ETRS89 AND DYNAMIC REFERENCE SYSTEMS IN EUROPE

EuroGeographics Webinar on Future Reference Frames 2025-11-25

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Thaks to colleagues for borrowing some illustrations!

OUTLINE

- What is EUREF
- Geodetic reference frames in Europe
- International Terrestrial Reference System and Frame
- European Terrestrial Reference System ETRS89, and ETRFs
- Implementation in Europe
- Products and guidelines provided by EUREF
- User needs and proposal
- Study group on alternatives for the ETRS89
- Summary

What is EUREF? –"WHO WE ARE"

"EUREF is the IAG Reference Frame Sub-Commission for Europe, integrated in the Sub-Commission 1.3, Regional Reference Frames, under Commission 1 – Reference Frames"

The Sub-Commission EUREF was founded in 1987 at the IUGG General Assembly held in Vancouver.[1]

However, since we also deals with gravity related heights etc., we are somewhat more and take a wider scope and responsibility for geodetic infrastructure (in a broad sense) for Europe.

We aim at continue to being the recognized expert organization on geodesy

[1] *From: http://www.euref.eu/*

EUREF's primary mission *and vision*

"EUREF's primary mission is to establish and maintain the European coordinate reference system and physical height reference system"[1,2]

EUREF's vision is to serve the European society with homogenous and sustainable geodetic reference frames, height and gravity systems, including data and products, services and tools, based on best available scientific background and taking into account user needs.

[1] *From EUREF Terms of References 2017*
[2] *"physical heights" or "gravity related heights"*

TERRESTRIAL REFERENCE SYSTEM AND FRAME

System:

- ***In geodesy, a terrestrial reference system (TRS)*** *describes the theoretical concept of a spatial reference system co-rotating with the Earth in its motion in space. (We have no coordinates in the "System")*

Frame:

- *The abstract concept is practically realized through a* ***terrestrial reference frame (TRF)*** *with the determination of the location of an origin, the orientation of an orthogonal set of Cartesian axes (X, Y, Z), the scaling of th system, and the evolution over time. (We have coordinates related to "Frame")*

From: *"Coordinate Systems Basic User Guide_NGI_EUROCONTROL_FOR REVIEW" (with minor mo*

The International Terrestrial Reference System, ITRS

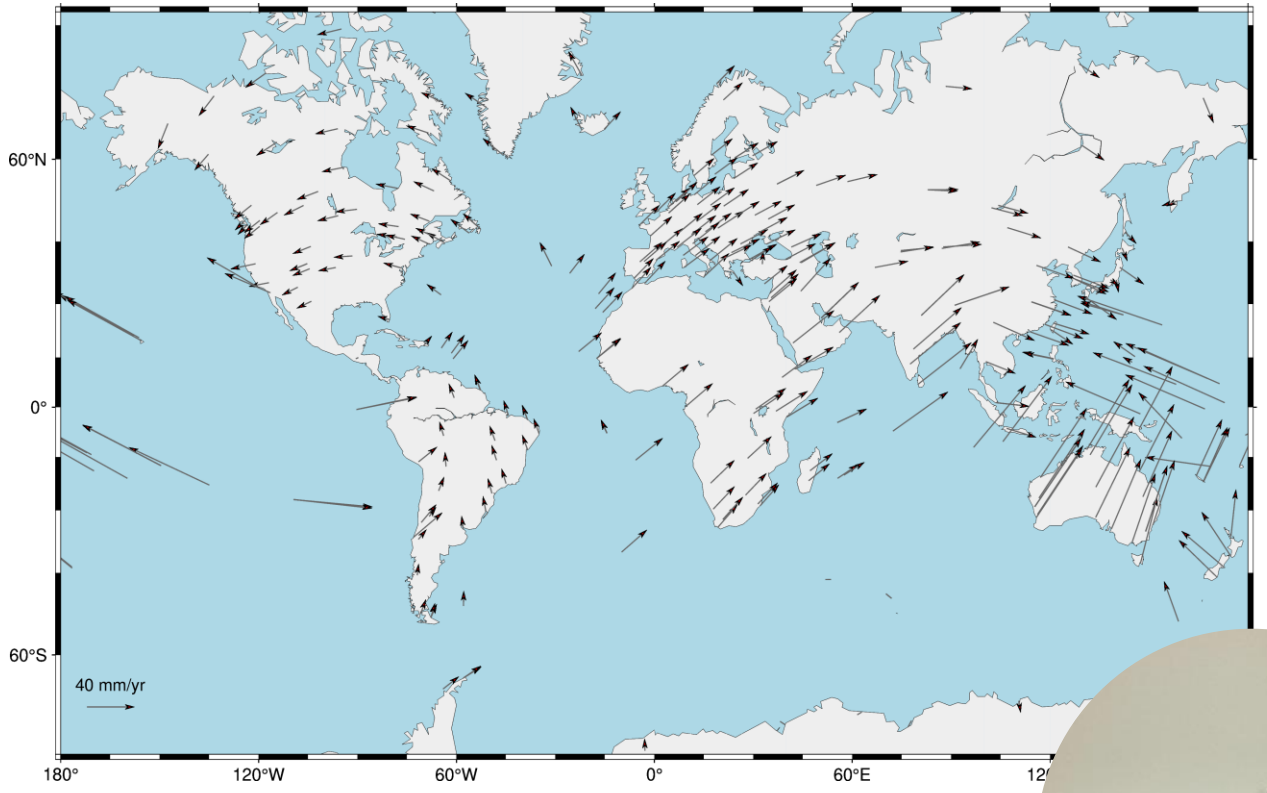
- Developed and maintained by the International Association of Geodesy, IAG
- Described in the "IERS Conventions"
- Realized in International Terrestrial Reference Frame, ITRF
- Adopted as an ISO standard (ISO-19161)
- GNSS system providers have agreed to have their reference systems and frames to be aligned to ITRS and its realizations, e.g. WGS84 and GTRF (Galileo)
- Precise products for position, navigation and time (PNT) are usually given in realizations of ITRS - ITRFs

THE DYNAMIC EARTH, PLATE TECTONICS AND VELOCITIES

The Earth is a dynamic planet, so continents are moving in relation to each other.

Velocities usually at "some cm/yr". Europe is drifting ~2,5 cm/yr towards NE.

In the global dynamic frame, ITRF.



Velocities of stations expressed in ITRS (ITRF2020 ep

The European Terrestrial Reference System 1989, ETRS89

"Invented" ~35 years ago, therefore 1989.

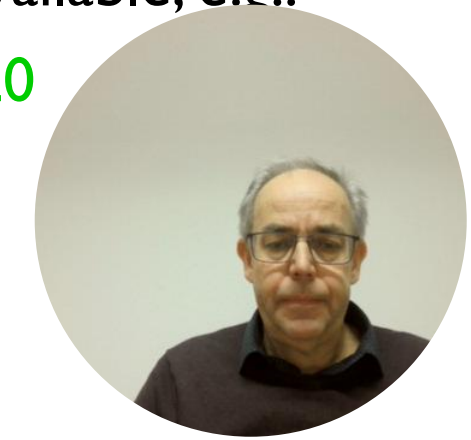
The ETRS89 is by its definition coincident with the ITRS at the epoch1989.0 and fixed to the stable part of the Eurasian plate.

In practice it is done by rotating ITRF coordinates back to epoch 1989.0 using a plate rotation model (*and possibly a translation to improve consistency to previous realization*)

Thus, usually a new European frame is derived when new ITRFs becomes available, e.g.:

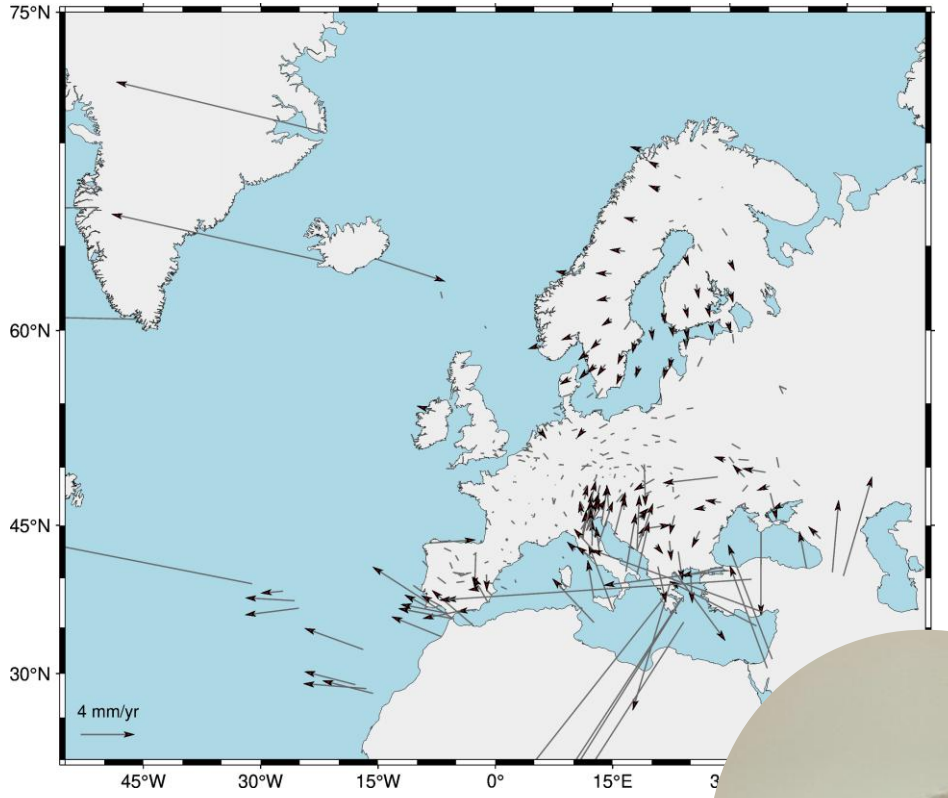
ETRF89, ETRF90, ETRF92, ..., **ETRF2000**, (ETRF2005), ETRF2014, ETRF2020

Developed and maintained by EUREF through the EPN



THE ETRS89 IS ITRS WITH THE PLATE MOTION REMOVED

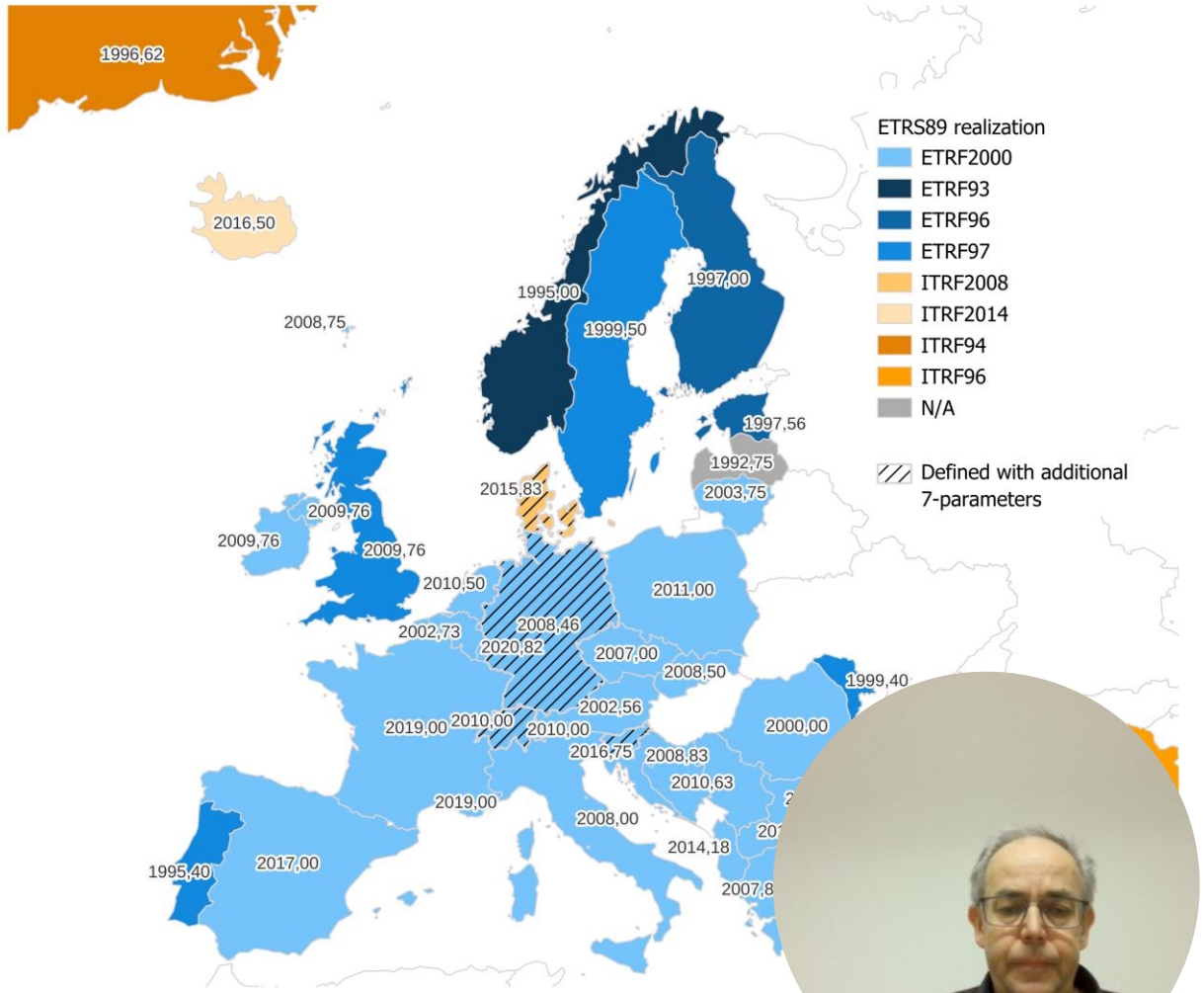
- ETRS89 is a kinematic/dynamic frame (not a static frame)
- For "stable part" of Europe, the velocities are small and coordinates stable
- But some areas is outside the "Eurasia tectonic plate" or in "deforming zones"
- Coordinates relate to where Europe was located 35 yrs ago,
- Therefore, difference in coordinates to ITRF by almost 1 m (2.5 cm x 35 yr)
- National realizations are usually static frames from "snap shots" in time of the ETRS89



Velocities of stations expres
ETRS89 (ETRF2000 epoch 20

NATIONAL REALIZATIONS OF THE ETRS89

- The national realizations are based on different ETRFs
- ETRF2000 is the most common (with most realizations between ~2000 and 2015)
- But they agree at the "few cm level"
- ETRF2000 based realizations even better (<1 cm ?)!



EUREF primarily "products" *(well – but there is much more too…)*

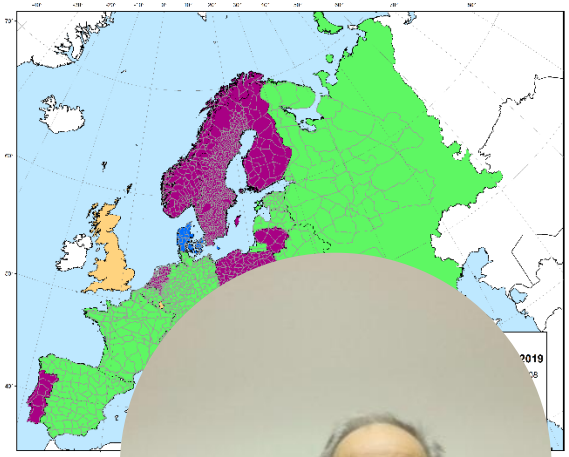
ETRS89 (European Terrestrial Reference System and Frame)

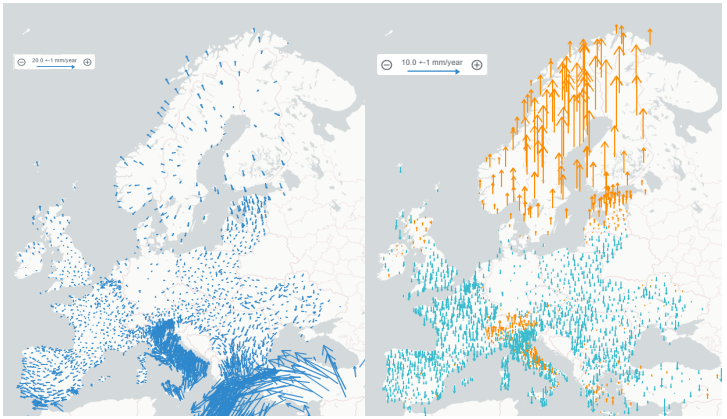
- is available in practically all countries in Europe through national realizations
- is maintained and developed through the EUREF Permanent GNSS Network, EPN

EVRS (European Vertical Reference System and Frame)

- realized and maintained through the UELN (United European Levelling Network)
- Also available in most European countries

ETRS89 and EVRS are mandatory for exchange of geodata under the European Union INSPIRE directive (Infrastructure for Spatial Information in Europe)

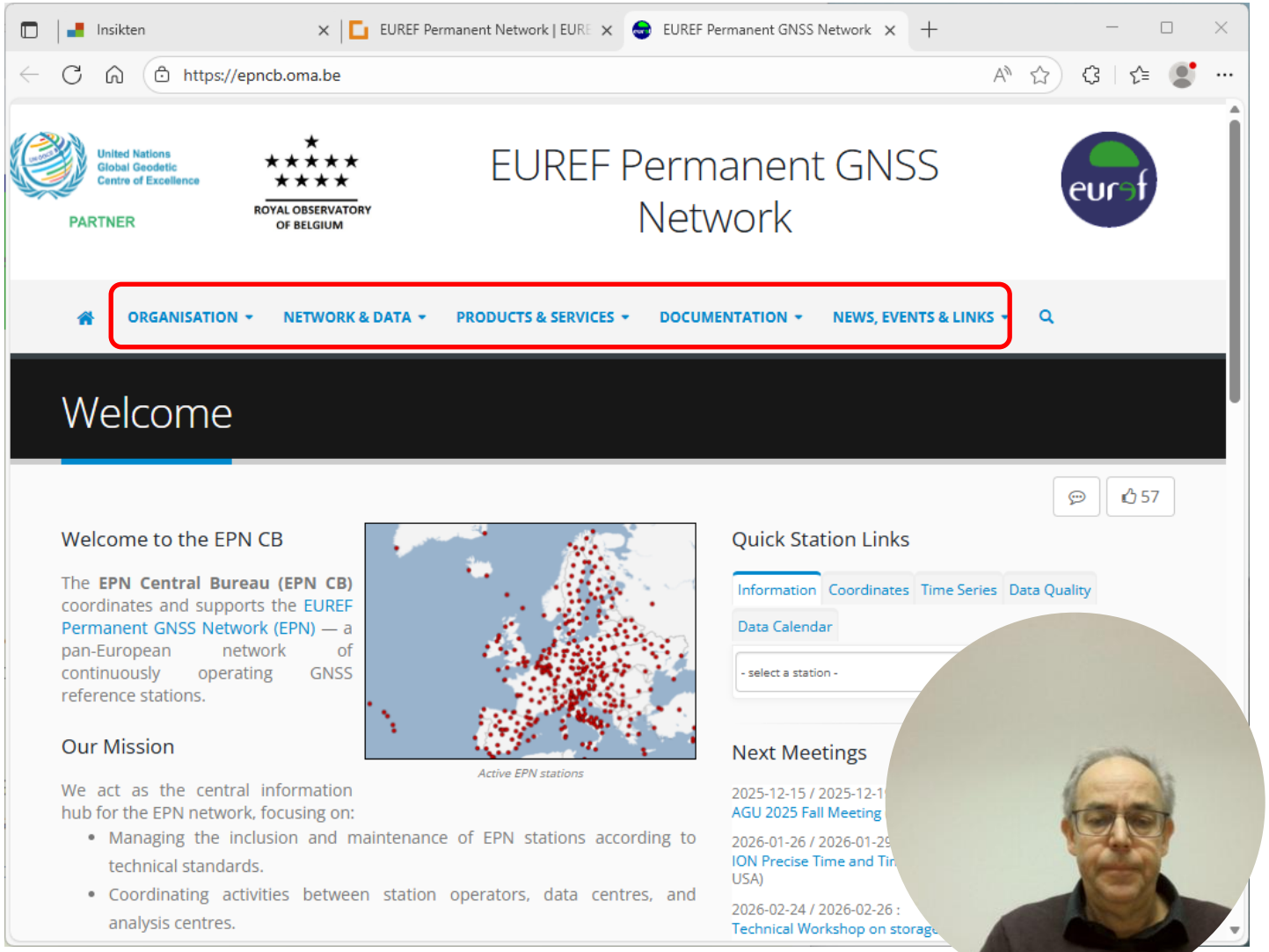




Crustal deformations / velocities are monitored through the "EPN Densification".

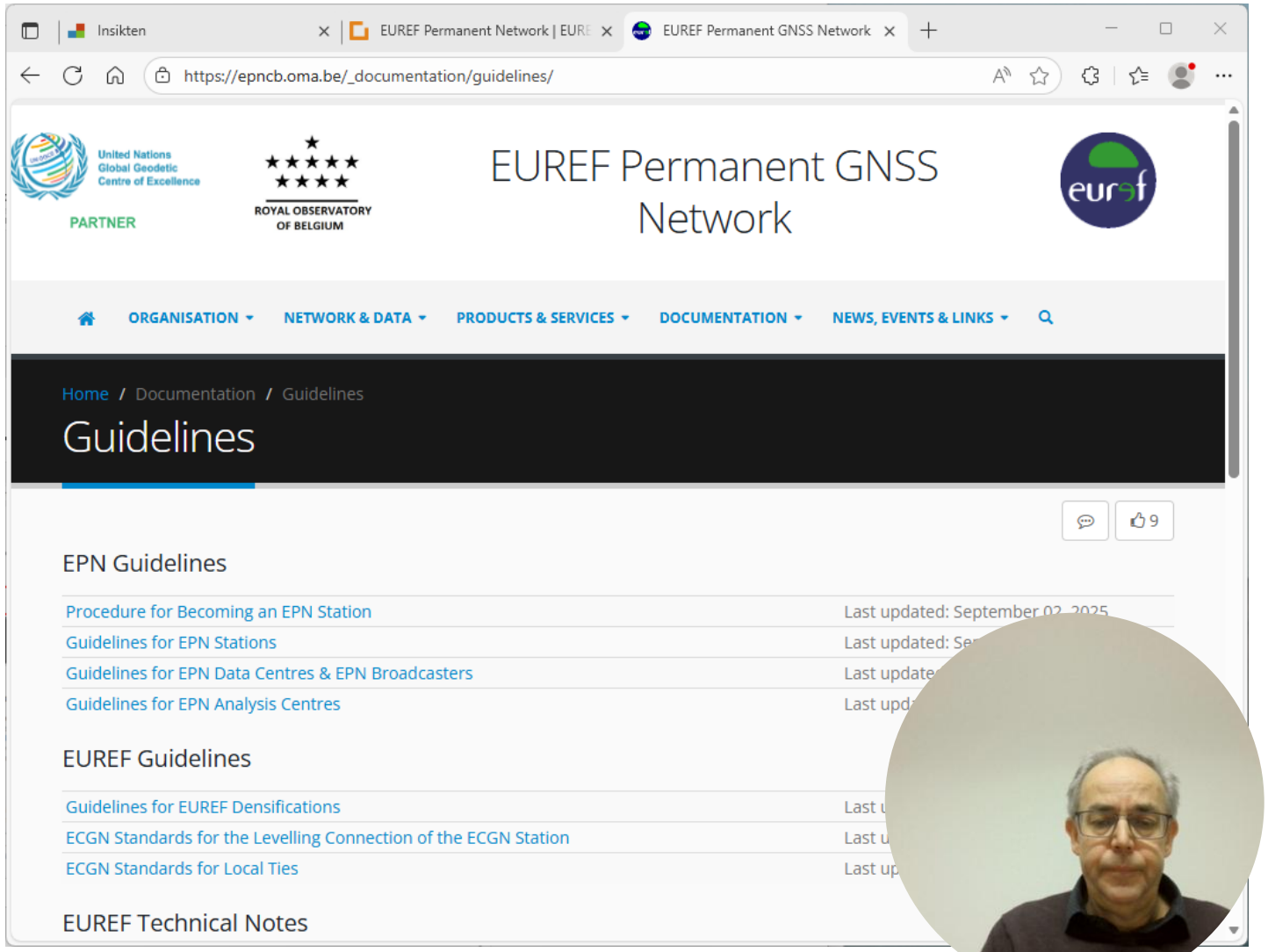
SOME PRODUCTS AND GUIDELINES FROM EUREF

- Information on the realization of the ETRS89 and the ITRF in Europe is available at the EPN website
- Stations, positions, velocities (in ITRFs and ETRFs)
- Transformation tool
- Guidelines

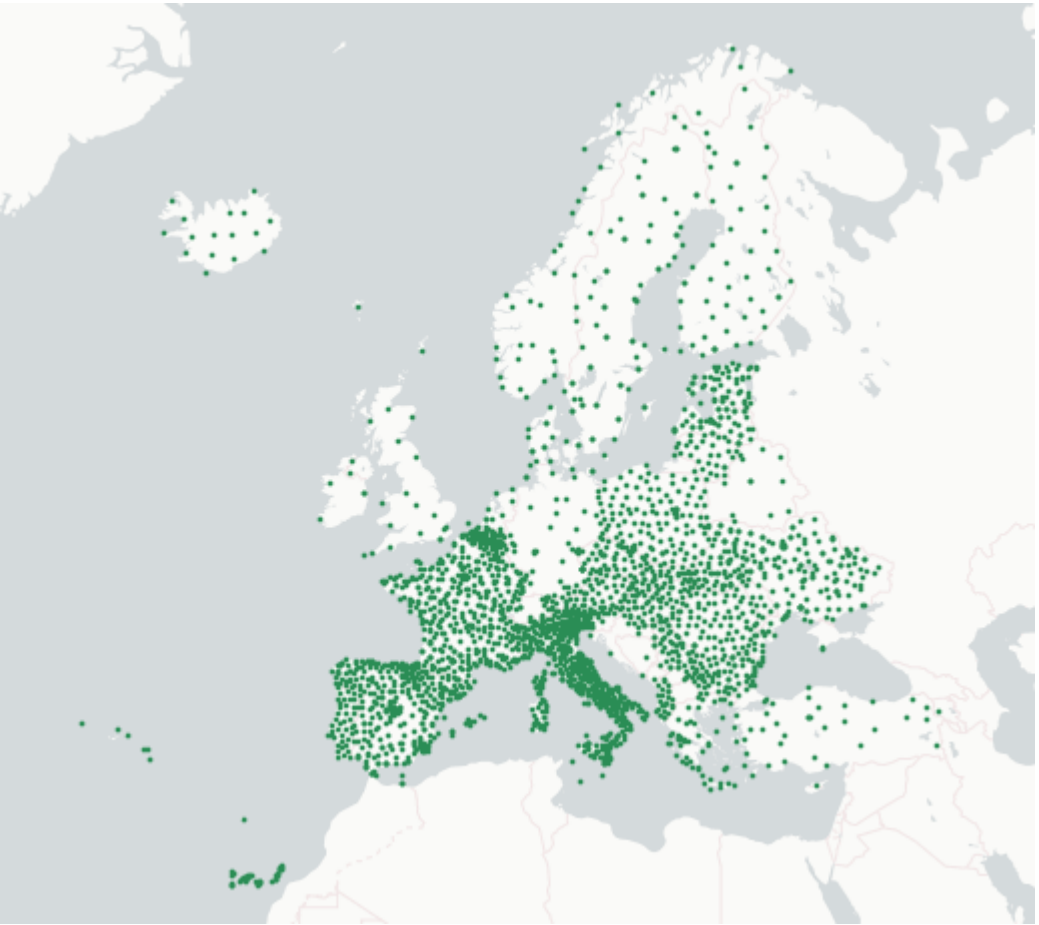


SOME PRODUCTS AND GUIDELINES FROM EUREF

- E.g. Gudelines for EUREF densification



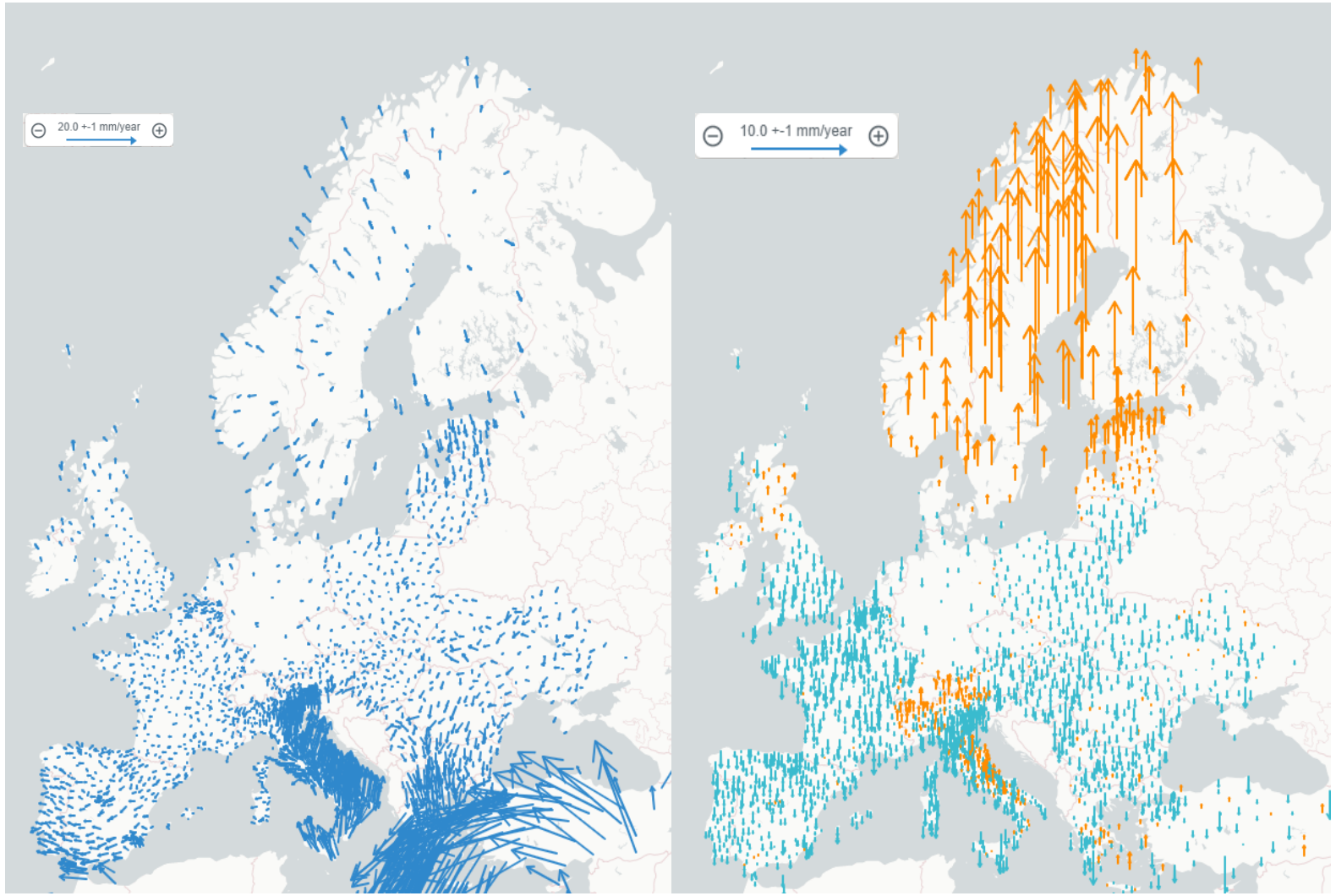
EPN densification, (EPND)



- Includes some ten times more stations compared to the core EPN
- Daily/weekly station position estimates from dense national or regional GNSS networks delivered in SINEX format (*Currently contribution from some 30 agencies*)
- These are combined into European weekly solutions
- After stacking of the weekly solution and time series analysis, the result is one homogeni[illegible]d set of station positions and velocities
- In both European and global frame[illegible] well as ITRF)

https://epnd.sgo-penc.hu/

EPND velocities



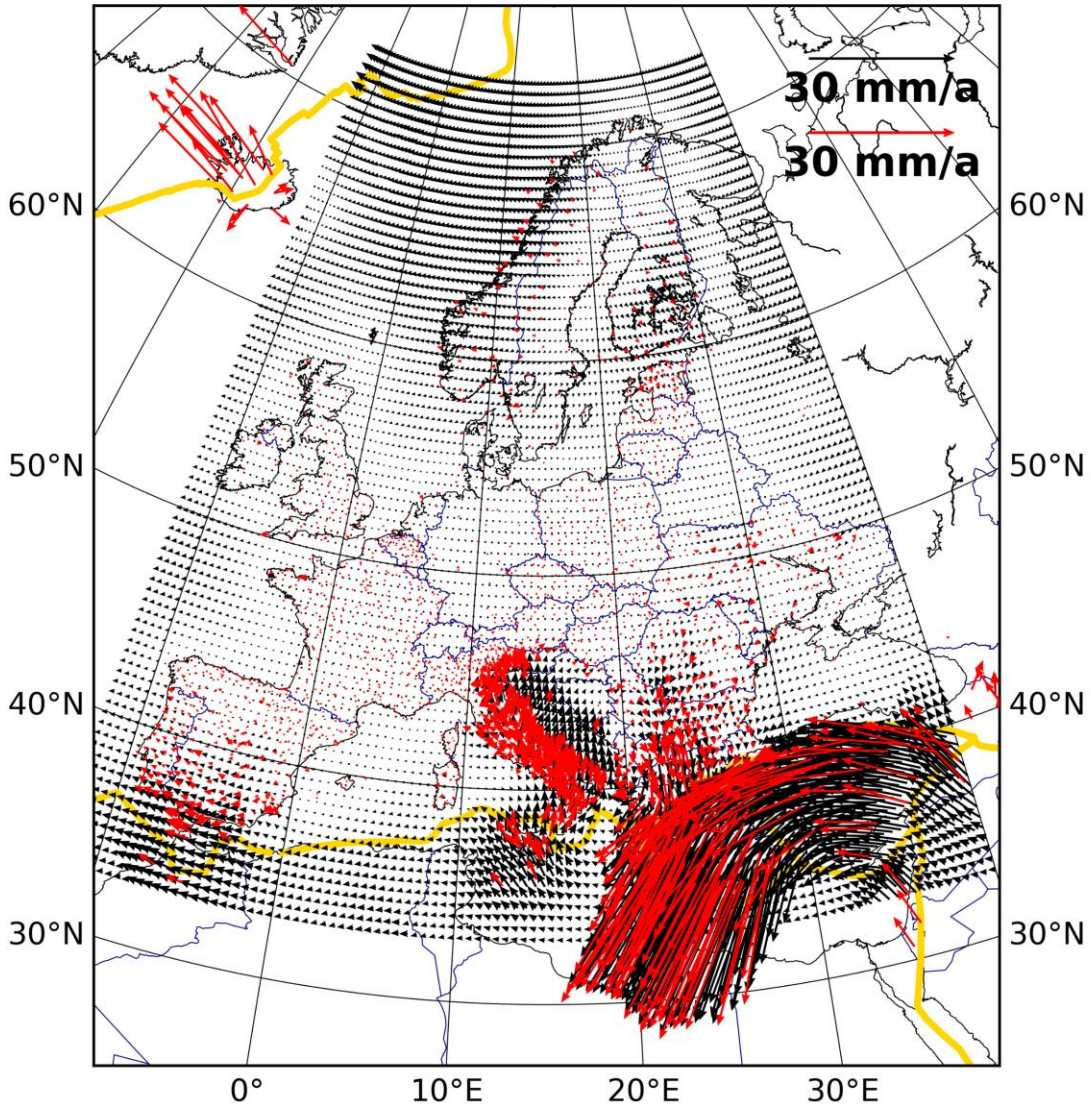
horizontal

vertical

EPND velocities

- D2200
- Published in IGS14, ETRF2000 and ETRF2014
- Future velocity solution after change to IGS20 (results will take some time…)

EuVeM2022: European Velocity Model 2022 - A 3D Velocity Field Model for Europe



- Gridded deformation model derived from GNSS station velocities using collocation methodology
- Based on EPND2150 station velocities
- Intended for both scientific use, as well as for practical geodetic needs (*coordinate transformations*)
- Some steps remains for easy use in coordinate transformations

- EuVeM2022

Current and Future needs from different user groups

- This is more a personal view
- Current professional user groups in construction, building, infrastructure and cadaster need best possible performance – and stable coordinates over time
- But some new groups may use global or regional positioning services, based on "PPP", and provide positions in Global Reference Frame (ITRF)
- There is a need for possibility to use both national and global reference frames in parallel – so called "two frame approach"
- For large part of Europe this is in place (relation between national realization of ETRS89 and ITRF), but may need refinement in some cases
  - May include precise models of deformations within the area of interest!
- And implement effective use for the user community!

EUREF STUDY GROUP ON ETRS89

- EUREF have a study group on the European reference frame
- Background are needs from new user groups, and the fact that the ETRS89 is now ~35 years old,
- Which cause the difference between ITRFs and ETRFs to reach almost a meter
- The task for the study group is in short to investigate:
  - possible alternatives for the ETRS89
  - and concepts on reference frames
- About 15 persons in the study group, and some 25 as corresp
  members. Meetings open for all.

SUMMARY

- In Europe we have the ETRS89 which is a plate fixed version of ITRS
- The realizations of the ETRS89 have a direct relation to the ITRFs which is the global dynamic frame.
- There is a national realization of ETRS89 in practically all countries in Europe, and these national realizations agree at the few centimetre level.
- The ETRS89 is recognized at the highest political level and is mandatory for exchange of geodata under the European Union INSPIRE directive.
- A EUREF study group are investigating possible alternatives for ETR
- You are all welcomed to contribute to the work, including discu
  user needs and how to meet these!

THANKS FOR YOUR INTEREST!

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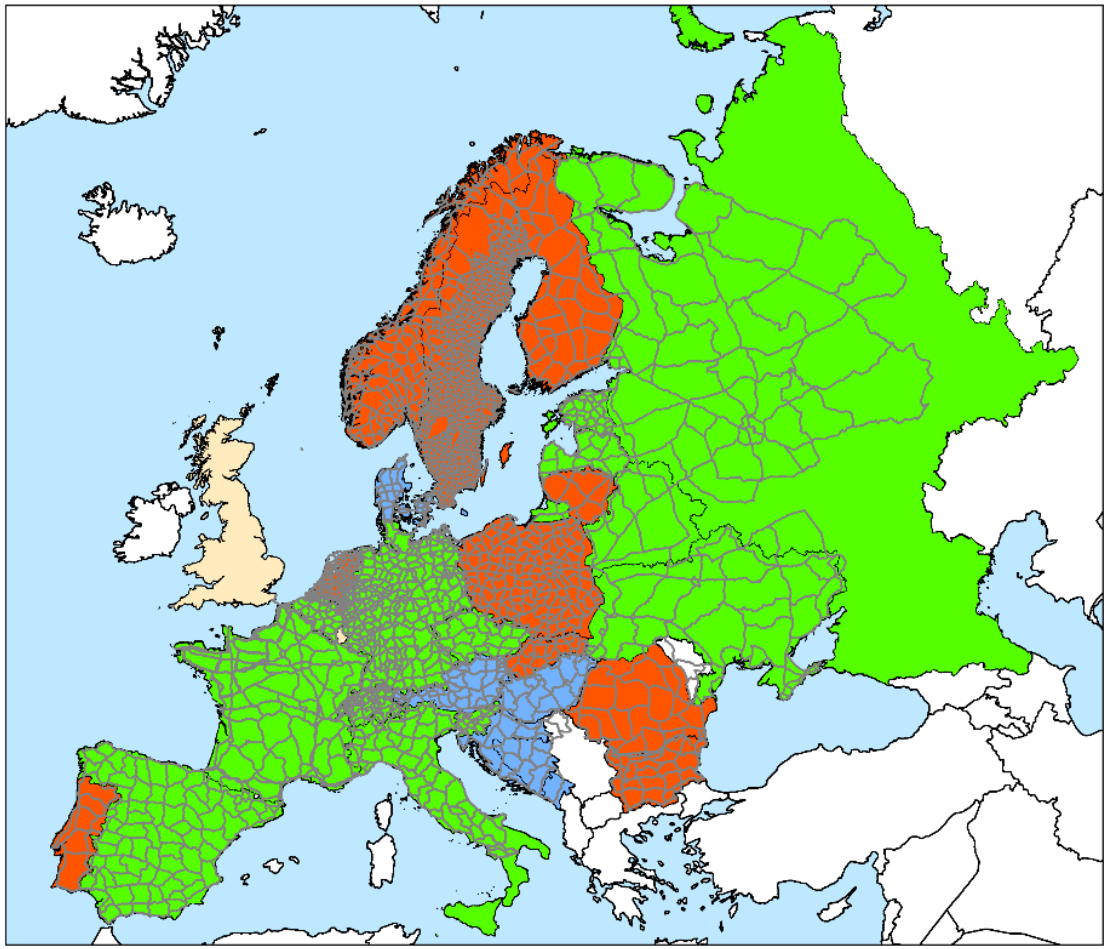
LANTMÄTERIET

European Vertical Reference System and Frame, EVRS/EVRF

- It is about heights
- For many applications in society (construction, waste-pipes etc.) heights is as important as the horizontal position
- EVRS is realized through a common adjustment of available national precise levelling networks that form the United European Levelling Network, UELN
- The height reference is the level of Normaal Amsterdam Peil, NAP
- The recent realization is EVRF2019



TACK! VI FINNS PÅ…

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