Federal Office of Metrology and Surveying

Landesamt für Digitalisierung, Breitband und Vermessung

GGOS/IERS Unified Analysis Workshop 2026

Munich, Germany, 5 – 6 March 2026

https://geodesy.science/event/unified-analysis-workshop-uaw-2026/

Meeting Summary

Under the umbrella of the International Association of Geodesy (IAG), the IAG's Global Geodetic Observing System (GGOS) and the International Earth Rotation and Reference Systems Service (IERS) periodically hold unified analysis workshops to discuss current issues in geodetic data analysis and the determination of geodetic reference frames, as well as the provision of reliable geodetic products for use in other geosciences and by society. The series of the GGOS/IERS Unified Analysis Workshop (UAW) include:

- UAW2026, Munich, Germany, 5 - 6 March 2026 https://geodesy.science/event/unified-analysis-workshop-uaw-2026/
- UAW2022, Thessaloniki, Greece, 21 - 23 October 2022 (https://geodesy.science/event/unified-analysis-workshop-uaw-2022/)
- UAW2019, Paris, France, 02 - 04 October 2019 (https://geodesy.science/event/uaw-unified-analysis-workshop-2019/)
- UAW2017, Paris, France, 10 - 12 July 2017
- UAW2014, Pasadena, California, USA, 27 - 28 June 2014 (https://www.iers.org/IERS/EN/Organization/Workshops/Workshop2014)
- UAW2011, Zürich, Switzerland, 16 - 17 September 2011 (https://www.iers.org/IERS/EN/Organization/Workshops/Workshop2011)
- UAW2009, San Francisco, California, USA, 11 - 12 December 2009 (https://www.iers.org/IERS/EN/Organization/Workshops/Workshop2009)
- UAW2007, Monterey, California, USA, 05 - 07 December 2007 (https://www.iers.org/IERS/EN/Organization/Workshops/Workshop2007Monterey)

This document summarises the main outcomes of the UAW2026. The UAW2026 premeeting reading material and presentations are available at https://geodesy.science/event/unified-analysis-workshop-uaw-2026/.

Session: IERS Conventions update

Conveners Sharyl Byram (Chair IERS Conventions)
Nick Stamatakos (Chair IERS Rapid Service/Prediction Centre)
Christian Bizouard (Chair IERS Earth Orientation Product Centre)

Objective

To report on the status of the IERS Conventions update, review for consistency and impact, and finalise the content in v2.0.0 through general discussion.

Recommendations

- Release IERS Conventions v2.0.0 near end of 2026
  - Chapters will note which version they were last updated for user awareness of potential inconsistencies that may occur when chapters are not updated simultaneously
  - Release minor updates as chapter updates are provided (ex. v2.1.0)
- Remove lunar system information from v2.0.0
  - IERS Directing Board to decide on creating a lunar product centre within IERS and information could be included in subsequent versions
- Move historical discussion to supplementary material or as references to previous conventions

Action Items

- Update a few values in chapter 1 table 1.1 per the poster presented by Stamatakos, et. al. at REFAG2026 and move table 1.2 to supplementary material
    - J2 value to be updated with epoch and tidal system
- Add other GNSS times (currently only GPS and GLONASS listed) to chapter 2
- Move Free Core Nutation (FCN) models in chapter 5 to supplementary material
- Update precession and nutation models in chapter 5 and publicize to community the need to implement in a consistent manner
- Update table 5.2 with long term polar motion info
- Harmonize tables/information on number of tides and tidal models especially across chapters 5, 6, 7, & 8
- Replace zonal tide model with model by Ray & Erofeeva (2014) but preserve the transformation to the Woolard model
- Provide DOI and citation to community when released
- Update software for all chapters as needed

Session: What do we need from the next generation of geophysical models, and their future use in geodetic data analysis and reference frames?

Conveners Jeff Freymueller (Chair Working Group "Impact of geophysical models on reference frames")
Jean-Paul Boy (Chair IERS Global Geophysical Fluids Centre)
Torsten Mayer-Guerr (Theoretical Geodesy and Satellite Geodesy, TU Graz)

Objective

To discuss the strengths and weaknesses of the current non-tidal loading models and identify what we should be doing differently if we truly understood/knew the changes in mass distribution.

Wide-ranging discussion

- Broad agreement on the utility of using non-tidal loading models
- Varied opinions on what should be removed, as opposed to remove-compute-restore
- Assuming zero (no model) is also a model assumption
- Removal of some effect can cause inconsistencies if that effect is not removed from all products
- There is a clear need for better information about what is included (or not) in various models
- Need more communication with modelers

Take-Away Messages

- To apply atmospheric/oceanic correction (the most precise models), the optimal approach should be through a separation between the "long-term" component of the model (wrt to the temporal resolution of the solution) and the stochastic part of the geophysical model (atmosphere & ocean).
- The long-term part can be restored afterwards if desired. In this case, the "mean field" (linked to the scale) is not fundamental.
- It appears to be more important to focus on the "high frequency" part (the one aliased) ; geodetic data are a tool to investigate long term hydrology/cryosphere changes.
- It is important to have a realistic estimate of the full covariance of the geophysical models.
- It is important to have different models available.

- Difficult to identify a best model, which may depend on the application.
- Users need to be able to introduce various models in their geodetic data processing and see how it improves (or not) the solution.
- When combining different timescales (from sub- daily atmospheric to thousands of years for GIA), the consistency of the Earth model should be considered (rheology). The geophysical corrections being (at least) a combination of a Earth model and a mass load model.

Session: Challenges in the new ITRF operational updates

Conveners Robert Heinkelmann (IERS Analysis Coordinator)
Zuheir Altamimi (ITRS Combination Centre IGN)
Christian Bizouard (Chair IERS Earth Orientation Product Centre)
Thomas Herring (IGS Analysis Coordinator)

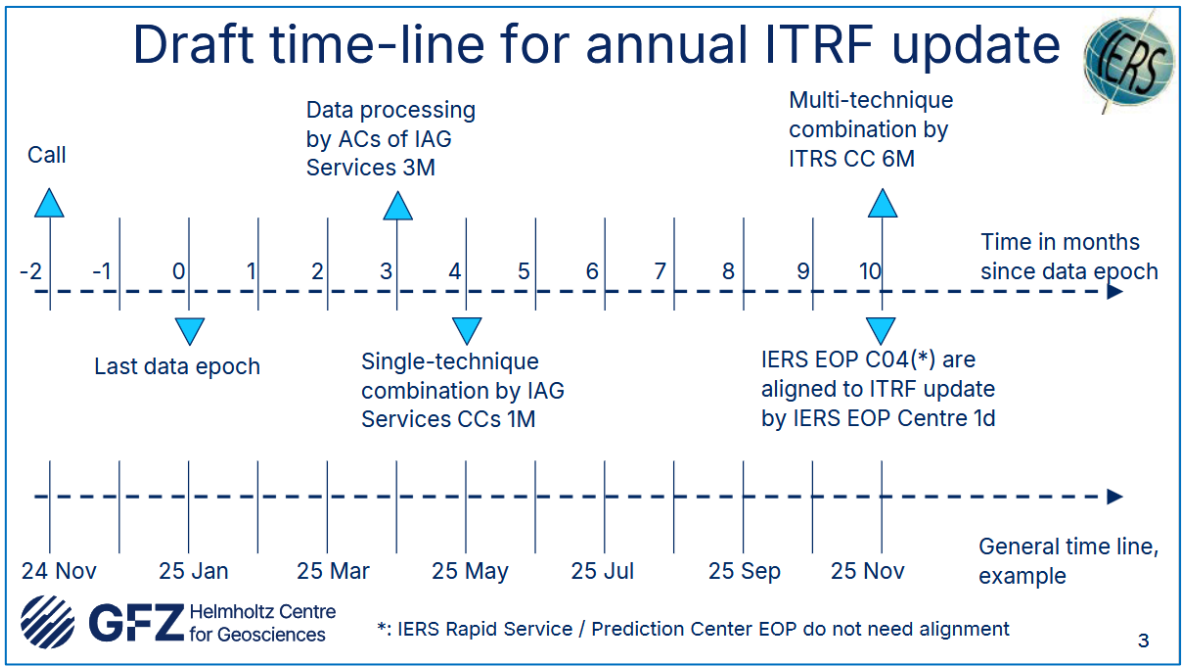
Objective

To define an appropriate and timely practice for updating IERS products, particularly the Terrestrial Reference Frame solutions and the Earth Orientation Parameters (EOP) time series. Given the annual TRF updates, it is essential to ensure consistency between TRF-dependent products.

Overview and scope

- After the first three annual updates u2023, u2024, u2025 of ITRF2000 took/take place, the intention of the session was to discuss difficulties, dependencies and generally the time-line of the processing chain involved in ITRF annual updates.
- One question to answer is whether annual updates work well and whether they are worth the effort of all participants (balance).
- There are two kinds of ITRF updates that cause very different amount of work:
  - Full re-processing
  - Annual updates (focus of this session)

Draft time-line for annual ITRF update



General concerns and requests

- Communicate the motivation for the annual updates better with the IAG Services.
- Demonstrate the improvements due to annual updates.
- Balance improvements and workload.
- It is requested to release ITRF and EOP C04 updates at the same time by various parties.
- Repro and operational solutions should adhere to the same standards and contain the same ACs.
- Full reprocessing might be needed relative often. Many changes ongoing… How often will we need to do a full reprocessing?

Consistency concerns

- Consistency of ITRF, EOP and ICRF (IVS), see recommendation #2
- Consistency of final, rapid, ultra rapid products (IGS), see recommendation #3
- Consistency of operational and re-processed series (IDS, IGS, ILRS,IVS), see recommendation #3

Dependencies

- DORIS processing depends on availibility of
  - Atmosphere/Ocean de-aliasing product
  - Geomagnetic indices and solar flux as input for atmosphere density models
- xTRF processing depends on
  - Availability of local tie vectors and data about seismic events
  - Non-tidal loading data provided by GGFC (atm., hydr., oceanic)

Recommendations

Recommendation #1:

Establishment of an IERS WG with the objectives

- Outline/Organize the ITRF update+EOP update transition procedure in a more professional way.
- Find a good update cycle that considers rapid turnaround, consistency and work load balance for all stakeholders.
- Develop a standardized communication procedure among stakeholders.
- Develop a standardized internal evaluation methodology to which stakeholders adhere. (Distribution of quality checking. What is the expectation from previous stakeholder?)

Recommendation #2:

- Assess consistency of EOP- and ITRF-updates with other EOP and ICRF (IVS)

Recommendation #3:

- Assess consistency of operational and re-processing series (IDS, ILRS, IVS)
- Assess consistency of rapid, ultra rapid and final IGS products

(Whose mandate is it? To be clarified.)

Session: Challenges and opportunities in analysing Genesis data

Conveners Johannes Böhm (Chair Working Group “Genesis”)
Urs Hugentobler (President IAG Commission 1 “Reference Frames”)
Susanne Glaser (Working Group “Genesis”)
Hanane Ait-Lakbir (Working Group “Genesis”)

Objective

To discuss the most suitable framework for robust, multi-technique orbit combination and data analysis for Genesis. This includes the development and validation of end-to-end simulations, calibration and observation strategies for the pilot phase of the mission, as well as the upgrade and harmonisation of existing analysis software and processing chains within the IAG Services for GNSS, VLBI, SLR and DORIS.

Recommendations

The Genesis mission by the European Space Agency (ESA) is dedicated to the improvement of the terrestrial reference frame, and it is a great opportunity for the geodetic community. The Preliminary Design Review (PDR) has been finalized at the end of 2025, and the satellite will be launched in 2028. With just two years before launch, preparations must be accelerated to be able to fully exploit the mission once data is available. These preparations concern the software packages as well as analysis and combination scenarios.

Joint pilot projects have been set up by the IAG Working Group on Genesis (joint with GGOS and the IERS) and ESA Working Group 1. The plan is to use real orbits from Sentinel 6A and LAGEOS 1, and a simulated Genesis orbit to use real and simulated data for analysis as anticipated for Genesis. Action Items are identified on compiling detailed specifications describing the exact plans and timeline for the pilot projects. In particular, a realistic orbit (attitude model, solar radiation pressure corresponding to the shape of the satellite, ..) is needed for the pilot project on Genesis.

One strategy is to determine orbits by combination of all four space geodetic techniques at the normal equation level, as suggested by Urs Hugentobler. For that purpose, the SINEX format must be extended to allow for all necessary transformations, plus auxiliary information will be useful. Of course, other orbit determination strategies are possible as well and should be considered. It will be important to account for the different time systems used by the four space geodetic techniques. This was not an issue for the determination of the terrestrial reference frames, but it will be critical with the estimation of orbits.

Finally, it has been recognized that a clear recommendation is needed concerning the near-field delay model for VLBI observations to satellites.

Session: Resilience of IAG Scientific Services

Conveners Richard Gross (President of the International Association of Geodesy)
Hansjörg Kutterer (Chair of GGOS D-A-CH)

Objective

The aim is to discuss ways of improving the availability of geodetic data and defining ways to make the geodetic infrastructure more resilient. The objective is also to eliminate single sources of failure in the generation of IAG Services' products and to explore ways of making IAG combined products more resilient.

Outcomes

The panel on Resilient Data Infrastructure in Geodesy first described how the resilience of geodetic data infrastructure is currently being addressed and then discussed ways that it could be improved. The panel recommended that the geodetic data infrastructure evolve in such a way that in the future it consists of a globally distributed, cybersecure network of data centers having synchronized, quality controlled holdings operated by dedicated staff with sustainable

governance. The panel emphasized the importance of collecting and archiving meta data along with the observations. And the panel noted that the geodetic data infrastructure is just one link in the global geodesy supply chain and that the entire supply chain needs to be made more resilient. Finally, the panel discussed the need to raise the awareness of the importance of geodesy to the public, to decision makers, and especially to students. For geodesy to thrive in the future we must attract students to the field. The panel on Improving the Resilience of IAG's Products first described how the products from IAG's Services are currently being determined, focusing on how combined products are generated. The panel then discussed how the resilience of the products could be improved, particularly the resilience of the combined products. While most Services have multiple Analysis Centers, some of the Analysis Centers have only one analyst. And most Services have only one Combination Center to determine the combined products. Eliminating these single sources of failure would greatly improve the resilience of IAG's products. This entails establishing multiple Combination Centers at each Service having independent processing chains determining combined products that are consistent with each other. The panel also discussed the need for resilient personnel with multiple people being trained in the analysis and determination of the Service's products. Finally, the panel also noted the need to raise the awareness of the importance of geodesy, echoing the concerns of the panel on Resilient Data Infrastructure in Geodesy.

Session: Availability of geodetic products for the Essential Geodetic Variables

Conveners Laura Sánchez (President of GGOS)
Detlef Angermann (Director of the GGOS Bureau of Products and Standards)
Thomas Gruber (Chair of the GGOS Committee "Definition of Essential Geodetic Variables")

Objective

The aim is to gather recommendations on how to characterise the geodetic products required for quantifying and monitoring the EGVs.

Main recommendations

- In addition to the initial proposed product characteristics (uncertainty, spatial and temporal resolution, timeliness, and data sources), it should be evaluated whether additional characteristics can be included, such as variance/covariance matrices, reliability, repeatability, stability, robustness, time-series correlations, etc.
- The proposed characteristics are not known for all products, and no inventory of this kind exists yet. The first step is to establish the current values of these characteristics in order to ascertain what is available. The next step is to define target values: what is desired but not yet achieved.
- The product characterisation should be as simple as possible for communication with non-geodetic experts. Additional expert-level information should be added in the form of "notes" or "comments".
- The characterisation of geodetic products should include a brief description of the data limitations.
- The catalogue of EGVs can be extended to include other geodetic products, such as those related to lunar reference frames or solid Earth modelling.

- The data/product providers should be identified first, followed by potential stewards for the EGVs.

Action item

The GGOS Bureau of Products and Standards (GGOS-BPS) will provide the framework for implementing these recommendations. The first step will be to reconvene the Committee on EGVs, comprising representatives from all IAG services and other IAG components, to begin characterising the products they make available. Once all geodetic products provided by the IAG have been covered, the GGOS-BPS will initiate a similar process with data and product providers outside the IAG.

Open Session

Topic A: Resolution on Modelling Gravity-Induced Deformations of the Radio Telescope Receiving Unit

Convener Cornelia Eschelbach (Chair of the Working Group Metrology of Space Geodetic Infrastructure)

Objective

Representatives of the IVS (International VLBI Service for Geodesy and Astrometry) and members of the Working Group Metrology of Space Geodetic Infrastructure were invited to discuss the feasibility and challenges of implementing following recommendations in the near future:

1) Modelling the main-reflector deformations not only via focal-length changes but also by more comprehensive approaches such as Zernike polynomials.
2) Including displacements and tilts of the sub-reflector or prime focus feed horn, instead of modelling solely an axial shift along the principal axis.
3) Using a pointing-direction dependent delay model, which considers both the primary and the secondary axis angle, rather than relying exclusively on elevation-dependent expression.

Report on topic and discussion

The topic was introduced by a presentation of Frankfurt UAS on gravitational deformations of the receiving unit at VLBI radio telescopes. The presentation included a detailed description of the various effects and their metrological verification. Previously published results of the survey and modelling of deformations of the 26m radio telescope at the Mount Pleasant Radio Observatory were presented. Deformations are modelled using a varying number of Zernike-polynomials, and azimuth-elevation dependent delays of the signal path are provided using spatial ray tracing. In addition, preliminary results from the survey of OTTW at the Onsala Space Observatory were shown, which exhibit an opposite deformation pattern compared to its twin OTTE. During the ensuing discussion members of the working group from TU Munich report on preliminary results of the survey of the 26m HartRAO radio telescope at Hartebeesthoek Radio Astronomy Observatory, which also confirm azimuth-elevation dependent delays. Various representatives of the IVS community, such as colleagues from DGFI-TUM and ETH Zürich, emphasize the importance of gravitational deformation models and confirm their influence on the height component of the telescope position.

Key findings

- Gravitational deformations possibly depend not only on elevation but also on azimuth if the telescope does not have an azimuth-elevation mount.
- Transferring deformation models from one telescope to another telescope of identical design is not recommended.
- Uncorrected gravitational deformations bias the telescope height.

Outcome and Follow-up

- Validation of useful application of ANTEX format for providing delays for VLBI analysis.
- The IVS is asked to adopt a resolution, which addresses the following aspects:
  Modelling of gravitationally induced deformations of the entire receiving unit of VLBI radio telescopes In accordance with Resolution IVS 2019-01, the IVS resolves examining radio telescopes observing in the IVS network for gravitationally induced deformation depending on the pointing direction, i.e. on both elevation and azimuth angles. This particularly applies to telescopes with equatorial mount and with xy mount, which are susceptible to azimuth- dependent systematics. The investigations should be fully spatial, and cover the entire receiving unit, including the main reflector, the receiver and, if applicable, the sub-reflector. The IVS encourages the determination of azimuth- and elevation-dependent delays and their integration into VLBI analysis.

Topic B: Correlations in atmospheric parameter estimation

Convener Benedikt Soja (IVS Analysis Coordinator, Chair GGOS-FA IA4G)

Objective

The aim is to discuss the rigorous treatment of correlations in atmospheric parameter estimation and simulations, and the path toward establishing a new operational IERS product for the troposphere.

Key findings

- Tropospheric delay remains the most significant source of error for most space-geodetic techniques.
- Current standard data analysis practices widely ignore the effects of atmospheric turbulence, leading to suboptimal parameter estimation.
- Advanced data and modelling tools are now sufficiently mature to incorporate turbulence-driven stochastic properties directly into the analysis via the observation covariance matrix.

Outcome and Follow-up

- Analysis Centres are encouraged to implement turbulence-based stochastic modelling (e.g., using Kolmogorov turbulence theory) to improve the reliability of geodetic products and station coordinate repeatability.
- It is recommended that the updated IERS Conventions include a concise statement (1-2 sentences) acknowledging the impact of atmospheric turbulence and providing guidance on its consideration within the estimation process.

Topic C: Increased automation in geodetic data analysis

Convener Benedikt Soja (IVS Analysis Coordinator, Chair GGOS-FA IA4G)

Objective

The aim is to discuss current and future automation in geodetic data analysis, with an overall goal of improving the reliability and timeliness of geodetic products.

Key findings

- The significant increase in data volume across all space geodetic techniques necessitates a transition toward high-level automation to maintain operational feasibility.
- While GNSS processing is already almost completely automated, other techniques – particularly VLBI – still require manual intervention for several stages of the analysis chain.
- Modern algorithmic developments and AI-based tools have reached a maturity level where they can be increasingly exploited to replace manual monitoring and data cleaning.

Outcome and Follow-up

- Groups across the entire geodetic chain (collection, processing, and analysis) are encouraged to explore automation to achieve efficiency gains and quality improvements, especially in areas where manual bottlenecks persist.
- The implementation of automation must be accompanied by robust validation protocols to maintain product integrity and scientific rigor.