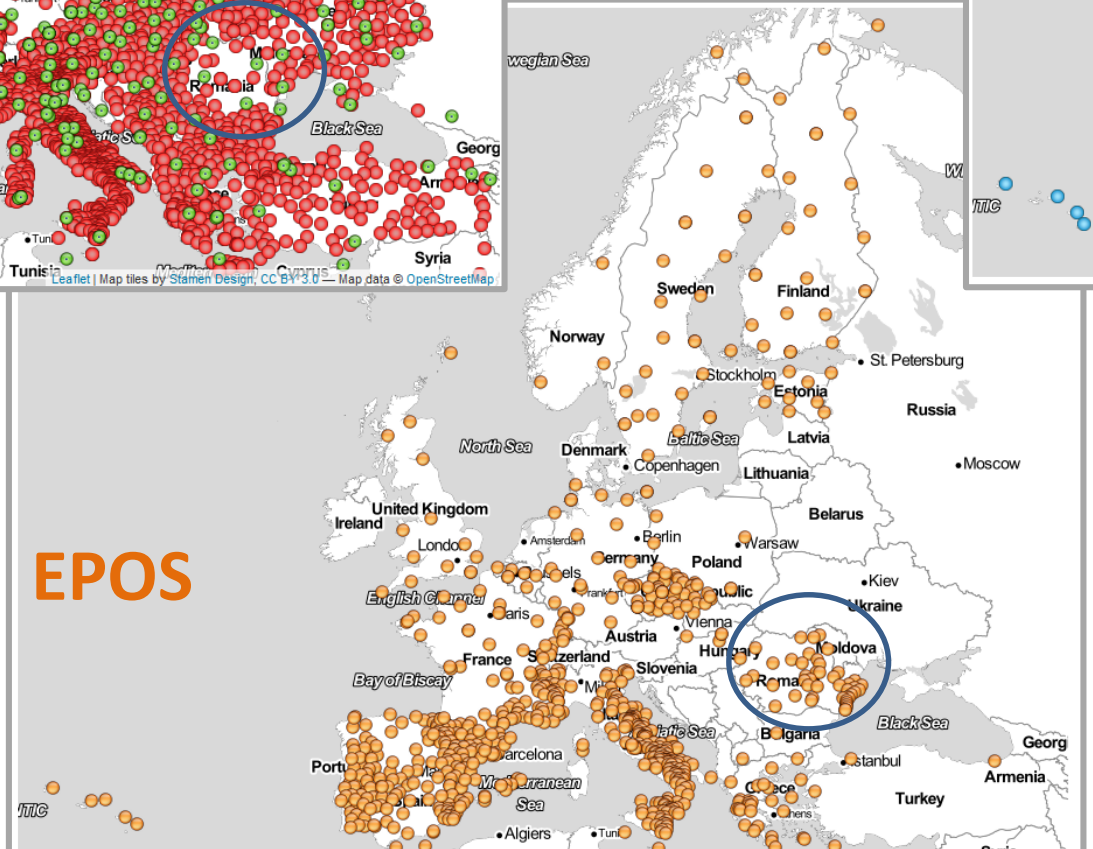
EPN Densification



E-GVAP



EPOS



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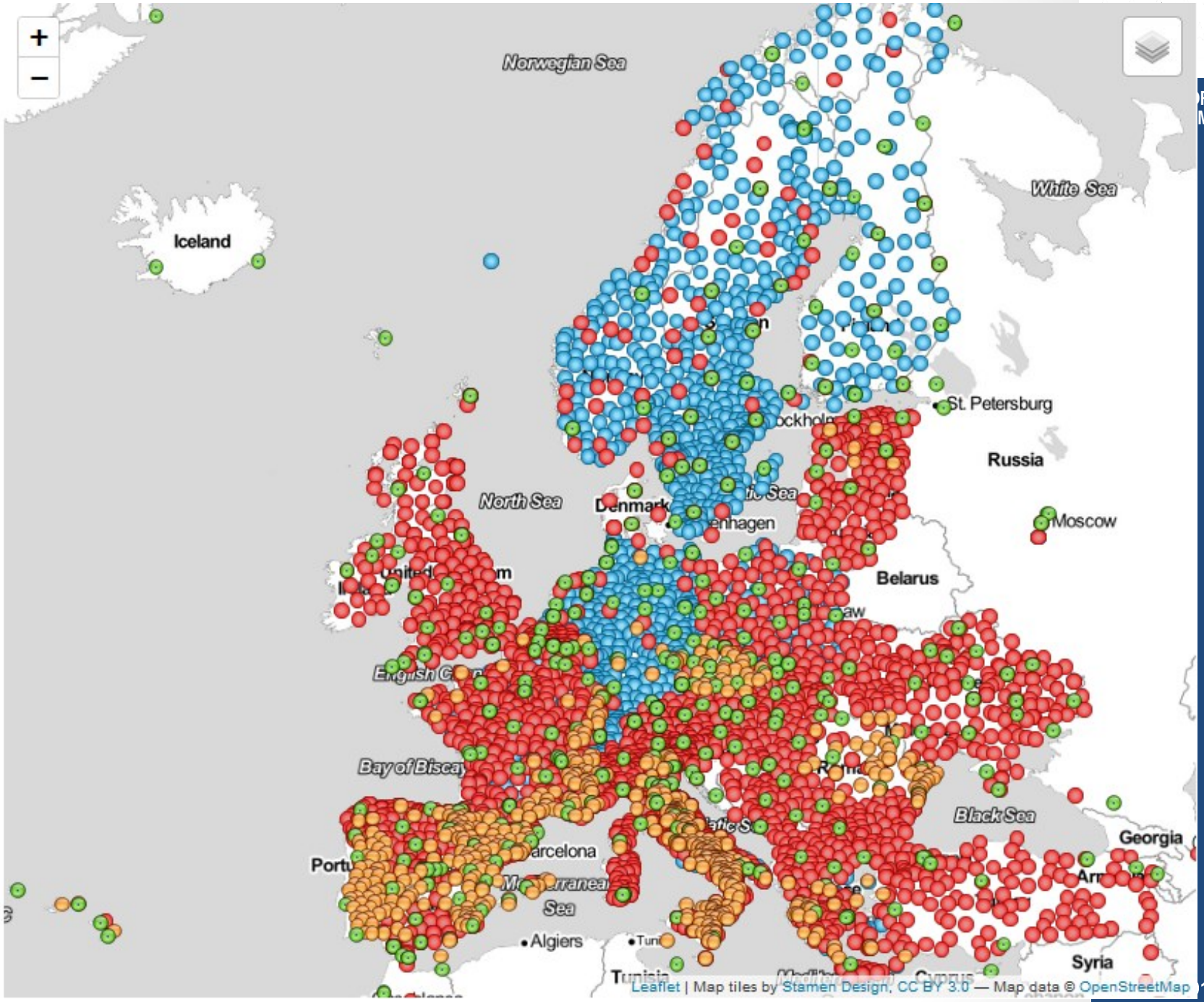
All Networks

4916 stations

- EPN (~400)
- EPOS (~770)
- E-GVAP (~2700),
- EPN Densification (~3500)



EPN, EPN Densification, EPOS

https://gnss-metadata.eu/

Metadata Management and distribution system for Multiple GNSS Networks

Site log availability:

EPN	100%
EPN densification	54%
EPOS	100%
E-GVAP	*35% (thanks to overlaps with other networks)*

All Networks

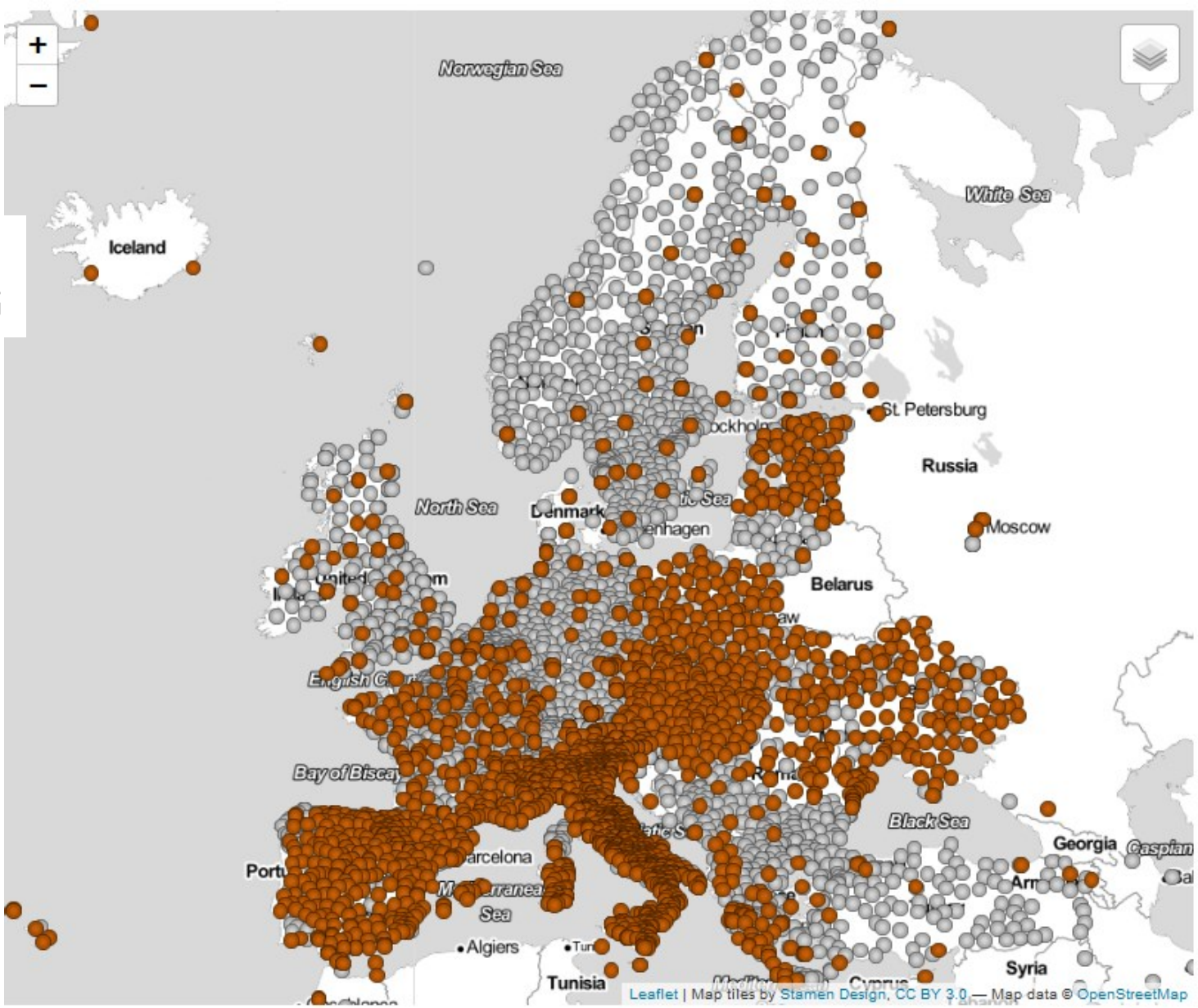
4916 stations

- 58% without centralized site log
- 42% with centralized site log in M^{3}G

Data are processed by a known agency for ‘geodetic quality’ applications

→ entry point to gather information on the stations

For several networks, site logs are available at national level



Steps to Realize the Vision

Almost 5000 GNSS stations → 4 networks are good starting point

3 Actions, to be started simultaneously

Action 1 Continue to collect and maintain GNSS station metadata

Minimal metadata

- *Station location*
- *Station name (9-char ID)*
- *Who owns station (acknowledgement)*

Alternative

Site Log

(Lots of stations with maintained site log, but not available through central access point)

- Who stores the data (access)
- Who preserves the data (long-term access)
- Conditions of use of the data (embargo time, license)
- Extend M^3G to include station metadata from E-GVAP stations

Steps to Realize the Vision

Action 2 Ensure all relevant GNSS data are preserved

- Large majority of GNSS data preserved by ACs (E-GVAP and EPN Densification) and Data Centers (EPN)
- Identify holes, talk to concerned people and find solutions
- Priority: no valuable daily RINEX data should be lost

Action 3 Agree on implementation of FAIR data principles

- Data should be identifiable using unique reference (persistent identifier)
- DOI (Digital Object Identifier) contains with minimal metadata, license, embargo time, data owner, url to site log or RINEX data (if available)
  - easy harvesting of DOI metadata, procedures are already existing + tracking of data usage

10-year plan

Thank you

Agencies interested to collaborate are invited to contact

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