EUREF 2025 SYMPOSIUM

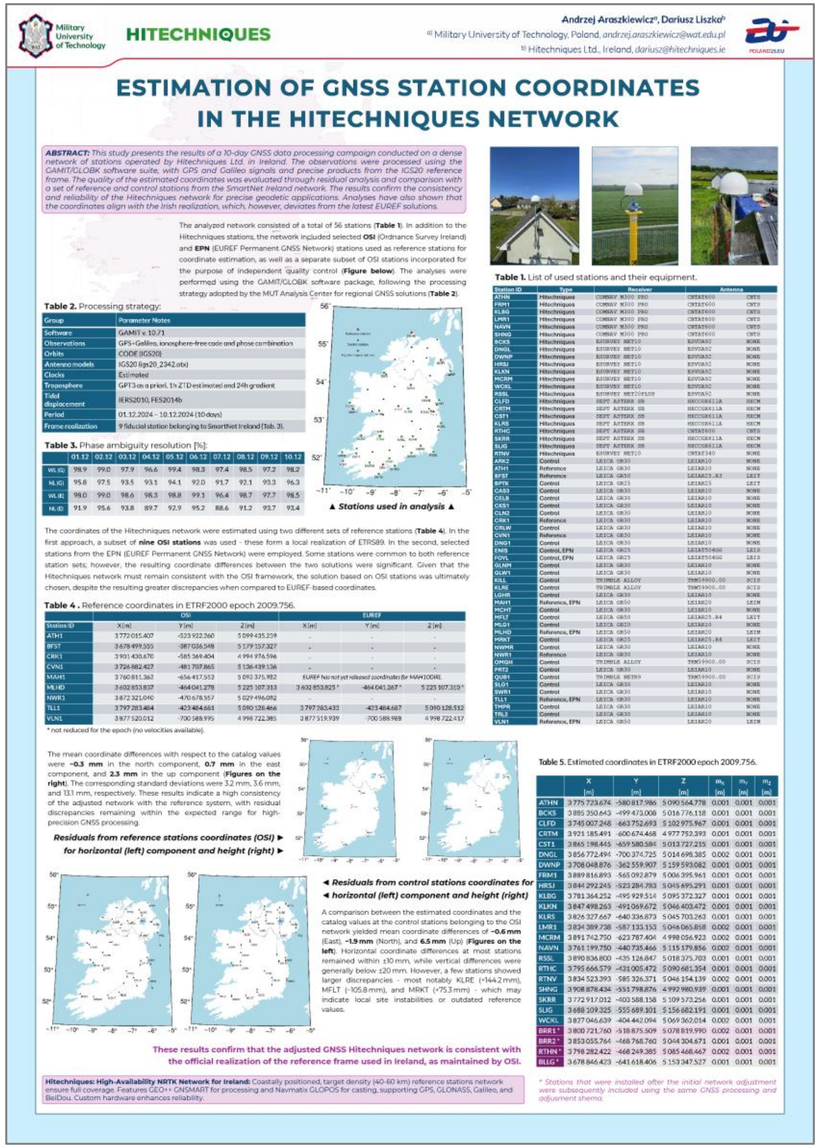
Scientific Sessions
Posters

UNIVERSIDADE BEIRA INTERIOR

INSTITUTO DOM LUIZ

SEGAL Space & Earth Geodetic Analysis Laboratory

dgTerritório Direção-Geral do Território



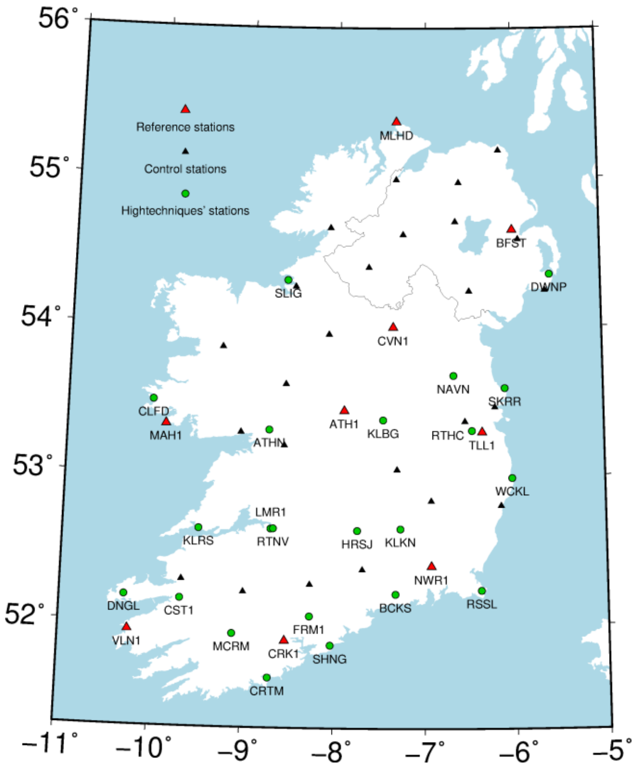
Estimation of GNSS station coordinates in the Hitechniques network

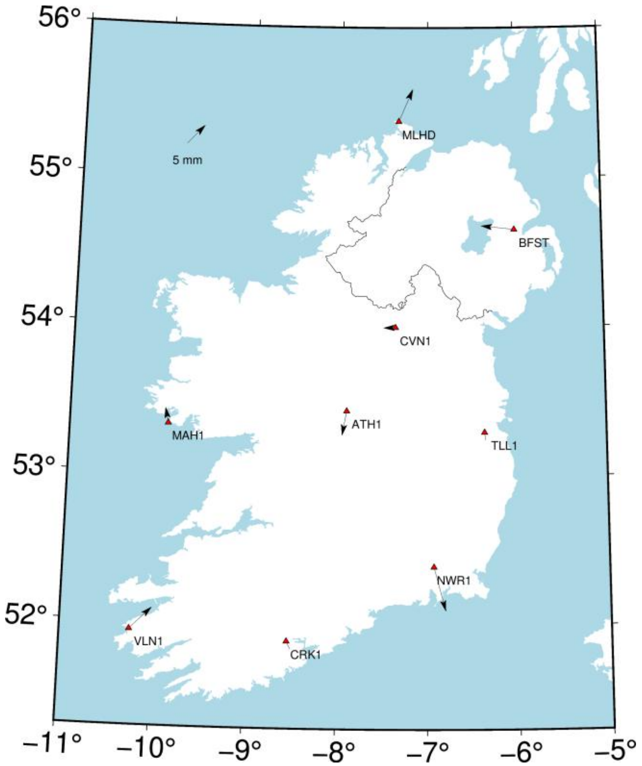
Andrzej Araszkiewicz[a], Dariusz Liszka[b]
[a)] Military University of Technology, Poland
[b)] Hitechniques Ltd., Ireland



- **10-day GNSS campaign on a new dense Irish network (Hitechniques Ltd.).**
- **Processed using GAMIT/GLOBK with GPS, Galileo, and IGS20 products.**
- **Quality checked via residuals and SmartNet Ireland stations.**
- **Hitechniques network proven reliable for precise geodesy.**
- **Coordinates match Irish realization, but differ from latest EUREF.**

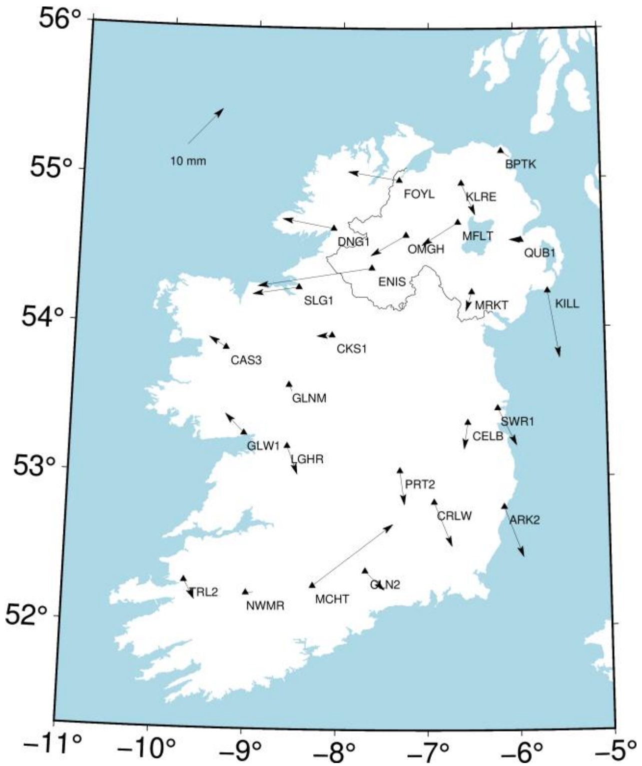
Stations used in analysis





Residuals from reference stations coordinates

Residuals from control stations coordinates



The new Portuguese National Geodetic Network adjustment

***Carolina Brito*[a]*, Ana Navarro*[b]*, João Catalão*[b]*, Ana Bernardes*[c]*, Ana Medeiro*[c]*, Helena Ribeiro*[c]**

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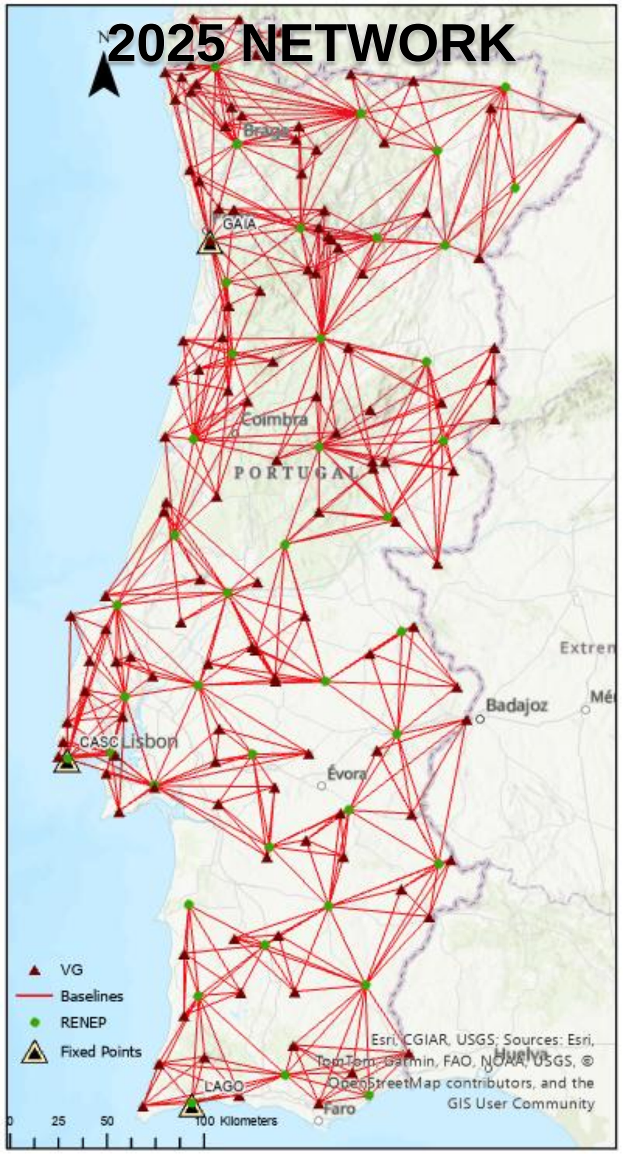

OBSERVATION CAMPAIGNS

1997-2005

- 127 first-order and 520 second-order vertices observed in mainland Portugal as part of the ETRS89 implementation
- GPS-only receivers
- Only one permanent GNSS station in 1997 (CASC, Cascais)
- Observation files in proprietary Trimble® format with inconsistent metadata

2025

- 130 geodetic landmarks are being re-observed using modern GNSS technologies
- Multi-GNSS (GPS, GLONASS, Galileo and BeiDou)
- Supported by ReNEP, the National CORS Network, which has 42 permanent GNSS stations across Portugal mainland
- Observation files in RINEX format that include comprehensive metadata

ADJUSTMENT STRATEGY

Using Leica Infinity 4.2.0, a two-stage network adjustment was performed:

1. **Minimally Constrained Adjustment**
   Identify gross errors, significant residuals, and evaluate internal inconsistency of the network;
2. **Constrained Adjustment**
   Fix at least three control points to official coordinates from DGT (*Direção-Geral do Território*) to ensure alignment with the national reference frame PT-TM06/ETRS89.

PRELIMINARY RESULTS

- Despite historical data limitations, the adjusted coordinates showed high consistency, with planimetric deviations < 2 mm and vertical deviations ~3 mm (orthometric) and ~6 mm (ellipsoidal), relative to the official coordinates of the RGN, after excluding problematic baselines;
- However, the F-test value was 4.74 (critical value: 0.97), still suggesting residual inconsistencies;
- The initial 2025 adjustment, performed without baseline removal or error filtering, resulted in a significantly high variance ratio (F-test);
- Ongoing analysis includes outlier detection and baseline validation using the W-test and the T-test.

THANK YOU

Ciências ULisboa
Faculdade de Ciências da Universidade de Lisboa

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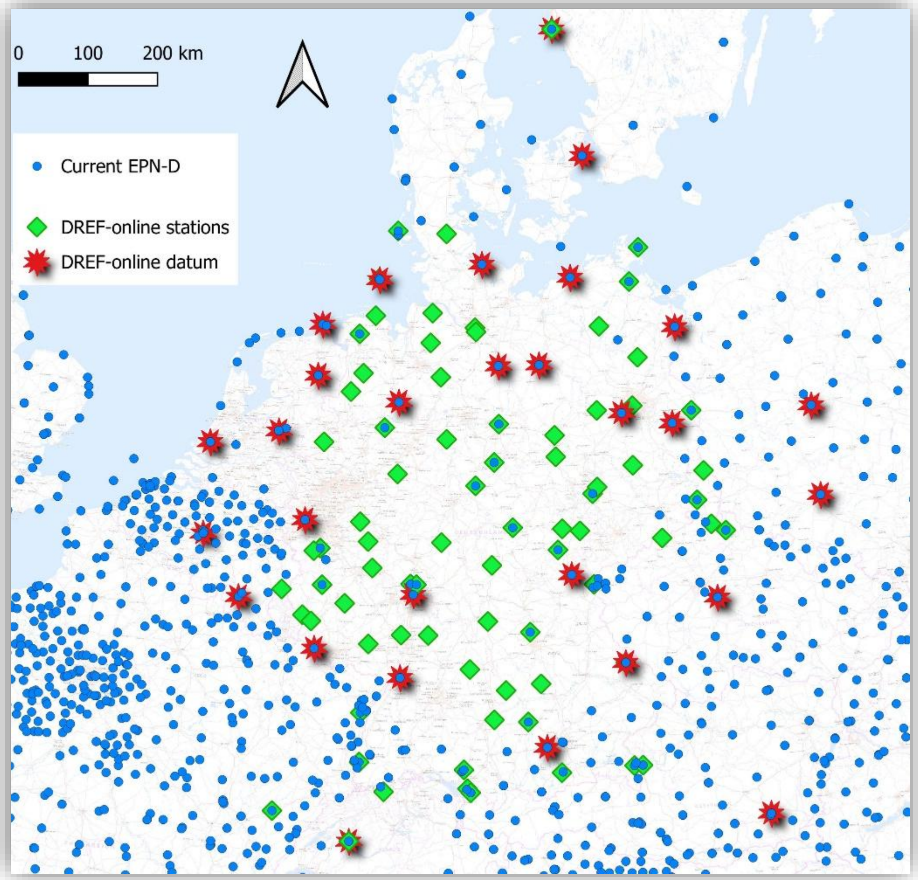
A permanent GNSS network in Germany joins the EPN-Densification Working Group

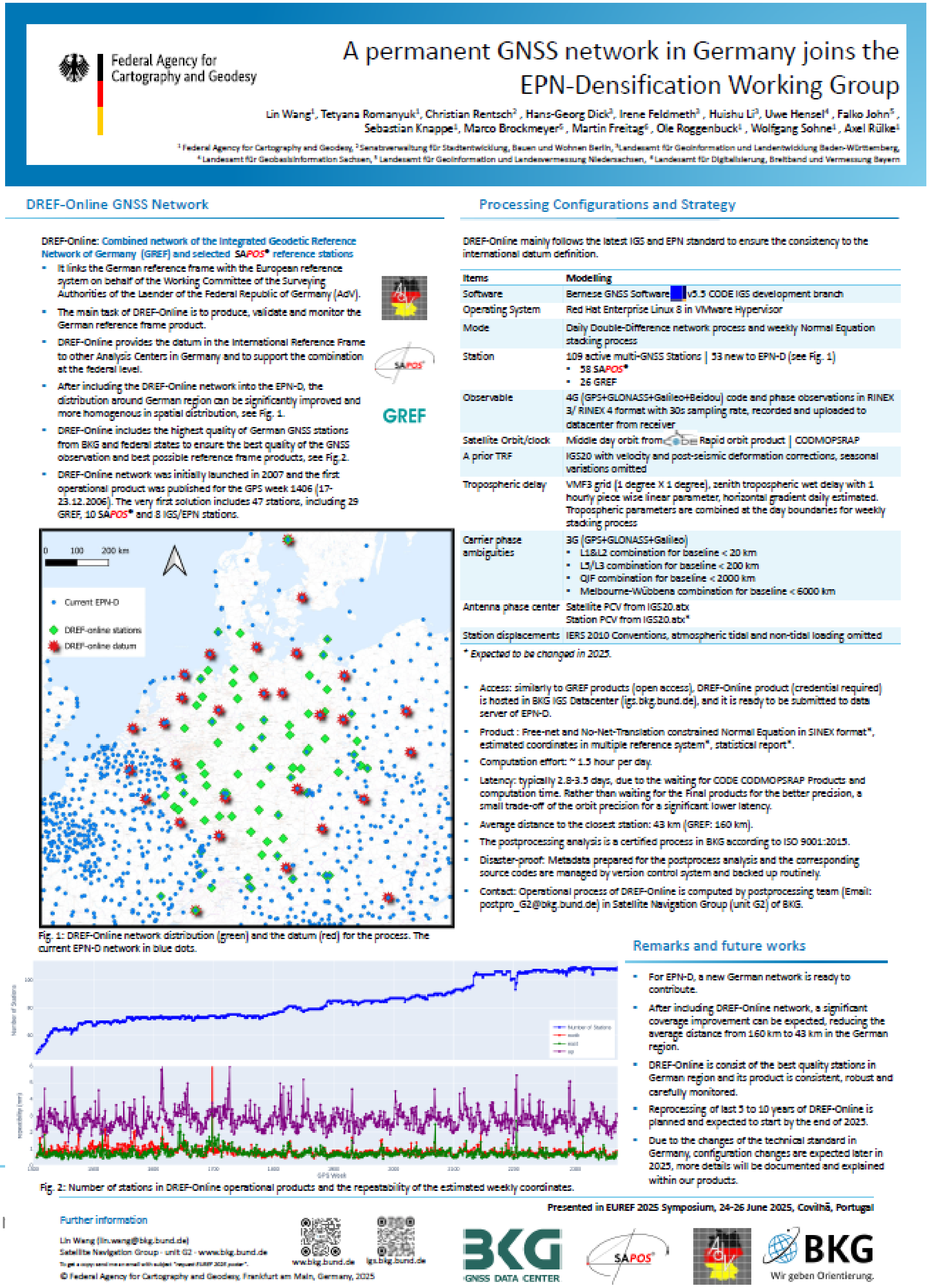
Current EPN-D (image from https://epnd.sgo-penc.hu/station-distribution/)

After inclusion of DREF-Online network



What does DREF-Online contribute?

- Best quality stations and best possible reference frame products with a low latency.
- 53 new permanent stations for EPN-D.
- Significant improvements of station coverage in Germany.
- Daily and weekly products with CODMOPSRAP orbit.
- ...
- For more details: talk to us!



Federal Agency for Cartography and Geodesy

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Thank you for your kind attention!

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34th EUREF Symposium
Covilhã, Portugal, June 25–26, 2025

Towards a 4D National Spatial Reference System
(National Report of Slovenia)

Poster

Sandi Berk[1], Niko Fabiani[3], Klemen Medved[1], Natalija Novak[3], Polona Pavlovčič Prešeren[2], Peter Prešeren[1], Klemen Ritlop[2], Oskar Sterle[2], Bojan Stopar[2]

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MINISTRY OF NATURAL RESOURCES AND SPATIAL PLANNING
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2 FGG UNIVERSITY OF LJUBLJANA
Faculty of Civil and Geodetic Engineering

3 Federal Agency for
GEODETIC INSTITUTE OF SLOVENIA

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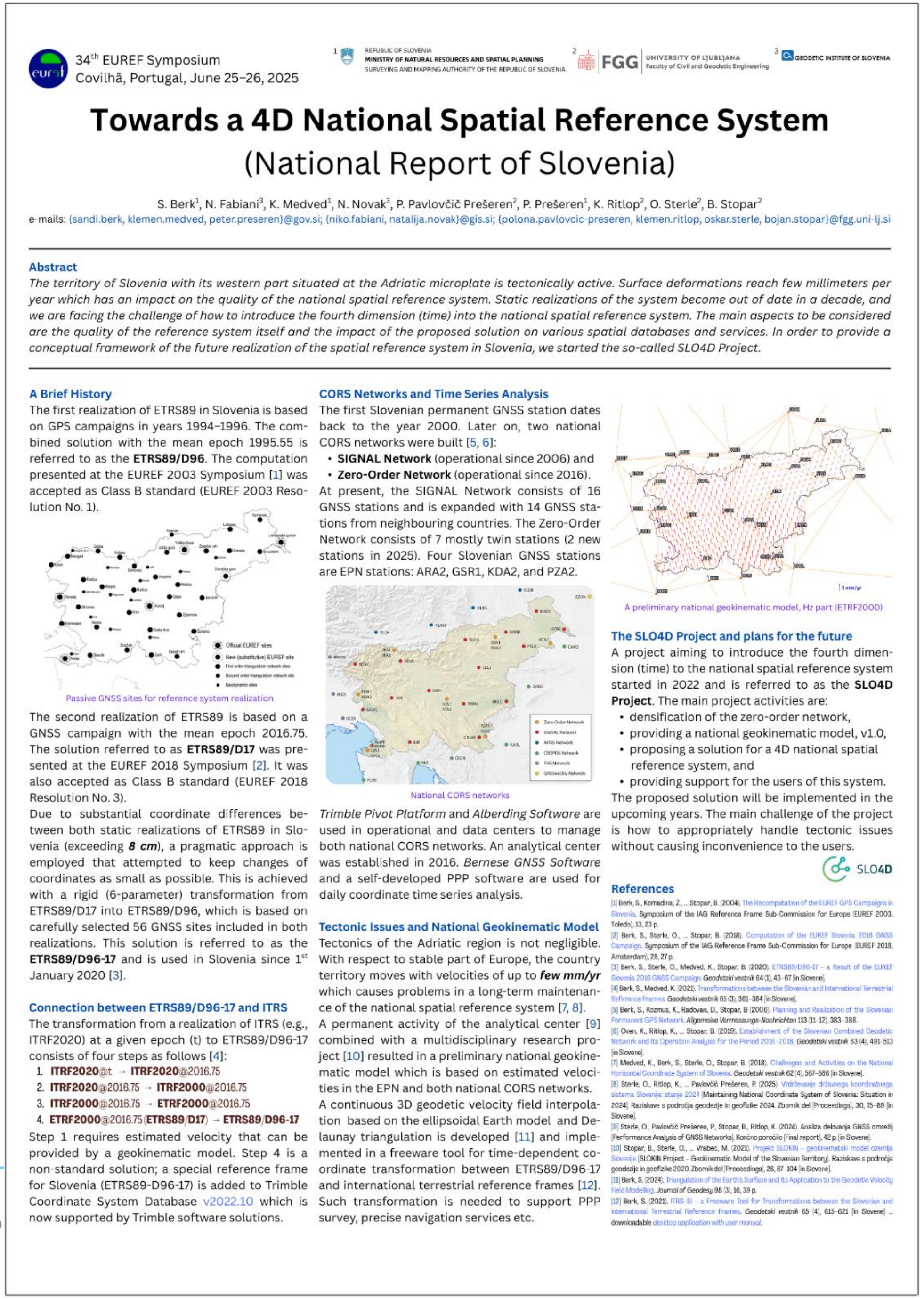

34th EUREF Symposium
Covilhã, Portugal, June 25–26, 2025

Towards a 4D National Spatial Reference System
(National Report of Slovenia)

S. Berk[1], N. Fabiani[3], K. Medved[1], N. Novak[3], P. Pavlovčič Prešeren[2], P. Prešeren[1], K. Ritlop[2], O. Sterle[2], B. Stopar[2]
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Abstract
The territory of Slovenia with its western part situated at the Adriatic microplate is tectonically active. Surface deformations reach few millimeters per year which has an impact on the quality of the national spatial reference system. Static realizations of the system become out of date in a decade, and we are facing the challenge of how to introduce the fourth dimension (time) into the national spatial reference system. The main aspects to be considered are the quality of the reference system itself and the impact of the proposed solution on various spatial databases and services. In order to provide a conceptual framework of the future realization of the spatial reference system in Slovenia, we started the so-called SLO4D Project.

A Brief History
The first realization of ETRS89 in Slovenia is based on GPS campaigns in years 1994–1996. The combined solution with the mean epoch 1995.55 is referred to as the **ETRS89/D96**. The computation presented at the EUREF 2003 Symposium [1] was accepted as Class B standard (EUREF 2003 Resolution No. 1).

Passive GNSS sites for reference system realization

The second realization of ETRS89 is based on a GNSS campaign with the mean epoch 2016.75. The solution referred to as **ETRS89/D17** was presented at the EUREF 2018 Symposium [2]. It was also accepted as Class B standard (EUREF 2018 Resolution No. 3).

Due to substantial coordinate differences between both static realizations of ETRS89 in Slovenia (exceeding ***8 cm***), a pragmatic approach is employed that attempted to keep changes of coordinates as small as possible. This is achieved with a rigid (6-parameter) transformation from ETRS89/D17 into ETRS89/D96, which is based on carefully selected 56 GNSS sites included in both realizations. This solution is referred to as the **ETRS89/D96-17** and is used in Slovenia since 1st January 2020 [3].

Connection between ETRS89/D96-17 and ITRS
The transformation from a realization of ITRS (e.g., ITRF2020) at a given epoch (t) to ETRS89/D96-17 consists of four steps as follows [4]:
1. **ITRF2020**@t → **ITRF2020**@2016.75
2. **ITRF2020**@2016.75 → **ITRF2000**@2016.75
3. **ITRF2000**@2016.75 → **ETRF2000**@2016.75
4. **ETRF2000**@2016.75 (**ETRS89/D17**) → **ETRS89/D96-17**

Step 1 requires estimated velocity that can be provided by a geokinematic model. Step 4 is a non-standard solution; a special reference frame for Slovenia (ETRS89-D96-17) is added to Trimble Coordinate System Database v2022.10 which is now supported by Trimble software solutions.

CORS Networks and Time Series Analysis
The first Slovenian permanent GNSS station dates back to the year 2000. Later on, two national CORS networks were built [5, 6]:
- **SIGNAL Network** (operational since 2006) and
- **Zero-Order Network** (operational since 2016).

At present, the SIGNAL Network consists of 16 GNSS stations and is expanded with 14 GNSS stations from neighbouring countries. The Zero-Order Network consists of 7 mostly twin stations (2 new stations in 2025). Four Slovenian GNSS stations are EPN stations: ARA2, GSR1, KDA2, and PZA2.

National CORS networks

Trimble Pivot Platform and *Alberding Software* are used in operational and data centers to manage both national CORS networks. An analytical center was established in 2016. *Bernese GNSS Software* and a self-developed PPP software are used for daily coordinate time series analysis.

Tectonic Issues and National Geokinematic Model
Tectonics of the Adriatic region is not negligible. With respect to stable part of Europe, the country territory moves with velocities of up to ***few mm/yr*** which causes problems in a long-term maintenance of the national spatial reference system [7, 8].

A permanent activity of the analytical center [9] combined with a multidisciplinary research project [10] resulted in a preliminary national geokinematic model which is based on estimated velocities in the EPN and both national CORS networks.

A continuous 3D geodetic velocity field interpolation based on the ellipsoidal Earth model and Delaunay triangulation is developed [11] and implemented in a freeware tool for time-dependent coordinate transformation between ETRS89/D96-17 and international terrestrial reference frames [12]. Such transformation is needed to support PPP survey, precise navigation services etc.

A preliminary national geokinematic model, Hz part (ETRF2000)

The SLO4D Project and plans for the future
A project aiming to introduce the fourth dimension (time) to the national spatial reference system started in 2022 and is referred to as the **SLO4D Project**. The main project activities are:
- densification of the zero-order network,
- providing a national geokinematic model, v1.0,
- proposing a solution for a 4D national spatial reference system, and
- providing support for the users of this system.

The proposed solution will be implemented in the upcoming years. The main challenge of the project is how to appropriately handle tectonic issues without causing inconvenience to the users.

SLO4D

References

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[11] Berk, S. (2024). Triangulation of the Earth's Surface and Its Application to the Geodetic Velocity Field Modelling. Journal of Geodesy 98 (3), 16, 39 p.
[12] Berk, S. (2021). ITRS-SI – a Freeware Tool for Transformations between the Slovenian and International Terrestrial Reference Frames. Geodetski vestnik 65 (4), 615–621 [in Slovene] ... downloadable desktop application with user manual.

Towards a 4D National Spatial Reference System (National Report of Slovenia)

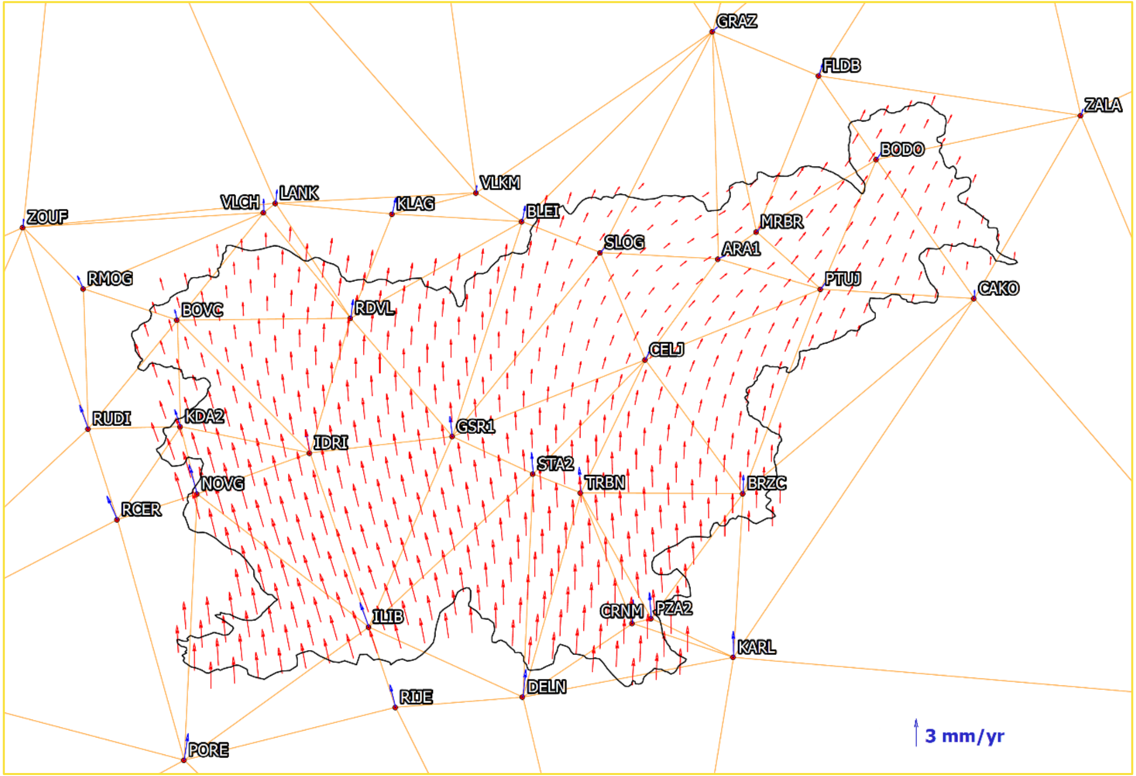
Why do we need to consider the fourth (time) dimension in the national SRS? What is an optimal solution:

- *to keep the required quality of the system over time*
- *without causing inconvenience to the users?*

The poster covers:

- A Brief History of Realizations of ETRS89 in Slovenia
- Connection between ETRS89/D96-17 and ITRS
- CORS Networks and Time Series Analysis in Slovenia
- Tectonic Issues and National Geokinematic Model

*The **SLO4D Project** (in progress) will address these issues.*



A preliminary national geokinematic model, Hz part (ETRF2000)

SLO4D

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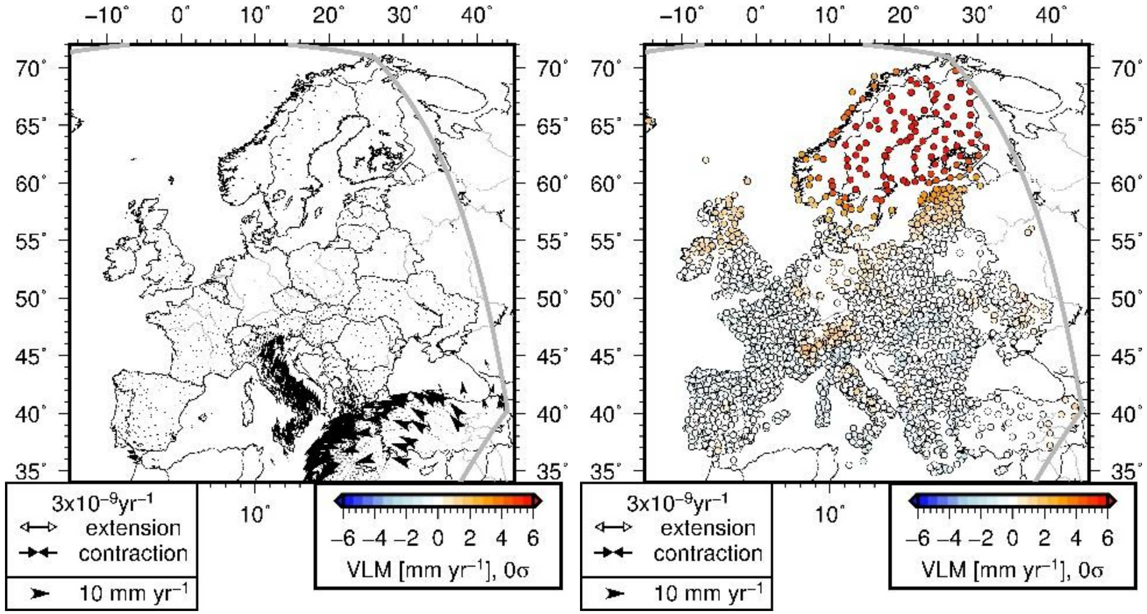
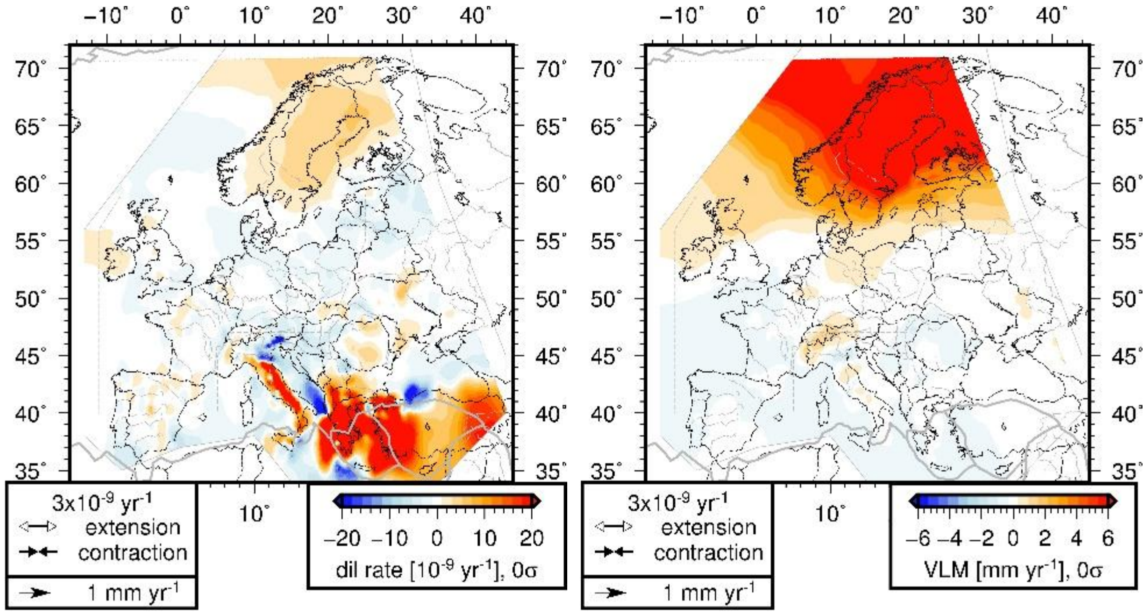
Assessing small-scale Surface Deformation Zones in Europe



- EPND velocity field
- NGL velocity field

RD3I

- Horizontal strain map
- Vertical imaging



GFZ Helmholtz Centre for Geosciences

ON THE STABILITY OF ETRS89

A comparison between recent observations and earlier national realisations in Serbia and Sweden
– using **different ETRFs** and the **EuVeM2022** velocity model

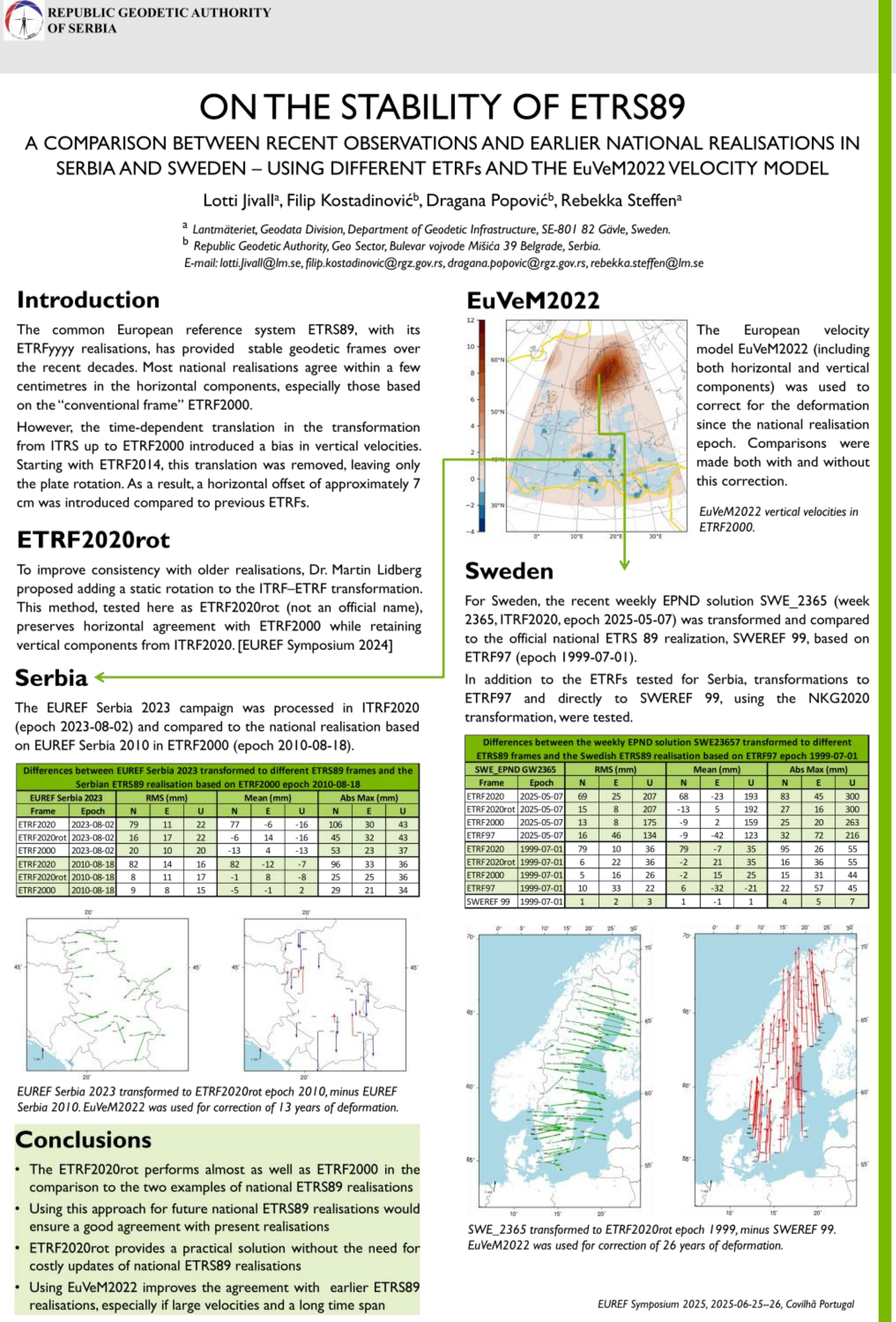
ITRF2020/IGS20 transformed to:

ETRF2020 "ETRF2020rot" ETRF2000 ETRF97 NKG2020

Lotti Jivall, Filip Kostadinović, Dragana Popović, Rebekka Steffen

REPUBLIC GEODETIC AUTHORITY OF SERBIA

LANTMÄTERIET



REPUBLIC GEODETIC AUTHORITY OF SERBIA

ON THE STABILITY OF ETRS89

A COMPARISON BETWEEN RECENT OBSERVATIONS AND EARLIER NATIONAL REALISATIONS IN SERBIA AND SWEDEN – USING DIFFERENT ETRFs AND THE EuVeM2022 VELOCITY MODEL

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Introduction

The common European reference system ETRS89, with its ETRFyyyy realisations, has provided stable geodetic frames over the recent decades. Most national realisations agree within a few centimetres in the horizontal components, especially those based on the "conventional frame" ETRF2000.

However, the time-dependent translation in the transformation from ITRS up to ETRF2000 introduced a bias in vertical velocities. Starting with ETRF2014, this translation was removed, leaving only the plate rotation. As a result, a horizontal offset of approximately 7 cm was introduced compared to previous ETRFs.

ETRF2020rot

To improve consistency with older realisations, Dr. Martin Lidberg proposed adding a static rotation to the ITRF–ETRF transformation. This method, tested here as ETRF2020rot (not an official name), preserves horizontal agreement with ETRF2000 while retaining vertical components from ITRF2020. [EUREF Symposium 2024]

Serbia

The EUREF Serbia 2023 campaign was processed in ITRF2020 (epoch 2023-08-02) and compared to the national realisation based on EUREF Serbia 2010 in ETRF2000 (epoch 2010-08-18).

Differences between EUREF Serbia 2023 transformed to different ETRS89 frames and the Serbian ETRS89 realisation based on ETRF2000 epoch 2010-08-18										
EUREF Serbia 2023		RMS (mm)			Mean (mm)			Abs Max (mm)		
Frame	Epoch	N	E	U	N	E	U	N	E	U
ETRF2020	2023-08-02	79	11	22	77	-6	-16	106	30	43
ETRF2020rot	2023-08-02	16	17	22	-6	14	-16	45	32	43
ETRF2000	2023-08-02	20	10	20	-13	4	-13	53	23	37
ETRF2020	2010-08-18	82	14	16	82	-12	-7	96	33	36
ETRF2020rot	2010-08-18	8	11	17	-1	8	-8	25	25	36
ETRF2000	2010-08-18	9	8	15	-5	-1	2	29	21	34

EUREF Serbia 2023 transformed to ETRF2020rot epoch 2010, minus EUREF Serbia 2010. EuVeM2022 was used for correction of 13 years of deformation.

Conclusions

- The ETRF2020rot performs almost as well as ETRF2000 in the comparison to the two examples of national ETRS89 realisations
- Using this approach for future national ETRS89 realisations would ensure a good agreement with present realisations
- ETRF2020rot provides a practical solution without the need for costly updates of national ETRS89 realisations
- Using EuVeM2022 improves the agreement with earlier ETRS89 realisations, especially if large velocities and a long time span

EuVeM2022

The European velocity model EuVeM2022 (including both horizontal and vertical components) was used to correct for the deformation since the national realisation epoch. Comparisons were made both with and without this correction.

EuVeM2022 vertical velocities in ETRF2000.

Sweden

For Sweden, the recent weekly EPND solution SWE_2365 (week 2365, ITRF2020, epoch 2025-05-07) was transformed and compared to the official national ETRS 89 realization, SWEREF 99, based on ETRF97 (epoch 1999-07-01).

In addition to the ETRFs tested for Serbia, transformations to ETRF97 and directly to SWEREF 99, using the NKG2020 transformation, were tested.

Differences between the weekly EPND solution SWE23657 transformed to different ETRS89 frames and the Swedish ETRS89 realisation based on ETRF97 epoch 1999-07-01										
SWE_EPND GW2365		RMS (mm)			Mean (mm)			Abs Max (mm)		
Frame	Epoch	N	E	U	N	E	U	N	E	U
ETRF2020	2025-05-07	69	25	207	68	-23	193	83	45	300
ETRF2020rot	2025-05-07	15	8	207	-13	5	192	27	16	300
ETRF2000	2025-05-07	13	8	175	-9	2	159	25	20	263
ETRF97	2025-05-07	16	46	134	-9	-42	123	32	72	216
ETRF2020	1999-07-01	79	10	36	79	-7	35	95	26	55
ETRF2020rot	1999-07-01	6	22	36	-2	21	35	16	36	55
ETRF2000	1999-07-01	5	16	26	-2	15	25	15	31	44
ETRF97	1999-07-01	10	33	22	6	-32	-21	22	57	45
SWEREF 99	1999-07-01	1	2	3	1	-1	1	4	5	7

SWE_2365 transformed to ETRF2020rot epoch 1999, minus SWEREF 99. EuVeM2022 was used for correction of 26 years of deformation.

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"ETRF2020rot" – presented with formulas and parameters in Barcelona 2024 by Martin Lidberg:

$$X^E(t_c) = X^I_{YY}(t_c) + R_{E20} \times X^I_{YY}(t_c) + \begin{pmatrix} 0 & -\dot{R}3_{YY} & \dot{R}2_{YY} \\ \dot{R}3_{YY} & 0 & -\dot{R}1_{YY} \\ -\dot{R}2_{YY} & \dot{R}1_{YY} & 0 \end{pmatrix} \times X^I_{YY}(t_c) \cdot (t_c - 1989.0)$$

"ETRF2020rot" is aligend to ETRF2000 with a static Euler pole rotation. Heights and vertical velocities are retained from ITRF2020.

- The "ETRF2020rot" performs almost as well as ETRF2000 in the comparison to the two examples of national ETRS89 realisations
- Using this approach for future national ETRS89 realisations would ensure a good agreement with present realisations
- To facilitate the use of this approach, we propose to include also this type of transformation in future versions of EUREF Technical Note 1.