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# EUREF NEWSLETTER

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## SEASON'S GREETINGS

BY THE EUREF CHAIR MARTIN LIDBERG

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*Dear colleagues,*

*While thinking of how to summarize the year 2022 some things are difficult to avoid. When we thought that the most critical phase of the Covid-19 pandemic was passed, we got the Russian invasion of Ukraine. My thoughts go to all the innocent victims.*

*Nevertheless, I think it is important to continue to work for a better world despite setbacks. For our profession it is about advancing the science of geodesy, refine our products and services, improve needed cooperation within Europe and around the world, and promote and provide our results for the benefit of society. Looking at the contribution in this newsletter I think we are doing progress!*

*After the cancellation of our Annual Symposium in 2020 and two fully online symposia 2021 and 2022, excellently organized by our colleagues from Slovenia and Croatia, we are very optimistic that we could have an in-person Symposium again in 2023, see invitation from Chalmers University, Gothenburg, Sweden. I hope we can meet physically and have interesting discussions at the sessions, breaks, and evenings (and maybe at the breakfast table?!)*

*I wish you, your relatives and friends a merry Christmas and all the best for 2023.*

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## EUREF GOVERNING BOARD 2022

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BY THE EUREF GB CHAIR WOLFGANG SÖHNE

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Like in the last two years, in 2022 the EUREF Governing Board was only able to meet virtually. In total we met six times, each two of the meetings allocated to one “official” GB meeting: March 03 and 15, May 04 and 11, Oct 24 and Dec 02. One main topic of the first half of this year was the preparation of the EUREF 2022 symposium – held online in and with our colleagues from Croatia – and in the second half the preparations for the symposium in 2023 – hopefully as in-person event.

The introduction of the new realization of the International Terrestrial Reference System, the ITRF2020, or, more precisely, its realization for GNSS by the International GNSS Service, IGS20, has been one of the ongoing tasks also for 2023. This goes along with the preparation of a third EPN reprocessing and detailed discussion on the handling of antenna calibrations in the future.

The multi-year GNSS campaign of Slovakia was validated by the GB members and, after presentation, accepted as resolution during the 2022 symposium.

New Memoranda of Understanding (MoU), in particular the MoU with the European Plate Observing System (EPOS), were finalized and signed by both sides, while older MoUs were reviewed.

Status and progress of the various EUREF Working Groups and the operational products supervised by the Coordinators were also discussed during the meetings as well as activities in UELN and EVRS.

The temporary outage of the GNSS data centre at BKG starting end of March 2022 exposed some shortcomings in terms of redundancy. Parallel upload of data as well as products to all data centres is mandatory for the operation of the EPN.

For 2023 we hope to have longer and in-person meeting of the Governing Board, because there is clearly not enough time for discussion during the virtual meetings.

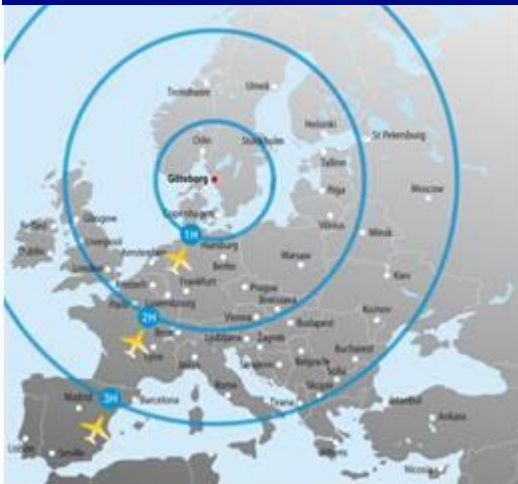


## EUREF SYMPOSIUM 2023

BY JAN JOHANNSON AND MARTIN LIDBERG

It is our pleasure to invite you to Gothenburg at the west coast of Sweden for the EUREF Symposium 2023. Location is the Conference Center of the Chalmers Technical University. It is planned to take place, according to our tradition, from Wednesday to Friday, May 24 to 26. We are also considering a – possibly half-day – Tutorial on Tuesday, May 23, but it is so far not decided. So please save the dates and watch for the information on the EUREF webpage.

Way to Gothenburg.



## ITRF2020

BY ZUHEIR ALTAMIMI

The new realization of the International Terrestrial Reference System, the ITRF2020, was published in April 2022 and is intended to be an improved version and replace ITRF2014. It is provided in the form of an augmented terrestrial reference frame so that in addition to station positions and velocities, parametric functions describing both post-seismic deformation (PSD) for sites impacted by major earthquakes and seasonal signals (expressed in the Center of Mass (CM) as sensed by Satellite Laser Ranging (SLR) and the Center of Figure (CF) frames) are provided to the users. It is expected that a subsequent new realization of the ETRS89, an ETRF2020, will be available in due time.

## THE EUREF PERMANENT GNSS NETWORK (EPN)

BY CARINE BRUYNINX AND JULIETTE LEGRAND



GNSS@ROB @be\_GNSS

The EPN Central Bureau (CB, managed by the Royal Observatory of Belgium) continued to monitor operationally EPN station performance in terms of data availability, correctness of metadata, and data quality. In 2022, the EPN Central Bureau (CB, <https://www.epncb.oma.be/>) added 32 new stations to the EPN (indicated in green on the map to the right).

The effort to move towards FAIR-aligned GNSS data continues with 94% of the EPN stations that have assigned a data license to their RINEX data in M3G (<https://gnss-metadata.eu>).

In order to comply with EU General Data Protection Regulation (GDPR), from Oct. 24 2022 on, all EPN site logs and GeodesyML files that can be retrieved from M3G (and EPN CB) have been stripped from any personal contact information coming from persons who have not given M3G the explicit permission to publish their personal information. Moreover, from that date on, M3G only allows to upload site logs that use non-personal contact information and emails in the "Prepared by" field (section 0), the "Primary contact" of the "On-Site, Point of Contact Agency Information" and the "Responsible Agency" (sections 11 and 12).

The EPN CB released version 2.0 of the ETRF/ITRF Coordinate Transformation Tool (ECTT) available from [https://epncb.oma.be/\\_productsservices/coord\\_trans/](https://epncb.oma.be/_productsservices/coord_trans/). It now allows transforming coordinates from and to ITRF2020.

Encouraged by Resolution No 2 of the 2019 EUREF symposium in Tallinn, more than 67% of the EPN stations are sharing their daily RINEX data with the European Plate Observing System (EPOS). These EPN data are made available to EPOS through the ROB-EUREF EPOS data node built on top of the historical EPN data centre managed by the EPN CB.

In March 2022, The EUREF Governing Board also updated the Guidelines for EPN stations and Operational Centres making the submission of RINEX 3 data mandatory for EPN stations and encouraged the submission of high-rate RINEX data files.

For more news, follow [https://twitter.com/be\\_gnss](https://twitter.com/be_gnss).

New GNSS stations (in green) integrated in the EPN in 2022.



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# The Coordinators

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## *Analysis Center Coordinator*

BY TOMASZ LIWOSZ AND ANDRZEJ ARASZKIEWICZ

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In 2022, the EPN Analysis Centres Coordinator (ACC) continued to combine GNSS coordinate solutions (final, rapid, near-real time) provided by the EPN Analysis Centres (AC). A new EPN analysis centre was established at the GeoForschungsZentrum (GFZ), Potsdam, Germany. A network of 114 EPN GNSS stations to be processed by the GFZ AC was chosen. The GFZ AC will start providing final solutions from GPS week 2238 onwards. The Federal Office of Metrology and Surveying, Austria (BEV) became a new EPN product centre. The EPN analysis centres and combined products can be found at: <https://gnss.bev.gv.at/at.gv.bev.dc>.

The activities of the ACC included also preparations for the switch to the IGS20/igs20.atx reference frame (published in July 2022) and IGS repro3 standards in operational EPN analysis. The IGS switched to the new reference frame for the generation of its operational products on November 27, 2022. To discuss the details regarding the switch to the IGS20 in EPN, the EPN Analysis Centres Workshop was organized on November 3, 2022. Changes in the EPN analysis in IGS20 will include, e.g.: the usage of consistent three-system IGS AC final products (e.g., CODE or GFZ), the usage of the new EPN antenna model (based almost exclusively on the IGS type-mean model with some additional calibrations for antenna-radome pairs not included in the IGS model), the correction of antennas not oriented to true north, the switch to FES2014b ocean tide model, the new long filenames for the EPN products. Presentations and minutes from the workshop are available at the EPN CB webpage at: [http://www.epncb.eu/\\_newseventslinks/workshops/EPNLACWS\\_2022/](http://www.epncb.eu/_newseventslinks/workshops/EPNLACWS_2022/).

## *Troposphere Coordinator*

BY ROSA PACIONE

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The status of the EPN operational tropospheric product has been reported to the community during the EPN Analysis Center Workshop, held online on November 3, 2022. In 2022, 32 new EPN stations - 17 in Italy (AGRN00ITA, ASIR00ITA, BIRG00ITA, BSVZ00ITA, ENZA00ITA, FRNE00ITA, GALH00ITA, ISRN00ITA, LIGN00ITA, RIVO00ITA, SART00ITA, SVLL00ITA, TEOS00ITA, TREU00ITA, TRMI00ITA, UBEN00ITA, VIRG00ITA); 6 in Ukraine (ARA200UKR, FRA200UKR, MUK200UKR, RAH100UKR, RVNE00UKR, TER200UKR); 2 in Portugal (PSTO00PRT STNB00PRT); 2 in Norway (PPSH00NOR, WUTH00NOR); 2 in Slovenia (KDA200SVN, PZA200SVN); 1 in Slovakia (DVCN00SVK); 1 in Sweden (SPT700SWE) and 1 in Hungary (ZZON00HUN) - have been successfully included in the tropospheric combined solution. In 2022, the ZTD combined estimates are available, on average, for 368 EPN stations (compared to the 355 in 2021). For each combined EPN station Integrated Water Vapour (IWV) is provided along with ZTD. Tropospheric products are disseminated in SINEX\_TRO v2.0 format and are available in the EUREF product directory at the BKG and BEV data centre. The EPN multi-year tropospheric solution (T2227) for the period 1996-September 2022, has been released as announced by the EUREF mail no. 11246.

## *Reference Frame Coordinator*

BY JULIETTE LEGRAND

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In 2022, three Reference Frame Solutions have been published (C2190 in April, C2205 in July, C2220 in October). This Reference Frame Product can be cited using the generic DOI <https://doi.org/10.24414/ROB-EUREF-CWWW>. And a DOI is also minted together with the release of a new solution. For example, the EPN Reference Frame solution C2220 has the DOI <https://doi.org/10.24414/ROB-EUREF-C2220>. The Reference Frame Product can be found on the EPN CB web site or ftp. The directory structure as well as the name of some files have been reorganized and the reference frame product can be found in <https://epncb.oma.be/ftp/product/referenceframe/> or on the ftp at <ftp://epncb.oma.be/pub/product/referenceframe/>. All the necessary information can be found at [http://epncb.oma.be/\\_productservices/coordinates/#product](http://epncb.oma.be/_productservices/coordinates/#product).

The latest solution with generic file names is available in the directory latest <https://epncb.oma.be/ftp/product/referenceframe/latest/>. In addition, archives of the published solutions can be found at <https://epncb.oma.be/ftp/product/referenceframe/> in the directories with the name of the solution, e.g. <https://epncb.oma.be/ftp/product/referenceframe/C2220> for the last solution published in 2022.

The last EPN reference frame solution C2220 provide the positions and velocities for 380 EPN stations. In order to evaluate the quality of these stations as reference stations, the “Tool for Reference Station Selection” is available and results are updated at each release of the Reference Frame Product: [https://epncb.oma.be/\\_productservices/ReferenceFrame/](https://epncb.oma.be/_productservices/ReferenceFrame/).



# The Working Groups

## WG on Dense Velocities

BY ELMAR BROCKMANN

Most of the existing velocity fields in Europe are already included in the data set of the Working Group on Dense Velocities. Totally, about 7900 individual station velocities are available for Europe.

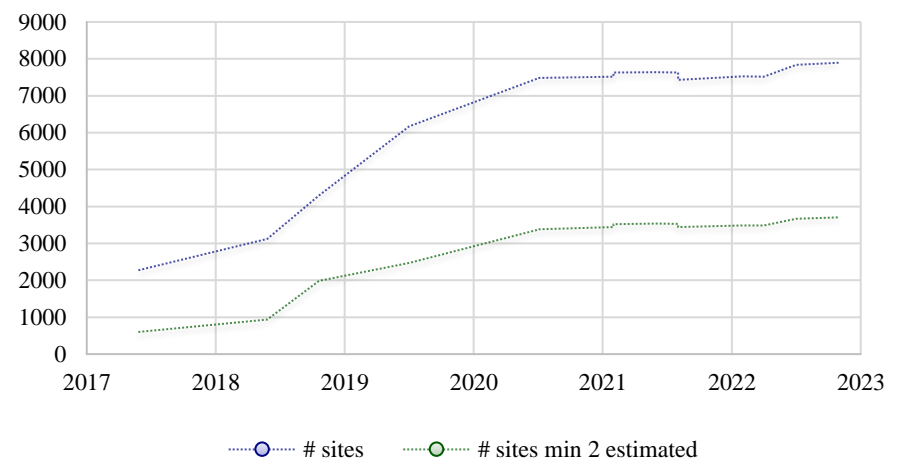
In 2022, several additional data sets were included, such as a dense velocity data set from INGV consisting of more than 2500 sites. As shown in the right figure, this big amount of stations did not increase the total number of stations, even not the number of stations which are already observed by two analysis centres. Additional solutions mainly improve the reliability of the velocity product.

Also, a campaign data set from Saudi Arabia or the velocities of ITRF2020 were included. The website of the project gives feedback to the providers and was moved from http to https: [https://pnac.swisstopo.admin.ch/divers/dens\\_vel/index.html](https://pnac.swisstopo.admin.ch/divers/dens_vel/index.html).

In parallel, an OGC working group met almost every 2 weeks in 2022 to work on standardizations on a deformation model which will be derived from this data set.

In the framework of an interdisciplinary project a student at ETH Zurich investigated several possibilities to fit a deformation model through the data using classical kriging methods, but also using machine learning algorithms.

Number of sites included in database of EG on Dense Velocities



## WG on EPN Densification

BY AMBRUS KENYERES

EPND activities are continued in 2022 and as the result of the annual update cycle a new combined multi-year position and velocity solution had been released in December. D2200 includes weekly combined solutions up to GPS week 2200 (early March 2022). The solution as first time was a simple update, adding one more year to D2150 without updating the earlier combined data. D2200 includes more than 2400 published stations, but further 1000 stations were retained due to quality concerns.

EPND data had been successfully applied in EUREF and EPOS velocity / strain rate products and also in the EGMS (European Ground Motion Service), where EPND was the primary component in the definition of the velocity reference for InSAR ground motion analysis. The next release will be D2237 including input solutions expressed in IGS14.

EPND is relying on 26 individual AC contributions, the work done by the single ACs are acknowledged and much appreciated!

## Multi-GNSS WG

BY ELMAR BROCKMANN

Multi-GNSS data processing in operational mode is standard. The majority of ACs are operationally using GPS, GLONASS, and Galileo data. BeiDou, especially BeiDou-3 processing, is not yet possible.

The change of the reference frame from IGB14 to IGS20 end of 2022 will keep the ACs busy till beginning 2023 because also various model changes are necessary. Some of the changes require to update to the newest analysis software tools. Analysis Centers using the Bernese software are asked to switch to the version 5.4, which was released in autumn 2022.

Almost all EPN stations deliver its data in RINEX 3, only few submissions of RINEX 2. In 2022, the RINEX 4 format version was confirmed by RTCM. The biggest changes occur for the RINEX navigation files. File naming is identical to RINEX 3 and the content of the observation files includes some minor changes. Therefore, the version change from 3 to 4 is not comparable with the version change from 2 to 3. Several vendors already implemented that new standard in their firmware versions. It is expected that in spring 2023 several EPN stations may provide their GNSS data in RINEX 4 and make them also available at the various data centers.

## WG on Reprocessing

BY CHRISTOF VÖLKSEN

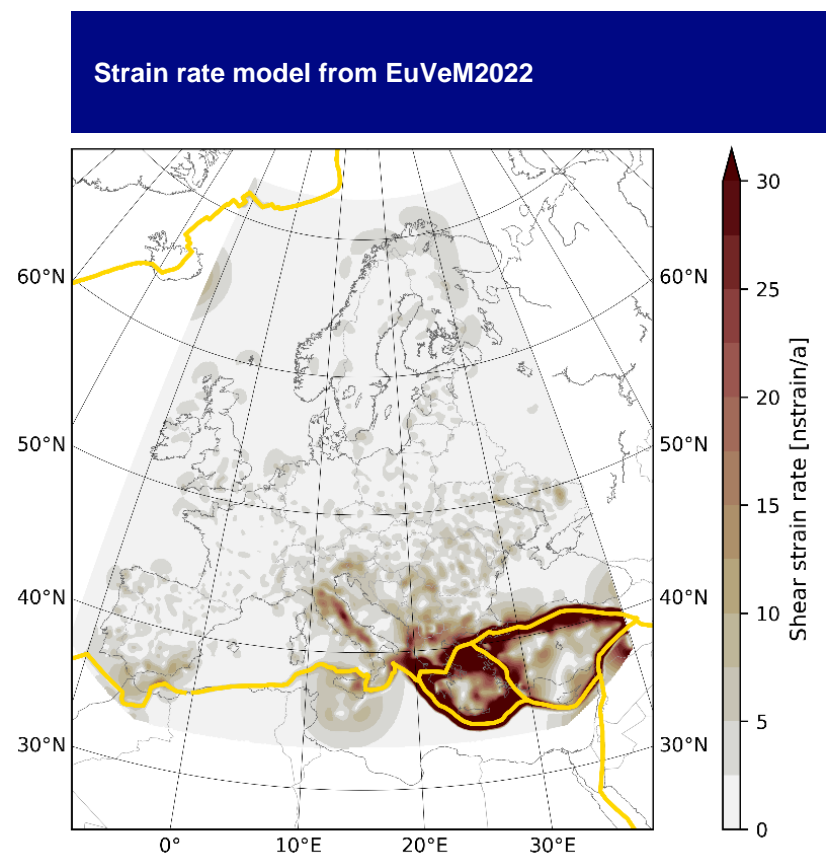
The EPN Reprocessing working group has been discussing the third reprocessing campaign of the entire EPN for quite some time. So far, small links in the chain have always been missing to actually start the work. Now that the change to the new realization of the ITRF has finally taken place, important foundations have been laid. Currently, data analysis strategies are being fine-tuned to ensure the best possible agreement between the IGS reprocessed and the upcoming EPN operational solutions. These tunings include the choice of antenna corrections models, the use of tropospheric mapping function, the treatment of atmospheric loading, and many other issues. Since only 12 ACs can participate in EPN reprocessing, the subnetworks had to be reordered to meet the important criterion that a single GNSS station is present in at least three subnetworks of the participating ACs. The GFZ as a new AC will participate with new software in the reprocessing as well as in the operational analysis of the EPN. At the moment a new version of the Berners software is being delivered, which will make work on EPN-Repro3 much easier, as many of the necessary standards have been implemented there. It is expected that the final tuning for the analysis of the data will be completed early next year. After some testing and comparison, the full evaluation can then begin. When the work will be completed cannot yet be conclusively predicted. After all, the data of more than 25 years must be analyzed.

## WG on Deformation Modeling

BY REBEKKA STEFFEN AND MARTIN LIDBERG

The WG on Deformation Modeling worked on a new deformation model based on the EPND2150 dataset, which was named EuVeM2022 (European Velocity Model 2022). Horizontal and vertical velocities were determined on a dense grid covering Europe using a modified least-squares collocation method, which was published in Journal of Geodesy in January 2022 (doi: [10.1007/s00190-022-01601-4](https://doi.org/10.1007/s00190-022-01601-4)). The horizontal gridded velocities have been used to obtain a strain rate map for Europe (see to the right). The velocity and strain rate models were presented at the REFAG2022 meeting in Thessaloniki (Greece) and will be made publicly available in early 2023 (depending on the status of the accompanying publication).

EuVeM2022 should be seen as a first version of a pan-european velocity model. So first step after its release will be to evaluate and compare to other data sets and models. A further version based on the data set from the WG Dence Velocities should also be considered.

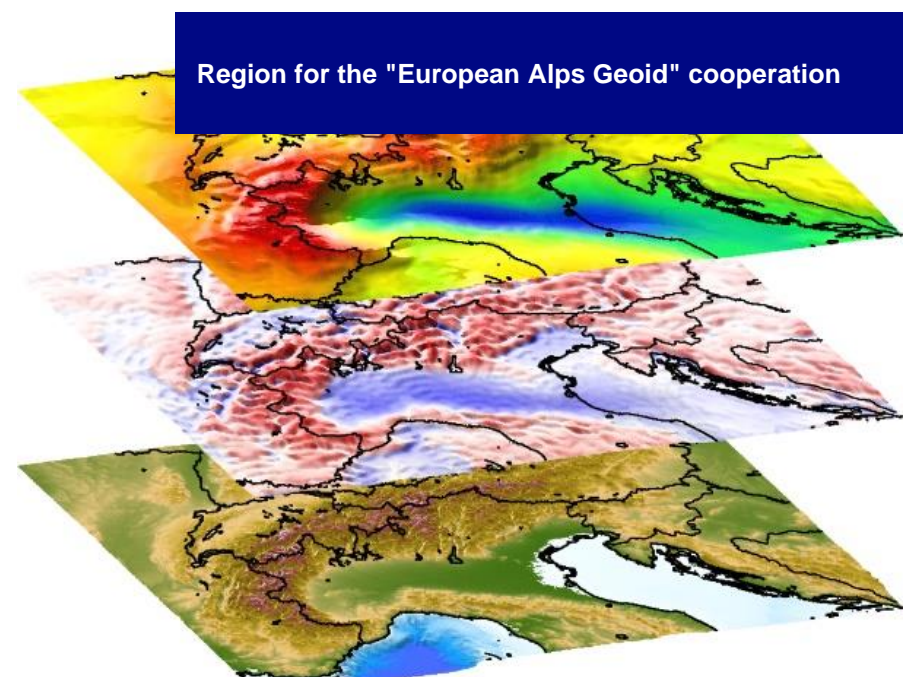


## Improved cross-border height determination in the European Alps – The "European Alps Geoid Project (EAlpG)"

BY JOACHIM SCHWABE

On September 29 and 30, 2022, delegates and geoid experts from the Alpine and neighboring countries convened in Vienna and online to bring forward the "European Alps Geoid" project. The hybrid meeting was hosted in Vienna, Austria, by the Federal Office of Metrology and Surveying (BEV). The "European Alps Geoid Project" (EAlpG) aims at harmonizing the basis for height determination in the German-speaking Alpine region, including the neighboring lowlands. This means that the "European Alps Geoid" also includes parts of Hungary, Slovakia and the Czech Republic. It is a joint initiative of the national bodies responsible for or involved in the integrated geodetic spatial reference:

- Federal Office of Metrology and Surveying (BEV, Austria)
- Federal Office of Topography (swisstopo, Switzerland)
- Federal Agency for Cartography and Geodesy (BKG, Germany)
- State Office for Geoinformation and Rural Development (LGL, Germany/Baden-Wuerttemberg)
- Agency for Digitisation, High-Speed Internet and Surveying (LDBV, Germany/Bavaria)
- National Institute of Geographic and Forest Information (IGN, France)
- Politecnico di Milano (Polimi, Italy)
- Cadastre of South Tyrol (Italy)
- Surveying and Mapping Authority (SMA, Slovenia)
- Geodetic and Cartographic Institute Bratislava (GKÚ, Slovak Republic)
- Slovak University of Technology in Bratislava (STU, Slovak Republic)
- Comenius University Bratislava (Slovak Republic)
- Slovak Academy of Sciences (SAS, Slovak Republic)
- Space Geodetic Observatory (SGO) c/o Lechner (LTK, Hungary)
- Land Survey Office (ZÚ, Czech Republic)



The EAlpG group is complemented by associated members from the scientific community:

- Graz University of Technology (TU Graz, Austria)
- Technical University of Munich (TUM, Germany)
- University of Ljubljana (Slovenia)

The Memorandum of Understanding was concluded on May 12, 2022, with the goal to promote the cooperation in the field of regional gravity field modeling, to exchange and improve the underlying data and models, and to facilitate cross-border height determination for users of geodetic coordinates. To this end, the following activities are planned:

#### Improved cross-border regional geoid model of the Alpine area

- Exchange and revision of the base data for the calculation of the geoid models: gravity data, digital elevation models, control points for validation
- Comparative studies on geoid modeling in high mountains

#### Improved height transformation between the Alpine countries

- Extensive comparative investigations and validation between the national height reference surfaces (geoid models and other height transformation grids) and the national and European heights along the borders
- Derivation of a consistent height transformation model accurate to a few centimeters
- Development of a corresponding web application

These works can build on the first experiences and findings gained within the previous “D-A-CH geoid” project, covering a test area around Lake Constance. It was a joint initiative of the federal and state authorities responsible for land surveying in Germany, Austria and Switzerland (BEV, swisstopo, BKG, LGL and LDBV). Achievements of this phase were presented at EGU2021 (Schwabe et al. 2021, <https://doi.org/10.5194/egusphere-egu21-7567>).

The activities are embedded in a pan-European initiative for a European Height Reference Surface within the framework of EUREF, the scientific sub-commission for Europe within the IAG. As a contribution to the EUREF Working Group “European Unified Height Reference”, the EAlpG will be one of many cornerstones for the first official realization of a unified European height reference surface connected to EVRS and ETRS89. The metadata about the national height reference frames and transformation products will also be used to modernize the information system for the European coordinate reference systems CRS-EU (<http://www.crs-geo.eu>). Another synergy arises from the fact that some of the new EAlpG members are also involved in the geophysical project AlpArray, providing a modernized Bouguer gravity map of the Alpine region (Zahorec et al. 2021, <https://doi.org/10.5194/essd-13-2165-2021>).

The meeting included status reports on development of the United European Leveling Network (UEN) as well as the national geodetic base data relevant for gravity, geoid and height determination. Ideas for joint geodetic fieldwork, e.g. to improve cross-border leveling connections or to create a local high-mountain test bed for geoid modelling, were discussed. Finally, special aspects of geoid modeling and validation were discussed in detail. More information can be found on the provisional website:

[https://bkg.bund.de/EN/About-BKG/Geodesy/Information-systems-and-Projects/EN\\_DACH\\_EAlpG\\_Details.html](https://bkg.bund.de/EN/About-BKG/Geodesy/Information-systems-and-Projects/EN_DACH_EAlpG_Details.html)