Abstracts EUREF 2023

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Opening session

Session: Opening Session

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Title

UN-GGCE: The New UN-Entity for Geodesy

In March the United Nations Global Geodetic Centre of Excellence (UN-GGCE) has been officially opened at the UN Campus in Bonn, Germany. The Centre's overarching goal is to assist Member States and geodetic organizations to coordinate and collaborate to enhance, access and utilize an accurate, accessible and sustainable Global Geodetic Reference Frame (GGRF) for science, society and global development. The objectives are to support within available resources the implementation of the United Nations General Assembly resolution 69/266 through strengthening and advancing: global geodetic cooperation and coordination; worldwide geodetic infrastructure; standards, policies and conventions; education, training and capacity building; and communication and awareness. An International Advisory Committee with representatives from the Member States, geodetic organisations and other geodetic stakeholders will provide the necessary guidance and advice for the operative programme of work of the Centre.

With this presentation we offer a closer look at the structure, purpose, mission, goal, expectation and the current status of the new UN-organisation advocating the global geodesy.

Session: Opening Session

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Title

Goals and Activities of the EUREF Governing Board

Abstract

The IAG Sub-commission 1.3a EUREF is a joint effort of research organizations and National Mapping and Cartographic Agencies. Its main goal is the definition, realization and maintenance of the European Reference Frames (realizations of ETRS89 and EVRS). The EUREF key infrastructures are the EPN (EUREF Permanent Network) and the UELN (United European Levelling Network). The EUREF activities are coordinated by the EUREF Governing Board (GB). The GB meets two or three times a year. Since the last EUREF symposium 2022 the GB had some digital meetings but also one hybrid meeting in March 2023. The main activities and progress within this period are outlined in this presentation. More details about EUREF can be found at http://www.euref.eu/.

Session 1 - Systems: ETRS89, EVRS, Geoid and related models

Session 1 - Systems: ETRS89, EVRS, Geoid and Related Models

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United Nations Working Group on Geodetic Reference Frames in Europe

The Global Geodetic Reference Frame (GGRF) is defined as the authoritative, reliable, high accuracy and global spatial referencing infrastructure. It includes the celestial and terrestrial reference frame products, the infrastructure used to create it, and the data, analysis and product generation systems. The GGRF also includes gravimetric observations, products and height systems, which underpin measurements of elevation. The Subcommittee on Geodesy of the United Nations Committee of Experts on Global Geospatial Information Management (UN GGIM) describes the GGRF as the foundation for evidence-based policies, decisions and program delivery. The GGRF underpins the collection and management of nationally integrated geospatial information and is used to monitor our dynamic Earth. It is relied upon for social, environmental and economic initiatives, Earth science, the measuring and monitoring of progress of the 2030 Agenda for Sustainable Development, the Sendai Framework for Disaster Risk Reduction, the Small Island Developing States Accelerated Modalities of Action (SAMOA) Pathway, and other global, regional and national development agenda and initiatives.

To support the working plans of both the Subcommittee on Geodesy (SCoG) and the recently established UN Global Geodetic Centre of Excellence (GGCE), several actions are planned to be undertaken by working groups of the Subcommittee on Geodesy, supported by regional working groups and other scientific organisations as the IAG and FIG. In this presentation, the roadmap of the European regional working group 'Geodetic Reference Frames - Europe' (GRF-Europe) and its importance for the outcomes of the working plans of the SCoG and the GGCE is clarified.

Session: 1

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Status report about the European Vertical Reference Frame

Abstract

After the release of EVRF2019, the new European heights could be used in the scope of the Working Group "European Unified Height Reference". The GNSS/leveling data of some countries have been improved significantly.

In the meantime, some additional data for the United European Leveling Network (UELN) came in.

France computed a reprocessing of the leveling data of IGN69 and delivered the results including all line points to the UELN data center. This data enables us to combine the IGN69 lines more closely with the NIREF lines and to establish additional connections to neighboring countries. The reprocessed IGN69 data has a higher accuracy than the old data which was part of EVRF2019. Furthermore, the French colleagues have observed some new border connections to neighboring countries and will continue to do so in the next years.

From the full leveling data set of Austria, some additional border connections to Czech Republic, Germany, Hungary and Switzerland can be used. With the new data of France and the additional border connections to Austria, a new preliminary realization of EVRS has been computed.

Moldova completed the measurements in its National Leveling network in 2021 and has started to prepare this data for the integration in the UELN. The measured height differences are already available at the UELN data center and could be used for first test computations. The preparation of the gravity data is still ongoing.

Session: 1

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Status report for the EUREF Working Group "European Unified Height Reference"

Abstract

ETRS89 has become the common standard for harmonized horizontal coordinates in the European countries. In contrast, the national height networks are still determined by leveling with respect to different tide gauges and standards (height types, tide systems). The differences in the definitions cause height discrepancies up to a few decimeters along the borders. National geoid models are defined accordingly.

Nowadays, GNSS-based height determination is widely used, which also increases the demand for geoid models as a height reference across borders. For large parts of the continent, the United European Leveling Network (UELN) provides harmonized heights based on the standards of the EVRS. However, EUREF has yet to adopt a corresponding height reference surface officially.

Thus, the EUREF Working Group "Unified European Height Reference" was formed by resolution in 2021 with the objective to enhance the usability of European heights for practical applications such as civil engineering, digital elevation models, etc. The main goal is to establish a European Height Reference Surface (EHRS) which is tailored to a consistent dataset of GNSS-leveling control points (EHRS_CP) referring to the latest ETRS89 and EVRS realizations.

Furthermore, comprehensive information about the national integrated spatial reference systems, including heights and geoid models, shall be made available through the Information and Service System for European Coordinate Reference Systems (CRS-EU).

The presentation will provide a status report for the past year. Focus will be given on the GNSS-leveling control points where substantial progress has been made. Preliminary comparisons with regional geoid models and first interpolation tests of a corrector surface demonstrate the improved accuracy and homogeneity of the datasets compared to the previous EUVN-DA dataset. In this context, current regional geoid projects such as the Baltic Sea Chart Datum 2000 and European Alps Geoid will be acknowledged. Furthermore, through this initiative, leveling data for a number of countries could be updated or even be added for the first time in the UELN. This will contribute to a new EVRS realization in the years ahead (see the related presentation by M. Sacher), which also shall eventually serve as a basis for the final GNSS-leveling dataset and the first release of the European Height Reference Surface.

Keywords: geoid, height, vertical reference, GNSS/leveling, EVRS

EUREF 2023 Symposium
23-26 May 2023, Gothenburg, Sweden

Session: Systems: ETRS89, EVRS, Geoid and Related Models

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Title:

Reference Frame Coordination Status Report

Abstract

The primary purpose of the EPN (EUREF Permanent GNSS Network) multi-year coordinate & velocity solution is to provide access to the European Terrestrial Reference System 89 (ETRS89) which is the standard precise GNSS coordinate system throughout Europe.

The EPN multi-year solution densifies the IGS14 realization of the ITRS in Europe. It is based on daily solutions coming from the EPN-repro2 completed by operational EPN solutions. It is computed with the CATREF software (Altamimi et al., 2007) and is expressed also in ETRF2000 and ETRF2014.

The presentation will present the latest updates and recent developments.

Session: Session 1: Systems: ETRS89, EVRS, Geoid and Related Models

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ETRF2020: a realization of the ETRS89

By definition, the European Terrestrial Reference System 89 (ETRS89) is intimately linked to the International Terrestrial Reference System (ITRS) through a 14-parameter similarity transformation formula which involves the three components of the rotation pole of the Eurasia tectonic plate and satisfies the condition that ETRS89 coincides with the ITRS at epoch 1989.0. Consequently, it becomes straightforward to derive the transformation formula allowing to derive an ETRF2020 from ITRF2020, once the ITRF2020 Plate Motion Model (PMM) is avaiblable. After a brief description of the ITRF2020 PMM and main results, the paper will present the main features of ETRF2020 and its relationship to ITRF2020. In particular, an accuracy assessment will be discussed for both the Eurasia rotation pole as well as the origin stability. Moreover, station position and velocity changes between ETRF2020 and past ETRF frames will be evaluated and discussed.

Session: ETRS89

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Test of global alignment of regional GNSS solutions

The datum of a regional GNSS solution is traditionally defined regionally, using a subset of the GNSS stations included in the solution. This approach has advantages as well as disadvantages compared to having the datum defined globally. One advantage of a regional datum definition is that regional effects such as geophysical loading impact the solution less. One disadvantage is, however, that the results for the stations located on the edge of the GNSS network are less accurate. This is especially true if those stations are located far from the stations used for the datum definition. To avoid the edge effects, one would have to apply a global datum, which requires that the solution includes data from many globally distributed GNSS stations, thus increasing the computational burden significantly.

One possible method for extending a regional GNSS solution to a global one, without needing to include additional stations in the processing, is to combine it with an already existing global solution. In this work we have tested this idea, called global alignment, by combining the NKG solution for the EPN with a global solution, using the CATREF software. Different aspects of the combination procedure and the solution are discussed. We show that the method works fine and that the accuracy of the obtained station coordinates is similar to that of the global solution.

Session 2- Networks: EPN, UELN, Densification

Session: 2

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Title

Report of the EPN Analysis Centres Coordinator. The switch from the IGb14 to IGS20 reference frame in EPN analysis.

Abstract

The EPN Analysis Centres Coordinator (ACC) combines and analyses GNSS coordinate solutions provided by the 17 EPN Analysis Centres (AC). The combined solutions created by ACC are used for the creation of the EPN cumulative solution, and also serve for rapid EPN station position monitoring.

In the presentation we will focus on the recent switch from the IGb14 to IGS20 reference frame in EPN analysis. We will describe the processing strategy according to new standards and present the status of EPN analysis centres and combined solutions. We will also present a new EPN analysis centre.

Session: Networks: EPN, UELN, Densification

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Status of the EUREF Permanent Network

Abstract

The EUREF Permanent Network (EPN) provides the GNSS reference stations to access the European Terrestrial Reference Frame. For the user, it is important to know at each epoch, which EPN stations perform according to expectations so that they can be effectively used as reference station during the data analysis. For that reason, the EPN Central Bureau (CB) is operationally monitoring EPN station performance in terms of data availability, correctness of metadata, and data quality. In addition, to improve its support to EPN reprocessing activities, the EPN CB revisited its historical EPN data center (HDC) containing the most complete data archive of daily RINEX data of the EPN stations. The HDC also makes EPN data discoverable to the European Plate Observing System (EPOS). This presentation describes the present status of the EUREF Permanent Network and HDC, concentrating on the major changes since the EUREF Symposium of 2022.

Session: Session 2 - Networks: EPN, UELN, Densification

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Title: EPN-Repro3: Activities of the working group on EPN reprocessing

Abstract

The EPN Reprocessing Working Group has taken on a major task following the launch of the new ITRF2020 and the release of IGS20. The aim is to reprocess all GNSS data accumulated in the EPN from 1996 until the end of 2022. This will be done using the latest standards used in GNSS analysis and will base on the reprocessed orbits and Earth rotation parameters, and in the case of Precise Point Positioning, also the precise satellite clocks as they have been estimated during the IGS repro3 campaign.

As things stand, 12 of the 16 EPN Analysis Centres will participate in this task. Each AC will work on a subnetwork of the EPN, which will then be combined into an overall EPN network. The main objective of this analysis is to be almost fully consistent with the operational analysis as it has started after the introduction of the IGS20 in GPS-Week 2238 in the end of November 2022.

In recent months, important decisions have been made about the strategy and standards for the data analysis of the GNSS data. To name just a few examples, these include tropospheric mapping functions to be used, antenna correction models for the satellite and receiver antennas and, for example, ocean loading correction models. This strategy for the EPN-Repro3 campaign was jointly coordinated with the strategy for operational GNSS analysis of the EPN. The presentation will briefly outline different aspects and present the current status.

Session: session 2

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Title

EPN Densification – D2237, the last igs14-based combination

Abstract

EPN Densification, the integration of pratically all European CORS networks on the product level is successfully running for more than a decade. The multi-year position and velocity product is updated annually and published on the https://epnd.sgo-penc.hu web portal. The last solution was published in November 2022. D2200 includes weekly AC inputs up to March 2022.

Now we arrived to a milestone as since GPS week 2238 (November 2022) the GNSS analysis changed the underlying reference frame and GNSS PCV models from IGS14 to IGS2020 and we update Bernese 5.2 to 5.4 which also bringings some modeling updates. Therefore the coming D2237 densification solution will be the last igs14-based combination. The results of D2237 will be presented and also some intercomparison with other existing solutions will be shown.

We note here that part of this solution (before GPS week 1934) included converted only inputs, where the igs08.atx based solutions were converted to igs14 on the SINEX level. Due to the complex changes in modeling and software repro3 cannot be avoided. The presentation will also call the attention to all ACs to plan and perform repro3 not only on the EPN level.

Session:

Session 2 - Networks: EPN, UELN, Densification

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DSO contribution to EUREF Densification and a dense velocity field for Greece.

In the last decade a platform has been developed to enable automatic processing of all available GNSS data in the region of Greece via Bernese GNSS software v.5.2. The processing scheme is carried out in two stages, the first concerns the immediate processing of the data one day after its recording, while the second concerns the reprocessing of the data 15 days after its recording, where the final solution of the network is produced as well as the final products of the analysis (estimated coordinates, ZPD, TEC maps, SINEX files). All useful results and products are stored and archived with the aim of their further use. Daily SINEX files are made available to EPN Densification.

For all the stations with available data greater than 2.5 years, position time series analysis was carried out by estimating various parameters such as discontinuities, linear trend, seasonal signals and post-seismic deformation. A dense velocity field was estimated and different kinematic models were investigated with the aim of better representing the kinematic behavior of the earth's crust in the area. Special emphasis was placed on areas with specific kinematic behavior, such as the Corinth Gulf, where the networks of permanent GNSS stations are denser compared to the established stations in the rest of the country. This makes it an ideal location for investigating crustal deformation.

Session: 2

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Title

SWEPOS™ 30 years of CORS operation

Abstract

SWEPOS™, the Swedish network of permanent reference stations for GNSS is celebrating

30 years of CORS operation. SWEPOS has been in operation since 1993 and is operated by Lantmäteriet, the National Mapping, Cadastral and Land Registration Authority in Sweden. Today (april 2023) the SWEPOS network consists of 479 permanent reference stations.

In 1993 the SWEPOS network consisted of 20 CORS stations providing RINEX data for postprocessing. A DGPS service was established based on some of the stations, the corrections were distributed via the FM radio RDS channel.

The SWEPOS Network-RTK service was established in 2004 covering the most populated areas of Sweden and during 2009 it became a national service covering the whole country with interstation distances of 70 km. Today the SWEPOS Network-RTK service provides GNSS corrections to more than 10000 subscribers. Together with the real-time services SWEPOS provides an easy access to the national reference frame SWEREF99 and provides RINEX data for post-processing, water vapor calculations and other scientific studies.

To meet the demands from the users for improved accuracy and redundancy, a decision was taken in 2010 to densify the network to 35 km interstation distances and in some areas down to 10-15 km in cooperation with the Swedish Transport Administration for infrastructure projects.

The presentation will cover topics regarding the status for SWEPOS today

Session: 2 - Networks: EPN, UELN, Densification

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Combining normal equations based on IGS20 or IGb14 standards and models: impact on the cumulative time series.

Abstract

Starting GPSW 2238 (2022/11/27), the IGS20 is introduced by the IGS as the new reference frame for its products. In addition to the datum switch, other conventions are implemented, such as:

- New antenna PCV file: igs20.atx
- Long filenames for IGS products

Focusing on the EUREF activities, the major goal of the EPN (EUREF Permanent Network) is to regularly align its solutions to the IGS and, therefore, the standards to compute the EPN operational solutions must tightly follow the IGS20 standards and recommendations. To achieve this target, the EPN will be computed considering the following changes:

- Do not use absolute individual calibration files. Only the antenna/radome pairs maintained by the EPNCB.
- No atmospheric loading
- Correct PCVs of antennas that are misaligned from North

Some of the models are updated:

- A priori troposphere: from VMF1 to VMF3,
- New/improved models: DESAI2016 (subdaily ERP),….

EPN will be recomputed using the new IGS20 standards (repro3 campaign). In this presentation, we show some time series of different EPN and EPND sites and we discuss the need for a repro3 for the EPND solutions.

Session: 2 Networks: EPN, UELN, Densification

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Title:

EPN Tropospheric Products

Abstract

In addition to station coordinates, the EPN ACs submit ZTDs and horizontal gradients on a routine basis. These ZTDs are used to generate the combined EPN troposphere solution containing the combined troposphere estimates with an hourly sampling rate. The coordinates, as a necessary part of this file, are taken from the EPN weekly combined SINEX file. Hence, stations without estimated coordinates in the weekly SINEX file are not included in the combined troposphere solution. The agreement among the AC solutions is evaluated in terms of weekly mean bias and standard deviation. Starting from GPS week 2139, IWV has been added in the EPN combined product. The last EPN multi-year tropospheric cumulative solutions (TC2227) has been released in November 2022. For each EPN station, plots of ZTD time series, ZTD monthly mean and comparison with respect to radiosonde data (if collocated) are available at the EPN CB. This presentation will report on the status of the EPN operational Troposphere Products.

Session 3 - Techniques: GNSS, Levelling, Combination

Session: 3 - Techniques: GNSS, Levelling, Combination

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Title:

New Optimisation method for Transformation parameters problem between WGS84 and Nord- Sahara Geodetic frames.

Abstract

Nowadays, mathematical algebraic methods give closed form solutions of geodetic transformations problem, which require high-level computer programming background. In everyday usage, the closed form solutions are much simple and have a higher precision than earlier procedures. Thus, it can be predicted that these new solutions will find their place in the practice. The present work deals with an important theoretical problem of geodesy: we are looking for a mathematical dependency between two spatial systems using common pairs of points whose coordinates are given in both systems. In geodesy and photogrammetry the most often used procedure to move from one coordinates system to the other, is the 3D, 7 parameters (Bursa Wolf, Molodensky-Badekas, and Helmert) similarity transformation. The paper discusses various methods used for estimation of the usual transformation parameters with taking in count some assumptions mentioned in the first paragraph to circumvent the problem of non-linearity of transformation functions. It is important to compare solutions based on seven parameters with those based on interpolation of data in planimetric and Altimetric Grid using B-spline model, Conjugated Gradient and even Jacobi method in case of non linear models (Levenberg Marquardt). This numerical task would be solved either by using iteration technics by applying the cited 3D models, or even by 2D formalism such as Multiple Regression Equation MRE's or Geodetic Lines method. In recent GPS/GNSS hybrid receivers, are implemented these algorithms in their systems to achieve a quick data processing like was implemented the Kalman Filter in the advent of this technic.

Session: 3 - Techniques: GNSS, Levelling, Combination

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A Comparative Performance Assessment of Galileo and GPS Satellite Clocks

Abstract

Galileo's system design is promising enhanced performance compared to other Global Navigation Satellite Systems (GNSS). Several studies have already demonstrated the good performance of Galileo. One key component of Galileo's superiority is the performance of the atomic frequency standards (AFS) used onboard the satellites. In this study we analyzed the performance of the Galileo AFSs in comparison to GPS. We performed a quantitative analysis based on the offset and the drift of the satellite clocks as well as their stability, which is assessed by means of the Allan deviation. Moreover, in our analysis we distinguished between the different types of AFSs (Rubidium, Cesium, H-maser) and the different satellite blocks. Our analysis showed that there is a significant difference in the AFS performance among Galileo and GPS, as well as among GPS satellites of different blocks. Generally speaking, the GPS clocks exhibit smaller drifts and offsets, whereas Galileo clocks are characterized by a better short-term stability, which is vital for advanced applications like high-rate Precise Point Positioning (PPP).

Keywords: GPS, Galileo, Clock stability, Rubidium, Cesium, H-maser, Allan deviation.

EUREF 2023 Symposium
23-26 May 2023, Gothenburg, Sweden

Session: 3

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A test of the Galileo's High Accuracy Service orbit, clock and carrier phase corrections

The Kinematic Real Time approach (RTK) is currently used to achieve a precision navigation where two receiving antennas are needed: the receiver antenna and the antenna of a ground station with known position. By means of the double differences technique it is possible to eliminate the common errors to both receiving antennas, obtaining a position with accuracy of the order of the centimetre. This method is widely used in many areas thanks to the precision it allows to obtain but it has aspects that can be problematic: a dense network of ground stations is needed to transmit the observations in the network, with the consequent possibility of network interruptions that do not allow to use this technique; moreover, this approach is complex and expensive.

In order to overcome these problems, the Precise Point Positioning (PPP) technique has been introduced, which allows to obtain an accuracy comparable to the RTK method but which has some advantages: there are ground stations that generate and transmit SSR (State Space Representation) corrections to satellites; subsequently the satellites retransmit these parameters to the ground receivers, which may be applied to the parameters calculated by the navigation messages obtained by the satellites themselves. In this way, a sharing network is no longer necessary, as the receivers directly obtain the information from the satellites themselves; the whole process is simpler and less expensive, and the receivers are independent of the network.

The objective of the following study is to assess the precision positioning service "High Accuracy Service (HAS)" provided by the Galileo constellation, which is based on the PPP approach described above. The following paper focuses on orbital, satellite clock and phase corrections for the Galileo and GPS constellations. The evaluation of the possible improvement on the position of a receiver, obtainable thanks to the HAS corrections, was obtained thanks to the Bernese GNSS Software v.5.4, through which it was possible to determine the position of the STONEX receiver of the CISAS in Padua; for the evaluation of the position and clock corrections of the satellites it was necessary to replace in the SP3 files the positions and the clock drifts of the Galileo and GPS satellites, with the same quantities obtained through the broadcast ephemeris (BRDM) corrected with HAS; for the evaluation of phase corrections, the RINEX observation files have been modified by applying the phase corrections. The evaluation was carried out for the HAS corrections available between day 187 and day 232 of 2022 (from 06/07/2022 to 20/08/2022).

Analysing the results obtained, we came to the following conclusion: the orbital and clock HAS corrections allowed to determine the position of the Padua station with decimetre accuracy, which makes promising HAS for real-time precision navigation. Regarding the HAS phase corrections, the evaluation

carried out has led to affirm that in the period under analysis the corrections have led to a worsening of the accuracy in the positioning of the Padua station.

Session: Session 2 (Networks: EPN, UELN, Densification)

Alternative: Session 3 (GNSS, levelling, Combination)

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Comparing GNSS receiver antenna patterns: methods and metrics

High-precision positioning applications and the generation of reliable reference frames require the use of GNSS receiver antenna calibration sets, so-called Phase Centre Corrections (PCC). Currently, two methods are used to calibrate receiver antennas for the ground segment, namely the chamber and the field-robot approach. Since for identical receiver antennas PCC differences of up ±6 mm exist, a sound comparison strategy is necessary as well as an assessment of the PCC impact on the parameter domain.

To address this issue, we propose a concept that employs scalar and graphical quality metrics to identify similarities of pattern differences in receiver PCCs. We used a set of 25 Leica AR25.R3 antennas from the European Permanent Network (EPN) for which both robot (Geo++ company) and chamber calibrations (University of Bonn) are available. Using newly developed scalar metrics, we successfully separated this set into seven groups with different PCC behaviour. We also applied singular value decomposition (SVD) to the whole pattern and PCC differences (dPCCs) to gain insights into their main structure and dependencies in elevation and azimuth. We found that the structure of PCCs, the local satellite distribution, and the processing parameters significantly affect the estimated parameters. Additionally, the impact of PCCs on geodetic results such as station coordinates, zenith wet delays (ZWDs), and receiver clock estimates varied depending on the deviation of dPCCs in the up-component. We used the precise point positioning (PPP) approach to analyse the effects on parameters and residuals, and found that the consistency of the reference point between code and phase observation is crucial for the size of the impact.

One main concern of GNSS station and network operators is the comparability of calibration facilities and their results, as this can affect the realization of reference frames . As such, under the umbrella of the International GNSS Service (IGS), calibration institutions have agreed to participate in an international ring calibration campaign. We will also present its objectives and current status in this contribution.

Session: Session 3 - Techniques: GNSS, Levelling, Combination

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Title:

An update of GFZ's contribution to EUREF

GFZ is preparing to become a EUREF Analysis Center. In cooperation with the analysis coordinator, an EPN subnetwork of about 94 stations was selected. As a mandatory contribution, we aim for weekly coordinate solutions computed and submitted to the EUREF. The new solutions are derived using GFZ's processing software EPOS.P8. This presentation discusses GFZ's new contribution to EUREF, especially the first test solutions. The first part will present the aspects of the station selection, parametrization, processing scheme, and used products. The second part focuses on the results by discussing station coordinates, troposphere delays, and gradients from the first solutions.

Keywords: GNSS, station coordinates, troposphere delay and gradients

Session: session 2

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Title

INGRIM: Modernization of the Height Reference Network using Satellite Technologies

Abstract

The classical approach of the realization and maintenance of the levelling reference networks is a time consuming and costly process. In Hungary the last national scale re-levelling has happened almost 4 decades ago and the chances of a new campaign are limited.

Building on the opportunities offered by space-borne technologies as GNSS and InSAR we proposed a new approach to build a new generation of primary height reference benchmarks and in connection to this a new national scale semi-kinematic, digital height reference model is offered.

There are two key elements of this infrastructure. The primary height reference benchmarks are integrated markers, where a CORS station and a double (acending-descending) InSAR corner reflector are installed. This benchmark is the same as the one designed by the Delft-group (IGRS by R Hanssen, Hvd Marel) shown in the EUREF2018 symposium tutorial. The other key element is the digital height reference, which is a combined gravimetric+GNSS/levelling geoid attributed with the time dependent ground deformation model coming from national scale InSAR analysis.

To prove the capability of the above idea a pilot project had been designed and supported by ESA NAVISP programme – the project name is INGRIM. We installed 7 IGRS-type station in the Central-Southern part of Hungary and the generation of all databases are in progress. Early next year the pilot solution should be available including a digital database may installed in RTK equipments to use for height determination.

Session 3: Techniques: GNSS, Levelling, Combination

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GNSS InSAR collocation in Slovakia (Building up of the National InSAR reflecting network)

Abstract

InSAR method was recognized as a new geodetic technique in Slovakia. Geodetic and Cartographic Institute Bratislava as a geodetic controls administrator has decided to build up a special network under the development name „National InSAR reflecting network“ in field to exploit the full potential of the method. The network is under construction now and in 2023 consist of 11 collocation sites with GNSS permanent stations. Benefit of the GNSS InSAR collocation is the possibility to help referencing of the InSAR images direct to the geodetic reference system ETRS89. Design of the network and all works are done in cooperation with InSAR experts from the Slovak university of Technology in Bratislava responsible for the processing. Results will be used in future for vertical movement monitoring of whole Slovakia and will partly replace levelling technique.

Session: 5. Applications: Earth Sciences, Geo-Information (?)

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Ahmed Adam Gido, Nureldin
Puwakpitiya Gedara, Chrishan
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Title:

Active and passive radar corner reflectors co-located with permanent GNSS stations in Sweden: installation and performance

Abstract

Lantmäteriet, the Swedish mapping, cadastral and land registration authority, started in 2020 to complement the national geodetic infrastrukture with installations of active and passive radar corner reflectors, co-located with permanent GNSS stations. Among others, these co-located corner reflectors can potentially contribute to the development of the national and European ground motion services in future updates. Moreover, the co-location helps to transform the relative ground motions estimated with InSAR to an absolute geodetic reference frame. In this presentation we share some experinces gained from this work, so far.

Session: Networks: EPN, UELN, Densification

Or

Session: Techniques: GNSS, Levelling, Combination

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Title**:**

Monitoring and Detection of GNSS Interference Using the Swedish CORS Network SWEPOS

Abstract

This work discusses the growing concern of GNSS signal interference, which poses a significant threat to GNSS technology and related infrastructures. The focus is on how the Swedish CORS network SWEPOS, with over 500 stations, can be utilized to control and monitor GNSS signal quality. An automated system has been designed for detecting GNSS interference, leveraging the SWEPOS network. This system can monitor all GNSS frequency bands, including GPS, GLONASS, Galileo, and Beidou. The system detects Radio Frequency (RF) interference by analyzing the Signal-to-Noise Ratio (SNR) of a tracked GNSS signal, comparing it to historical data.

The system uses statistical analysis to assess the SNR of multiple satellites simultaneously to identify RF interference. It can differentiate between RF and non-RF interference based on the SNR characteristics of satellites. The system has been successfully tested using both simulated interference and real interference events. In conclusion, the proposed system provides a practical solution to the issue of GNSS signal interference. The utilization of the SWEPOS network and statistical analysis enables the accurate detection and classification of interference sources. This facilitates the identification and resolution of interference issues in near real-time.

Session: 3

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Title:

The GeoMetre project: large-scale dimensional measurements for geodesy

Abstract

We provide a survey on the joint European research project “GeoMetre”, which explores novel technologies and their inclusion to existing surveying strategies to improve the traceability of geodetic reference frames to the SI definition of the metre. This work includes the development of novel distance meters with a range of up to 5 km, the realisation of optical multilateration systems for large structure monitoring at an operation distance of 50 m and beyond, and a novel strategy for GNSS-based distance determination. Different methods for refractivity compensation, based on classical sensors, on dispersion, on spectroscopic thermometry, and on the speed of sound to reduce the meteorological uncertainties in precise distance measurements, are developed further and characterised. These systems are validated at and applied to the novel European standard baseline EURO5000 at the Pieniny Kippen Belt, Poland, which was completely refurbished and intensely studied in this project. We use our novel instruments for a reduced uncertainty of the scale in the surveillance networks solutions for local tie measurements at space-geodetic co-location stations. We also investigate novel approaches like close-range photogrammetry to reference point determination of space-geodetic telescopes. Finally, we also investigate the inclusion of the local gravity field to consider the deviations of the vertical in the data analysis and to reduce the uncertainty of coordinate transformations in this complex problem.

Session 4 – National reports

Session: ***Systems: ETRS89, EVRS, Geoid and Related Models.***

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Title :

Albania: NEW GEODETIC REFERENCE FRAME OF ALBANIA

Abstract.

PREVIOUS SITUATION OF GEODETIC REFERENCE FRAME

The old official coordinate reference system in Albania is called ALB86. This reference include the horizontal reference system (triangulation network) and vertical reference system (levelling network).

The triangulation network consists of 3 orders where the 1st order network consists of 159 points and 2nd and 3rd order network consists of about 1813 points. This network was measured during 1975-1985 and today the most of the triangulation points are damaged due to various constructions.

The Leveling network consist of 3 orders whare the 1st order network consists of 4 loops with a 400-500 km perimeter each. The average distance between benchmarks is 2-5 km (many of the benchmarks have been lost and damaged today). This network was measured during 1970-1985 without gravimetric measurements and measurements were only corrected for normal gravity. Also the leveling network was connected to the tide gauge located in Durrës port which had measured the MSL of the Adriatic Sea from 1958 to 1977 and was later damaged due to the construction of the port of Durres.

During 2007 and 2008 in Albania are performed a GNSS campaign on around 150 points from the existing datum in order to establish a mathematical connection between the old existing Datum (ALB86) to the new European one such as ETRS89. Due to this work did not support all Geodetic activities in Albania, in 2013 is created the National Authority for Geospatial Information (hereinafter ASIG) with the main mission to establish NSDI in Albania. ASIG activities are based on law no. 72/2012 which are to implement and creation: the national policy for Geospatial Information Infrastructure,the national Base Maps, the standards/rules for the National GIS and Development, administrate the national Geoportal. Also ASIG as the responsible organisation for creating and maintaining the new geodetic reference frame (hereinafter GRF) in Albania including the following networks:

1. The National GNSS Network
2. The National Gravimetric Network
3. The National Tide Gauge Stations Network
4. The National Magnetometric Stations Network
5. The National Levelling Network

The new GRF will provide a common, accurate and reliable reference for positioning throughout our country, and it will provide the following effects:

- Improve the quality of the existing Geo-information (support creation of cadastral maps which will prevent property conflicts; have smooth transactions etc.).
- Monitoring horizontal and vertical crustal motion and plate tectonics for natural disaster mitigation and prediction (high demand from the Albanian Institute of Geosciences).
- Provide accurate and reliable information for urban planning and decision making to territory management.
- Support development of geographic information systems for planning and service management functions. These include boundary determination for site planning, land use regulation, hydrology, soil conservation etc.
- Provide a reliable and accurate geodetic base to Surveying and Mapping companies for implementation of all engineering projects throughout our country (cost and time effective).

CURRENT SITUATION OF GEODETIC REFERENCE FRAME

1. The National GNSS Network

In support of horizontal datum we have designed a new National GNSS network consisting of passive and active points. The new designed active network, ALBCORS system, provides an accurate and reliable positioning infrastructure and facilitate the access, sharing, and utilization of GNSS data in an efficient and effective way in order to meet the needs of the public and private sectors to support economic growth and sustainable development in Albania. There are 27 CORS stations in order to guarantee the network sustainability and coverage with the required quality all over Albania. The coordinates of 27 CORS stations of ALBCORS are processed by Geo ++ company in Germany in ETRF2000 in epoch 2014.177. The control centre of ALBCORS called GNSMART which enable two main services: RTK service which has accuracy 2-3 cm and which PP (post- processing). Currently, we have 200 users working with ALBCORS network and, actually, we have agreements with Kosovo and Montenegro for data exchange. The National GNSS Network also has 42 passive points for the purpose of geodetic control in the country and the maintenance of the European system ETRS89.

2. The National Gravimetric Network

This network contains 4 orders and until now we are already implemented: The zero-order gravimetric network which contains three absolute gravimetric points and they are located in Tirana, Shkodra, and Saranda. The measurement was done with Norwegian support in 2015,where FG5 is used (at least over 2 nights and one day on each station) and the measurements uncertainty varies between ± 2.4 and ± 2.7 μGal. Also, we have implemented the first order Gravimetric Network which contains 42 points and the relative gravity measurements has completed in 2018, with accuracy 10 μGal,. For the second and third-order, we have completed the relative gravity measurements only in the Tirana-Durres area with accuracy 20-30 μGal and we have created a test Geoid.

3. The National Tide Gauge Stations Network

The State Tide Gauges Stations Network contains 4 tide gauges which are located in Shengjin, Durres, Orikum, and Saranda. Currently, these 4 tide gauge stations are working and collecting data since February 2018. The control center of the 4-Tide Gauge Stations Network is called Hydromet Cloud which enables collecting, processing, and sharing of data for all users. Also, we have established micro-networks near each tidal gauge station which consists of 3 BM and we have measured the leveling lines between benchmarks with the purpose to control Tide Gauge Stations.The main goal for ASIG is to determine the equipotential surface of the geoid (W0) based on the collected data from 4 tide gauges.

4. The National Magnetometric Stations Network

Magnetometric Station Network will contain 11 "Repeat Stations". The network will serve to determine:

- Magnetic declination **'D'**
- Magnetic inclination **'I'**

5. The National Levelling Network

We have drafted the Project of State Levelling Network wich will contain 4 polygons. The Levelling lines will follow the main routes in Albania, and the existing BMs in old reference ALB86 will be included in the new network of levelling. This project has not been implemented yet. *However, ASIG* have measured *25 km levelling lines according to first class criteria in* Tirana-Durres area with the purpose to control the geoid that we have created in this area. Also, we have drafted the guidelines for the geometric levelling procedure for first class.

FUTURE VISION OF GEODETIC REFERENCE FRAME

The goals of ASIG for the future are:

- Determine the precise geoid in Albania
- Become integrated part of EPN stations
- Connect to EVRS through levelling and connected with 4 Tide Gauges Stations with main purpose to validate the Geoid.

The main goal of G.R.F for this years is to determine the Geoid model.

ASIG has prepared technical specifications for the construction of the second order of the State GNSS Network and the State Gravimetric Network in Albania. ASIG has planned to use the technique of terrestrial gravimetric measurements for densification with gravimetric measurements throughout the territory of the Republic of Albania. The target area is the entire territory of the Republic of Albania with 300 new points divided by density:

- Field area with a density of 5x5 km
- Rural or mountainous area with a density of 10x10 km

Session: Session 4 - National Reports

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Title:

Austria: National Report of Austria

Abstract:

This presentation reports on recent developments and activities in Austria.

Session: 4 - National Reports

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Title

Finland: National Report of Finland

Abstract

Session: 4 – National Reports

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Great Britain: National Report of Great Britain 2023

Abstract : Report on activities in Great Briatin of interest to EUREF since 2022 Sympsoium

Session: 4 - National Reports

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Greece: National Report of Greece

Abstract

This national report describes the main activities of the Hellenic Cadastre related to EUREF.

Session: 4

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Title

Poland: National Report of Poland

Abstract

In the report we will present the main geodetic activities at the national level in Poland which were conducted during the last year. These activities concentrated on the maintenance of horizontal, vertical, gravity and geomagnetic controls, operational works of GNSS permanent stations (IGS, EPN, ASG-EUPOS), regular GNSS analysis for EPN, combinations of EPN analysis centres' coordinate solutions. We will also present works of Polish institutions on GNSS meteorology, ionosphere monitoring, GNSS receiver antenna calibrations, advanced methods for GNSS positioning, monitoring of gravity changes, precise geoid modelling, and activities in satellite laser ranging.

Session: National Reports

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Slovakia: National report of Slovakia

Abstract

National report of Slovakia presents joint contribution of geodetic national authority, university and research institutes about present status and news focused primarily on the field of geodetic controls, geodesy, geoinformatics, metrology, InSAR and Earth sciences which have happened since the last EUREF 2022 online symposium.

Session: National Reports

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Switzerland: National Report of Switzerland

Important highlights and developments at the national mapping agency swisstopo are presented. This includes aspects of the Geostation Zimmerwald, the Permanent Network Anlaysis Center PNAC, the LV95 measurement campaign CHTRF2022, the Swiss Positioning Service swipos, as well as GNSS meteorology..

Session 5 - Applications: Earth Sciences, Geo-information

EUREF 2023 Symposium
23-26 May 2023, Gothenburg, Sweden

Session: Session 5 – Applications: Earth Sciences, Geoinformation

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Title The VLBI Global Observing System (VGOS)

Abstract

VGOS, the VLBI Global Observing System, is the next generation Very Long Baseline Interferometry (VLBI) system for geodesy and astrometry that is currently being rolled out and implemented by the International VLBI Service for Geodesy and Astrometry (IVS). The IVS is one of four services of the International Association for Geodesy (IAG) that collaborate and contribute as technique centres to the efforts of the International Earth Rotation and Reference Systems Service (IERS). Important products that arise from this cooperative work are time series of Earth orientation parameters (EOP), as well as the celestial and terrestrial reference frames (CRF, TRF). The four techniques contributing to the IERS have individual advantages and complement each other. In this context, VLBI is unique in providing the International Celestial Reference Frame (ICRF), the celestial pole offsets and the earth rotation angle, expressed as UT1-UTC.

In this presentation, the principles of geodetic VLBI will be shortly described as well as the current status of the IVS and its prospects, in particular concerning VGOS. Several agencies worldwide have already built VGOS stations, or are in the process of doing so. One example it the Onsala Space Observatory (OSO) that operates since 2019 the currently only VGOS twin telescope worldwide. VGOS makes use of relatively small and stiff radio telescopes that allow high speed motion in azimuth and elevation and thus many observations per time unit in many different directions on the sky. This provides a suitable local sky coverage and allows to estimate parameters describing the signal delay in the atmosphere with high temporal resolution. The VGOS receiving systems are broadband and cover about 2–14 GHz in two polarizations and allow high data rates. Using this approach, the expectations are that VGOS will improve the performance of geodetic VLBI by one order of magnitude compared to the legacy VLBI system that has been operated since the early 80ies. Recent examples of VGOS result derived will be presented.

Session: 5 – Applications: Earth Sciences, Geo-Information

Author(s): Grinde, Gro, Skaar, Karoline and Himle, Sveinung

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Title:

How do we handle geodata and services with positions in global reference frames?

There are now several international high presision GNSS positioning services. Galileo High Accuracy Service and Hexagon HxGN SmartNet Global deliver positions in global reference frames, such as GTRFyy and ITRFyyyy. We believe that the use of global reference frames will increase in the future and that new user groups will contribute with geodata collection, e.g. within crowdsourcing, ITS, Mobile platforms, IoT, drones and similar.

How do we handle geodata and services positioned in global references?

The Norwegian Mapping Authority's aim is to facilitate the geographical infrastructure and geo-information system of the future, with a view to handling both static and global reference frames. What work and preparation are required to get a geographic ecosystem that can handle data seamlessly in both national and global frames of reference?

Session: 5

Author(s): Family name, First name

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Title

The NKG2020 transformations

Abstract

Coordinates in global reference frames are becoming more and more common in positioning whereas most of the geospatial data are stored in registries in national reference frames. It is therefore essential to know the relation between global and national coordinates, i.e., the transformation, as accurately as possible. Officially provided pan-European transformations do not account for the special conditions in the Nordic and Baltic countries, namely crustal deformations caused by the Glacial Isostatic Adjustment (GIA). Therefore, they do not fulfill the demands for most accurate applications like long-term reference frame maintenance. Consequently, the Nordic Geodetic Commission (NKG) has developed customized and accurate transformations from the global ITRF to the national ETRS89 realizations for the Nordic and Baltic countries. We present the latest update, called the NKG2020 transformation, with several improvements and uncertainty estimates.

Session: 5 - Applications: Earth Sciences, Geo-Information

Author(s): Bamahry, Fikri; Legrand, Juliette; Pottiaux, Eric; Bruyninx, Carine; Fabian, Andras

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Title

Using Machine Learning Algorithms for Automated Data Cleaning of GNSS Position Time Series Based on Data Quality Indicators

Abstract

Data cleaning in GNSS position time series analysis is a critical step that can affect the accuracy and reliability of daily GNSS position and velocity estimates. GNSS time series cleaning methods often involve identifying positions that differ statistically from other positions without knowing the cause of the position outlier. However, data quality degradation is a crucial factor affecting the quality of GNSS position estimates. In this investigation, we implemented a supervised machine-learning algorithm to automatically identify possible position outliers caused by degraded data quality. Our approach investigated the correlation between GPS data quality indicators and outliers in daily position time series to construct a predictive model that can identify possible outliers in daily position time series. Our algorithm was trained using the position time series of EPN stations along with six GPS daily data quality indicators: the number of observed versus expected observations in dual frequency, the lowest elevation cut-off observed, the number of missing epochs, the number of satellites, the number of observations, and the number of cycle slips. Through this process, we identified the most important GPS data quality indicators explaining outliers in the GPS position time series. In this presentation, we will present the preliminary results of our work.

Session:

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Title

The NITE model for ground-based GNSS-IR tropospheric error correction: theory and validation

Abstract

We deduce a new tropospheric error model for ground-based GNSS interferometric reflectometry (GNSS-IR), the NITE (New Interferometric Tropo-spheric Error) model. This model contains two parts, a straight-line geometric error and a path delay. The geometric error uses specular reflection, with the atmospheric bending and the earth curvature effects integrated. The path delay follows the definition of the mapping function. We validate the NITE model together with two previously used models, the bending correction and the mapping function path delay (MPF delay) using raytracing and radiosonde data. The raytracing results show that the newly-developed NITE model is more accurate than the previous models. Numerically, for a GNSS antenna with a 20 m height difference to the sea level, the geometric tropospheric error is < 5 % of the path delay error. We further investigate and compare six tropospheric error correction strategies for GNSS-IR sea level monitoring using two sets of experiments. With an elevation angle range test using GNSS stations with large height differences to the sea level, we show that applying no troposphere error corrections and applying the bending correction plus the MPF delay both introduce large elevation-dependent biases. Analyzing time series of differences between GNSS-IR derived sea level and corresponding results from co-located tide gauges, we show that the bending correction with the widely used Bennett equation introduces long-term (4 h to months) trends in the sea-level retrievals. This is eliminated by using the Ulich equation in the bending correction. In our experiment, the accuracy improvement due to the NITE model is not as clear as in the raytracing simulations. We identify one station (ELLY in north America east coast) where the NITE model produces better long-term ($\tau > 4$ h) stability. In others situations, the results from the NITE model have similar levels of random error. Finally, we give a theoretical deduction showing that, except for extreme situations, both the bending correction and the MPF delay are approximations of the rigorous NITE model. Unlike what is previously regarded, the bending correction and the MPF delay are not complementary but equivalent at low elevation angles.

Session: *5 - Applications: Earth Sciences, Geo-Information*

Author(s): Family name, First name

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Title

GNSS techniques for natural hazards detection and monitoring in the Iberian region

Abstract

GNSS has become a fundamental tool in the detection, monitoring and analysis of various types of natural disasters. The precursor deformation of the terrain in a volcanic crisis is well known, but the GNSS can also contribute to the study and detection of other natural disasters such as tsunamis or earthquakes.

GNSS high-frequency measurements are becoming an important contribution for earthquake source determination. Although there is no area of large earthquakes, the seismic activity in Spain is relevant and there have been earthquakes below Mw 7 capable of causing serious damage. In this contribution, the focus is set on the work by Colosimo et al. (2011), who shown the feasibility of a GNSS-based real-time estimation of coseismic displacements, within a few centimeters. This methodology is used as starting point to develop a method based on a Kalman Filter, which is applied to several earthquakes of moderate magnitude that took place in the Iberian region.

On the other hand, during the propagation of a tsunami, gravity and sound waves can be produced, spreading from its source to the ionosphere's upper layers, thus generating perturbed electron densities in its E and F regions. These ionospheric disturbances can be studied in detail using measurements of the ionosphere's Total Electron Content (TEC), registered by permanent GNSS stations. Based in the VARION method (Variometric Approach for Real-time Ionosphere Observation TEC's temporal variations are obtained with the aim of detecting such ionospheric disturbances. Moreover, the numerical results obtained after applying this method to real cases of tsunamis monitored by those satellites whose Ionospheric Pierce Points (IPPs) are closest to the tsunami source are presented. Lastly, based on these ionospheric perturbations reflected in the signals emitted by the satellites, a preliminary design is described for its potential integration into a Tsunami early Warning System (TWS) for the Iberian Peninsula.

Poster Session

Session: Session 5 - Applications: Earth Sciences, Geo-Information

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EuVeM2022: a new European GNSS velocity model

The European continent is divided into several tectonic plates and velocity variations appear along plate boundaries. However, velocity changes inside a tectonic plate can also occur due to local effects or other geodynamic processes, which is of interest for researchers trying to understand intraplate deformations in the horizontal and vertical directions. These changes can be observed by a dense network of GNSS (Global Navigation Satellite System) stations or more recently by the usage of InSAR (Interferometric Synthetic Aperture Radar). However, a dense GNSS network cannot be maintained over large areas due to, e.g., high costs and topographical obstacles, thus a regional velocity model to study intraplate deformation has to be obtained via an interpolation of scattered GNSS station velocities. In addition, the obtained velocity models can be used to estimate strain rates.

The increased availability of GNSS station velocities in Europe via the EUREF Permanent Network Densification (EPND) project (https://epnd.sgo-penc.hu) allows to obtain a complete picture of the horizontal and vertical deformation in Europe via an interpolation. Here, we apply a new interpolation technique to a velocity field solution from EPND. The homogenized and quality-checked velocity field is interpolated via a least-square collocation including the knowledge of existing plate boundaries to avoid a smoothing of nearby velocities on different tectonic plates. We also use a moving variance approach to avoid effects of non-stationarity, which arise due to the variable station densities. We will present the new 3D GNSS velocity model EuVeM2022 and the obtained strain rates.

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Session: Systems: ETRS89, EVRS, Geoid and Related Models

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Application Of The KSA-GEOID Model For The Validation Of KSA-DTM

Key words: KSA-Geoid, gravity, GNSS/Levelling, KSA-DTM, Gravimetric geoid, Orthometric height

Abstract

A new accurate geoid model for the Kingdom of Saudi Arabia has been computed (KSA-GEOID21). The gravimetric geoid model is based on all available land, marine, airborne, and satellite gravity data, satellite altimetry. The resulting model was fitted to the National Vertical Reference Frame (KSA-VRF14) and validated with respect to the set of about 4000 GPS levelling points. . The validation of this new KSA-Geoid model has been conducted in advance and presented. After thta, it was decided to perform the evaluation by using orthometric heights from field test compared to those from the topography of the Kingdom as represented by the 3'' SRTM model and from the KSA-DTM models with diffrent resolutions.

This KSA-GEOID21 model has been used to validate GASGI Digital Terrain Model, which covers the territory of KSA with a resolution of three meters. The evaluation has been conducted in following two stages:

- Office-based evaluation utilizing a set of 17000 geodetic benchmarks with ellipsoidal heights.
- Field-based evaluation utilizing more than 56000 pointwise static GNSS RTK observations on the geodetic benchmarks, together with utilizing kinametic mode during the traveling along the roads between benchmarks.

As a result, DTM heights of both sets of control points (office and field based) have been compared with orthometric heights determined with respect ellipsoidal heights and heights interpolated form KSA-GEOID21. In addition, the 3RMS was applied to the residuals in order to detect and remove the blunders. In order to conclude, the results of the comparison indicated that the current KSA-DTM should be improved by the development of a transformation model based on KSA-GEOID21.

Session: Poster

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Exchange of antennas on SWEPOS fundamental station

It is desirable to minimize the changes of the antenna mounting at GNSS stations used for reference frames and geodynamic studies in order to get long time series of data without jumps.
Nevertheless, in 2021 Lantmäteriet started to exchange antennas at some SWEPOS stations, even though they were still working. Why did we do that?
The motivations, strategies and plans for the exchange of antennas at both the pillars and masts at the 21 SWEPOS fundamental stations are presented.

Session: Poster

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Automatic snow cleaning of GNSS antennas

It is well known that some GNSS stations, like the ones in the northern part of Sweden, have problems with snow accumulation on the top of the antenna/radome every now and then during the wintertime. Specially if the layer of snow is thick and irregular, this will cause coordinate changes up to several centimetres. To get good GNSS data all around the year, an antenna heater system has been developed and tested.
The system has been developed in cooperation with a Swedish company, IHP International Heating Products AB, and has been tested during the last winter at a test pillar close to the IGS/EPN stations KIR0 and KIR8.
Another antenna of the same type with a similar heating system has been calibrated at Geo++, both with the heating system turned on and off, as well as without the heating system.