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EUREF NEWSLETTER

SEASON'S GREETINGS

BY THE EUREF CHAIR MARTIN LIDBERG

Dear colleagues,

While trying to summarize the year 2024 we should think of the world beyond geodesy in Europe and EUREF. We have a conflict in Europe which we do not know how long it will last, and we also have the conflict in the middle east. This should never be accepted as "normal", but we should on the other hand be prepared for endurance since it is hard to foresee when it will end. My thoughts go to innocent victims.

From the EUREF community perspective we have during 2024 worked a lot together with updated analysis of our GNSS networks, the maintenance and development of the EPN including meta data and products, new national levelling data are provided to the UELN, we see progress from the W.G. Unified European Height Reference, and much more! From all these activities we foresee new realization on the EVRS in 2025, the results from the EPN-Repro3, and somewhat later re-processing results from the EPN-Densification. Regarding reference frames, I am personally very happy about the new study group on ETRS89 (see below).

Since progress in geodesy require cooperation, I am very happy for the successful EUREF Symposia in Barcelona 1st week of June. Many thanks again for excellent arrangements of the LOC, and for fruitful contributions from all participants!

For 2025 we have not yet found a volunteer for arranging the EUREF Symposia 2025. Two organizations have been asked, but no conformation yet. Therefore, proposals for arranging EUREF Symposia 2025 or the coming years are more than welcomed!

By that, I wish you, your relatives and friends a merry Christmas and happy end of 2024, and all the best for 2025!

Martin

EUREF GOVERNING BOARD 2024

BY THE EUREF GB CHAIR WOLFGANG SÖHNE

In 2024, the EUREF Governing Board had again a mixture of digital and in-person meetings. On February 06 and 07, 2024, we met at the Royal Observatory of Belgium in Brussels. Beside the preparation of the symposium in Summer the resolutions of the 2023 symposium were discussed, in particular resolution number 2 on ETRS89. The EUREF chair Martin Lidberg was asked to find some volunteers from the EUREF community to work on this topic. Following resolution number 4 on additional GNSS data for the Historical Data Centre the EPN Central Bureau could report on some new data. Following the switch to IGS20 and upgrades of the processing softwares used by the Analysis Centres (ACs) it could be stated that the gap coming from delay in processing has been almost closed by the ACs. Consequently, the combination for coordinates and troposphere could be re-established. The third EPN Reprocessing has been still behind schedule but all Repro ACs were working on their contributions.

The next meeting was divided into an online part mid of May and the in-person meeting on the occasion of the symposium in Barcelona in June. After discussing final steps for the symposium and some news on the EUREF web page Michele Manunta as invited guest presented the EPOS Thematic Core Service on "Satellite Data" to the GB. Since the EUREF-EPOS Memorandum of Understanding exists and the corresponding Work Plan for 2024 and 2025 has been prepared by Carine Bruyninx, it should be figured out how a collaboration with the GNSS community could serve both sides. Another invited guest, Jeffrey Verbeurgt, explained to the GB the plan for the Geodetic Reference Frame (GRF) by UN-GGIM:Europe. Since EUREF has the best overview on GRFs used in Europe, the collaboration on this topic should be intensified. Xavier Collilieux as invited guest explained the first yearly update of the ITRF2020. Since there will be only very small changes, no impact on ETRF2020 is expected.

The third meeting of the year was a pure online meeting, divided into two parts mid of October and mid of November. The resolutions of the symposium were discussed. Concerning the InSAR equipment a consolidated action together with the International GNSS Service (IGS) should be established. A first discussion within the IGS Infrastructure Committee took place. For a future or alternative ERTS89 realisation, the GB decided to establish a new Study Group (SG) with Xavier Collilieux as the chair. A draft version of the Terms of References and a preliminary list of SG members were already compiled. The EUREF chair Martin Lidberg joined an EUREF-EUROSDR workshop in October in Norway and he reported on the agenda. A follow-up workshop is planned for 2025.

For 2025, the GB plans again three meetings as in-person and online meeting, depending on the events EUREF can carry out next year.

The Reference Frames

ETRS89

BY ZUHEIR ALTAMIMI AND XAVIER COLLILIEUX

The European Terrestrial Reference System 89 (ETRS89) was adopted in 1990 in Firenze, Italy, following the EUREF Resolution 1. 12 realizations have been published so far, the most recent being ETRF2020. Since then, European countries have aligned their national reference frame with respect to an ETRS89 realization. Most of them have chosen ETRF2000 but at various epochs.

Only a few countries have adopted the recent unbiased updates. On 15th October 2024, the EUREF Governing Board decided to form a Study Group (SG) to investigate if ETRS89 is still in line with user needs and to propose an alternative definition of the system if it is relevant. The conclusions of the SG are expected by the end of 2025.

EVRS

BY MARTINA SACHER AND JOACHIM SCHWABE

INSPIRE endorsed the use of the European Vertical Reference System (EVRS) to express gravity-related heights in Europe. The heights of EVRS are determined by the common adjustment of national levelling networks in the United European Levelling Network (UELN). The latest EVRS realization is EVRF2019, which has been released in 2019 and updated in 2020. The heights in EVRF2019 can be downloaded from the EVRS website: **https://evrs.bkg.bund.de/Subsites/EVRS/EN/RealizationofEVRS/EVRF2019/evrf2019.html**.

Since 2020, some new data have been included in the UELN:

- In 2022, France provided an update of its levelling data. This comprises on the zero-order network NIREF, which has been expanded, and a reprocessed version of the IGN69, including all intermediate points on the levelling lines. Therefore, much more connection points between NIREF and IGN69 have been found as in EVRF2019.
- In 2024, the national levelling network of Moldova could be included in UELN for the first time.
- Further, in the autumn of 2024, Czechia provided an update of its levelling network, which have been measured between 2007 and 2024. However, some connection measurements to the neighboring countries are not yet available and have to be taken from the old data set, which was measured between the 1970s and 1990s.

The evaluation of GNSS/levelling data sets shows considerable tilts between the gravimetric geoid and the difference of ellipsoidal and levelling heights in the areas of Great Britain and France. It is assumed that these tilts are caused by systematic errors in the levelling networks of both countries. It is currently considered to include additional hydrodynamic levelling connections in order to reduce these effects, as described in the dissertation of Yosra Afrasteh: “Model based Hydrodynamic levelling – an impact study on the European Vertical Reference Frame”. The final selection of the hydrodynamic levellings is still under discussion.

We plan to release a new realization of EVRS around mid-2025. So, if you consider to deliver updated or additional levelling data, please send them to **martina.sacher@bkg.bund.de** as soon as possible, but latest May 2025.

THE EUREF PERMANENT GNSS NETWORK (EPN)

BY CARINE BRUYNINX AND JULIETTE LEGRAND

GNSS@ROB @be_GNSS

The EPN Central Bureau (CB, **https://epncb.oma.be**), managed by the Royal Observatory of Belgium, has continued its operational oversight of the EPN network in 2024, focusing on station performance in terms of data availability, metadata accuracy, and data quality. This year, 11 new GNSS stations were integrated into the EPN (highlighted in green in Figure 1: six in Italy, one in Greenland (not shown on the map), one in Greece, and three in Serbia. At the same time, six stations were decommissioned, including three in Ukraine, two in Great Britain, and one in Finland. Additionally, on December 4, the EPN CB transitioned to the IGS site log format v2.0, aligning the network with the IGS standards.

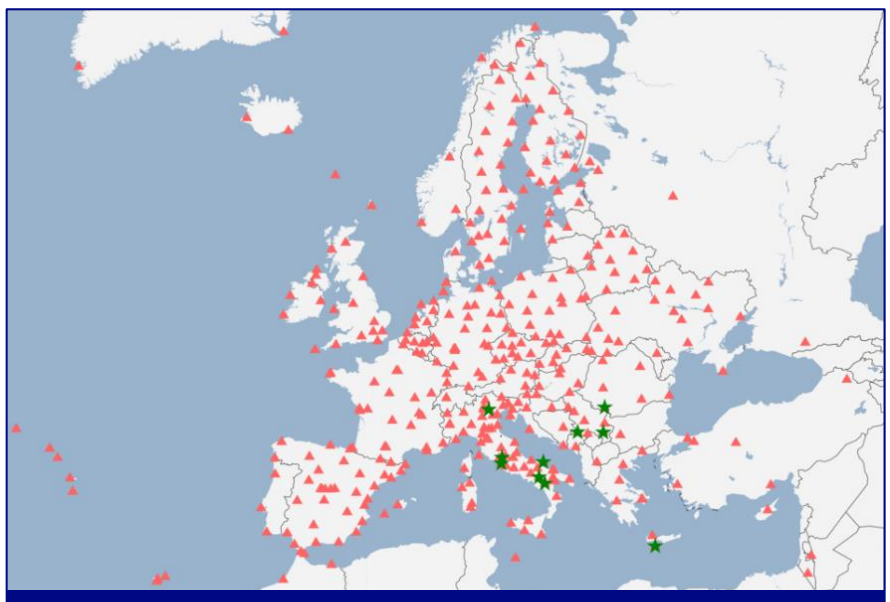

Figure 1. New GNSS stations (in green) integrated in the EPN in 2024.

In line with Resolution No. 1 of the 2024 EUREF Symposium in Barcelona, the EPN CB has taken significant steps to promote FAIR (Findable, Accessible, Interoperable, Reusable) data practices. A key milestone is the assignment of Digital Object Identifiers (DOIs) to datasets from EPN stations. Over 150 stations now have DOIs, which are accessible via the M^3G platform (**https://gnss-metadata.eu**). This initiative enhances the discoverability of data and enables users to properly cite it, ensuring that data providers receive appropriate recognition. To ensure the DOIs comply with international standards, the EPN CB collaborates closely with the GGOS Committee on DOIs for Geodetic Data.

In addition, historical EPN data is now available through a new open data portal (**https://gnss.be/opendataportal/**). This platform, currently in beta, not only provides access to RINEX data but also enriches it with standardized metadata compliant with the GNSS-DCAT-AP schema (**https://zenodo.org/records/10955559**). These advancements make GNSS data more accessible and reusable for the scientific community.

Through these initiatives, the EPN CB remains committed to enhancing GNSS data access and encourage international collaboration in this field.

The Coordinators

Analysis Center Coordinator

BY TOMASZ LIWOSZ AND ANDRZEJ ARASZKIEWICZ

In 2024, the EPN Analysis Centres Coordinator (ACC) continued to analyze and combine the operational solutions of the EPN Analysis Centres (AC) provided within the IGS20 framework.

Since June 2024, the EPN combined operational solutions have been based on contributions from all 17 ACs. Previously, from November 2022 to May 2024, two AC solutions were missing, but these were provided in 2024. To improve the consistency of the combined solutions, the ACC decided to recombine the earlier AC solutions to include the previously missing solutions. The updated combined solutions for this period will be released at the beginning of 2025.

In 2024, the EPN ACC also reviewed the AC solutions submitted for the EPN Reprocessing 3 project (repro3). A total of 12 EPN ACs are participating in this project. As of December 2024, 10 ACs have provided solutions covering the entire period from 1996 to 2022. Currently, the ACC is analyzing the AC solutions individually. The analysis begins with verifying the correctness of metadata provided in SINEX files. Next, the daily solutions from each AC are stacked into a multi-year solution to evaluate the quality of station position time series. During this step, residual station position time series are inspected, and outliers are removed. Based on the cleaned AC daily solutions, the repro3 combined solutions will be generated and are expected to be released in the first half of 2025.

Troposphere Coordinator

BY ROSA PACIONE

In 2024, the EPN Troposphere Coordinator (TC) worked on the operational combinations of the Analysis Centres (AC) final solutions. All the 17 EPN ACs are delivering final tropospheric operational products conformed to IGS20 standards and the comparisons of AC final solutions can be found at the EPNCB website: **https://epncb.oma.be/_productsservices/troposphere/mean_zpd_biases.php**.

In addition, 10 EPN ACs are delivering rapid troposphere estimates obtained as a by-product of the rapid site coordinate processing. These rapid solutions are the input for a rapid operational troposphere combination available with a latency of 22 hours after the end of observations of the analysed day. Because of the distributed processing of the EPN stations, about 200 stations are included in the rapid combination. The troposphere multi-year troposphere solution T2295 (1996-2023) has been released on May 2024. Due to the transition to IGS20 standards occurred on November 27th, 2022 this time series is not homogeneous and it will be replaced in the near future by EPN-Repro3 products.

Reference Frame Coordinator

BY JULIETTE LEGRAND

The last official Reference Frame Solution C2235 in IGb14 was published in January 2023 (**https://doi.org/10.24414/ROB-EUREF-C2235**).

To bridge the gap while awaiting the EPN Repro3 solution allowing to generate a new official reference frame solution in the new IGS20, a temporary hybrid reference frame solution was developed. This solution, aligned with IGS20, provides only updated station positions from November 2022 onward.

The hybrid solution combines daily solutions from EPN-repro2 (IGS14/igs14.atx) and operational EPN solutions (IGS20/igs20.atx). It includes revised position and velocity discontinuities aligned with the IGS/ITRF list and incorporates ITRF2020 post-seismic deformation models for ISTA00TUR, REYK00ISL, and TUBI00TUR (ITRF2020 PSD models **https://itrf.ign.fr/ftp/pub/itrf/itrf2020/ITRF2020-psd-gnss.snx**).

Presented at the EUREF Symposium in June 2024, the hybrid solution covers 492 stations, adding velocities for 47 stations and positions for 37 new stations compared to C2235. For 101 stations, a discontinuity was introduced at GPS week 2238 due to the switch to IGS20/epn20.atx. And, 21 stations where affected by an additional discontinuity after November 2022.

The temporary hybrid solution and updated time series are available online:

- **https://epncb.oma.be/_productsservices/coordinates/hybrid.php**
- **https://epncb.oma.be/_productsservices/timeseries/hybrid.php?station=ACOR00ESP**.

The Working Groups

WG on EPN Densification

BY AMBRUS KENYERES

In 2024 no new combined EPND solution had been published. The latest one is EDD2237 from 2023, which was the last solution expressed in IGb14. However behind the curtain all WG members are busy with repro3, where following the completion of EPN reprocessing the national networks are in the queue. The overall status is quite variable, few ACs already completed repro3, while some only plan to start it in Q1 2025. The new IGS2020 EPND solution is not expected before Q3 2025. However a new solution, still in IGb14 may expected in Q1 2025, where we take the advantage of the EPOS pan-European processing completed by UGA. This GAMIT solution includes 1600+ European stations. Its advantages are the homogeneity and the inclusion of the UK BIGF network. At the present EPND solution UK data was included only by GPS week 1830 (early 2015), so its temporal extension will much improve the reliability of the UK velocity field.

The WG chair expresses his highest appreciation of the WG members, who devote endless capacities for realizing the new reprocessed data series.

WG on Reprocessing

BY CHRISTOF VÖLKSEN

Work on EPN-Repro3 gained momentum during the last year. A total of 12 ACs participated in the analysis of GNSS data from the entire EUREF Permanent Network (EPN), starting back in 1996. After the work is going to be completed, it will be ensured that a set of products of the EPN are based on a uniform reference frame (IGS20). Together with the current operational solutions that are already available in IGS20, this will create a consistent time series of coordinates that form the basis for an improved realization of the ETRS.

Each analysis centre processes a subnetwork of the EPN, whose size can vary greatly. While smaller subnetworks consist of about 60 stations, the largest subnetworks reach around 150 stations. In total, 27 years of GNSS data have to be re-processed, which is a considerable amount. In principle the data is automatically processed, but a check is still needed at the end to identify outliers and to carry out any necessary recalculations. As of the end of 2024, more than 80% of the data has been processed and only a few Analysis Centres still have work to complete. The next steps involve the daily combination of individual subnetworks, a task managed by the Analysis Centre Coordinator. Subsequently, the Reference Frame Coordinator will use these combined results to estimate a multi-year solution, delivering precise coordinates and velocities within a unified reference frame. Additionally, the EUREF Troposphere Coordinator integrates the recalculated tropospheric products to produce zenith delay solutions starting from 1996. These tropospheric data will serve as a valuable resource for validating results obtained through other meteorological methods.

EPN-Repro3 is a task that is carried out in addition to the normal work of an EPN-AC. Processing 27 years of data in a homogeneous way is a substantial task that requires a great deal of effort and has to be done alongside day-to-day business. The end is in sight and will make an important contribution to the realization of the European Terrestrial Reference System.

WG on European Unified Height Reference

BY JOACHIM SCHWABE AND MARTINA SACHER

One goal of the Working Group is to include in the CRS-EU database (**https://www.crs-geo.eu/**) information about national height transformation surfaces (a.k.a. geoid models). The aim is to provide easier access and use of these models for GNSS-based height determination. This also implies detailed information about the corresponding national ETRS89 realizations and height systems.

As an intermediate step, an overview document with the most relevant metadata has been compiled. It is available via the EVRS website under **https://gibs.bkg.bund.de/DOI/web/landingPage.php?name=NatRefEurope**. The information is based on the contributions that the bodies responsible for the national geodetic reference (e.g. national mapping agencies) have submitted since 2022. The document also contains specifics on the national ETRS89 realizations and their relations to the European realizations (ETRF). This information is relevant for centimeter accuracy and frequently not included in inventories of coordinate reference systems such as the EPSG. For details, please refer to the corresponding EVRS website:

- **https://evrs.bkg.bund.de/Subsites/EVRS/EN/Results_and_Products/NationalRealizationsETRS89/national_realization.html**.