Commission 3 - Earth Rotation and Geodynamics

https://doi.org/10.82507/iag-travaux2025_com3

President: Rebekka Steffen (Sweden)
Vice President: José M. Ferrándiz (Spain)

Commission 3 website - https://geodesy.science/com3/

1 Structure

Sub-Commissions

SC 3.1 Earth Tides and Geodynamics
Chair: Séverine Rosat (France)
SC 3.2 Volcano Geodesy (joint with IAVCEI)
Chair: Susanna Ebmeier (United Kingdom)
SC 3.3 Earth Rotation and Geophysical Fluids
Chair: Sigrid Böhm (Austria)
SC 3.4 Cryospheric Deformation (joint with IACS)
Chair: Karen Simon (Canada)
SC 3.5 Seismogeodesy (joint with IASPEI)
Chair: Jean-Mathieu Nocquet (France)

Working Groups

WG 3.1 Hydrologic signature in geodetic observations
Chair: Carla Braitenberg (Italy)

Joint Working Groups

JWG 3.1 Consistent improvement of the Earth's rotation theory
(Joint with IAU)
Chair: José M. Ferrándiz (Spain)

Joint Study Groups

JSG 3.1 Model representation and geodetic signature of solid-Earth rheology in surface loading problems
(Joint with Comm 1, Comm 2)
Chair: Lambert Caron (USA)

2 Overview

The current structure of commission 3 was set-up after the last IUGG General Assembly in Berlin in July 2023. All sub-commissions, except SC3.5, started with a new chair and in most cases with a new co-chair as well. In addition, three new working and study groups were set up to cover topics in addition to the five existing sub-commissions. One working group became a joint working group with the International Astronomical Union (IAU) and one study group is joined between IAG commissions 1, 2 and 3. Chairs of the sub-commissions and working/study groups build the steering committee of commission 3. Additionally, two members-at-large (one from Argentina, one from Malawi) were appointed to the steering committee as well as three service representatives and a GGOS representative. To emphasize the interdisciplinary character of commission 3, for the first time representatives of the IAU as well as the IUGG commission of the "Study of Earth's Deep Interior" (SEDI) were invited to become members of the steering committee. In addition, an ECS representative was invited to join the steering committee. The steering committee met several times in the last two years to get to know each other, discuss research ideas and share updates from other IAG bodies.

Each sub-commission, working group and study group organized activities in form of in-person meetings or webinars throughout the last two years. In addition, commission 3 is currently planning its first commission symposium, which will be held in Gävle (Sweden) in September and October 2026. The commission 3 symposium will run under the title "TIGER Symposium in Geodesy" with TIGER standing for "Tracking and Investigating Geodynamics and Earth Rotation". The TIGER Synmposium 2026 will be in conjunction with the Journées "Systèmes de référence spatio-temporels" and will be followed by the GGOS Topical Meeting on Geohazards and the GGOS Days 2026. The TIGER symposium will have a length of four days (September 28th to October 1st, 2026) with four keynote presentations per day and the remaining presentations as posters. Most of the time during the conference will be dedicated for extended discussions. The meeting will allow virtual attendance (listening and discussing possibilities) but no virtual presentations. We expect up to 150 people joining the symposium. More details avaialble via the meeting website: https://sites.google.com/view/tiger-geodesy-2026/.

3 Sub-commission 3.1: Earth Tides and Geodynamics

Chair: Séverine Rosat (France)
Vice-Chair: Xiaoming Cui (China)

https://geodesy.science/com3/structure/sub-commissions/sc-3-1/, https://iag-sc31.github.io/

Activities during the period 2023-2025

Organization of the 20th International Symposium on Geodynamics and Earth Tides (G-ETS) held on August 25-30, 2024 in Strasbourg, France.

Website: https://gets2024.sciencesconf.org/

- Session 1: Tides and non-tidal loading in space geodetic and subsurface observations
  - ◇ Conveners: J.-P. Boy, U. Riccardi, H. Wziontek
- Session 2: Geodesy for hazard monitoring (seismo- and volcano-geodesy, etc.)
  - ◇ Conveners: D. Carbone, X. Chen, F. Greco
- Session 3: Monitoring of subsurface fluids (hydro-geodesy, hydro-gravimetry, geothermal monitoring, etc.)
  - ◇ Conveners: C. Braitenberg, M. Calvo
- Session 4: New technologies, software and innovative concepts (cold-atom gravimetry, gradiometry, etc.)
  - ◇ Conveners: P. Dykowski, S. Merlet
- Session 5: Time variable gravity and mass redistribution (glacial isostatic adjustment, ice mass changes, ocean dynamics, etc.)
  - ◇ Conveners: M. Nordman, H. Steffen, R. Sulzbach
- Session 6: Temporal variations of the Earth's rotation
  - ◇ Conveners: X. Cui, C. Bizouard

Organization of the call and committee for the assignment of the 2024 Paul Melchior's medal

The Paul Melchior's medal awards some outstanding scientists who have had an extraordinary experience and influence in the Earth Tidal and Geodynamics Community. The 2024 awardees are D. C. Agnew and J. Hinderer (https://iag-sc31.github.io/melchior.html).

Organization of a new prize: the G-ETS early-career scientist prize

The G-ETS early-career scientist prize awards a scientist being a researcher within 10 years, or equivalent full-time working, of receiving a PhD. Decision is made from the voting results by all G-ETS participants based on the criteria:

1. Novelty & quality of the research.
2. Quality & design of the presentation.
3. Ability to answer questions.

The 2024 awardee is M. Reich (https://iag-sc31.github.io/ECS.html).

Special sessions at international meetings

- **IAG Scientific Assembly 2025, Rimini, Italy, 1–5 September 2025**
  Session "G04-2: Tidal and non-tidal mass signatures in space and surface geodetic observations"

Editorial activities

Following the 20th Geodynamics and Earth Tides Symposium, two open calls have been made for contributions to:

- Topical collection: "Geodynamics and earth Tides: observing, measuring and modeling our dynamics globe" for Pure and Applied Geophysics
- Special issue in Geodesy and Geodynamics, centered on the "20th G-ETS" symposium [SI:Scientific advances in Geodynamics and Earth Tides]

Peer-reviewed publications

[1] G. Areggi, G. Pezzo, J. P. Merryman Boncori, L. Anderlini, G. Rossi, E. Serpelloni, D. Zuliani, and L. Bonini. Present-Day Surface Deformation in North-East Italy Using InSAR and GNSS Data. *Remote Sensing*, 15(6):1704, Mar 2023. doi:10.3390/rs15061704.

[2] I.M. Barbosa, R. Steffen, H. Steffen, E. Seidel, K. Gohl, and C. Hübscher. Circum-antarctic glacially induced fault reactivation since the last glacial maximum. *Tectonics*, 44(4):e2024TC008464, 2025. doi:10.1029/2024TC008464.

[3] M. Branchesi, M. Falanga, J. Harms, K. Jani, S. Katsanevas, P. Lognonné, F. Badaracco, L. Cacciapuoti, E. Cappellaro, S. Dell'Agnello, S. de Raucourt, F. Frigeri, D. Giardini, O. Jennrich, T. Kawamura, V. Korol, M. Landrø, J. Majstorović, P. Marmat, P. Mazzali, M. Muccino, F. Patat, E. Pian, T. Piran, S. Rosat, S. Rowan, S. Stähler, and J. Tissino. Lunar gravitational-wave detection. *Space Science Reviews*, 219, 2023. doi:10.1007/s11214-023-01015-4.

[4] J. Bódi, P. Vajda, A. G. Camacho, J. Papčo, and J. Fernández. On Gravimetric Detection of Thin Elongated Sources Using the Growth Inversion Approach. *Surveys in Geophysics*, 44(6):1811–1835, 2023. doi:10.1007/s10712-023-09790-z.

[5] A. G. Camacho, P. Vajda, and J. Fernández. GROWTH-23: An integrated code for inversion of complete Bouguer gravity anomaly or temporal gravity changes. *Computers & Geosciences*, 182:105495, 2024. doi:10.1016/j.cageo.2023.105495.

[6] C. Fodor, P. Varga, and N. Sneeuw. Impact of tidal friction on the motion of lithospheric plates and earthquake activity. *Terra Nova*, 36(1):8–14, 2024. doi:10.1111/ter.12685.

[7] S.P. Golovachev, M.N. Dubrov, V.A. Volkov, D.V. Aleksandrov, I.S. Eremin, and D.S. Kalenov. Study of interrelations between the atmosphere, ocean and lithosphere from the example of intense tropical cyclones and the strongest earthquakes interaction. *Sovremennye problemy distantsionnogo zondirovaniya Zemli iz kosmosa*, 21(4):99–111, 2024. doi:10.21046/2070-7401-2024-21-4-99-111.

[8] P. Huang, R. Steffen, H. Steffen, V. Klemann, P. Wu, W. van der Wal, Z. Martinec, and Y. Tanaka. A commercial finite element approach to modelling Glacial Isostatic Adjustment on spherical self-gravitating compressible earth models. *Geophysical Journal International*, 235(3):2231–2256, 2023. doi:10.1093/gji/ggad354.

[9] D. Kern, F. Magri, V. Malkovsky, H. Steffen, and T. Nagel. Effects of Glacial Isostatic Adjustment on Fault Reactivation and Its Consequences on Radionuclide Migration in Crystalline Host Rocks. *Environmental Modeling & Assessment*, 30(1):177–192, Feb 2025. doi:10.1007/s10666-024-09997-3.

[10] H.C.P. Lau and M. Schindelegger. Solid Earth tides. *A Journey Through Tides*, pages 365–387, 2023. doi:10.1016/b978-0-323-90851-1.00016-9.

[11] H. Lecomte, S. Rosat, and M. Mandea. Gap-filling between GRACE and GRACE-FO missions: assessment of interpolation techniques. *J. of Geodesy*, 98, 2024. doi:10.1007/s00190-024-01917-3.

[12] H. Lecomte, S. Rosat, M. Mandea, J.-P. Boy, and J. Pfeffer. Uncertainty of low-degree space gravimetry observations: surface processes versus Earth's core signal. *J. of Geophys. Res.: Solid Earth*, 128, 2023. doi:10.1029/2023JB026503.

[13] H. Lecomte, S. Rosat, M. Mandea, and M. Dumberry. Gravitational constraints on the Earth's inner core differential rotation. *Geophys. Res. Lett.*, 50, 2023. doi:10.1029/2023GL104790.

[14] S. Merlet, N. Le Moigne, G. Pajot Métivier, J.-D. Bernard, F. Littel, J.-P. Boy, S. Rosat, G. Gabalda, L. Seoane, S. Bonvalot, C. Champollion, A. Mémin, M. Maia, and O. Charade. French gravimetry organization and its instrumental park. *IEEE Instrumentation and Measurement Magazine*, 27:24–31, 2024. URL: https://ieeexplore.ieee.org/document/10654723.

[15] B. Meurers. Correction of high-frequency ($>$ 0.3 mhz) air pressure effects in gravity time-series. *Geophysical Journal International*, 237(1):14–30, 2024. doi:10.1093/gji/ggae030.

[16] J. Pfeffer, A. Cazenave, S. Rosat, L. Moreira, M. Mandea, V. Dehant, and B. Coupry. A 6-year cycle in the Earth system. *Global and Planetary Change*, 2023. doi:10.1016/j.gloplacha.2023.104245.

[17] T. Pivetta, C. Braitenberg, F. Gabrovšek, G. Gabriel, and B. Meurers. Gravimetry and hydrologic data to constrain the hydrodynamics of a karstic area:

The Škocjan caves study case. *Journal of Hydrology*, 629:130453, 2024. doi:10.1016/j.jhydrol.2023.130453.

[18] J.M. Reusen, R. Steffen, H. Steffen, B. C. Root, and W. van der Wal. Simulating horizontal crustal motions of glacial isostatic adjustment using compressible cartesian models. *Geophysical Journal International*, 235(1):542–553, May 2023. doi:10.1093/gji/ggad232.

[19] U. Riccardi, S. Carlino, T. Pivetta, J. Hinderer, S. Rosat, and G. Ricciardi. Continuous Gravity Observations at Mt. Somma-Vesuvius with a gPhoneX Gravimeter: In-Depth Instrumental Response characterization and Tidal Model. *Pure Appl. Geophys.*, 2023. doi:10.1007/s00024-023-03313-y.

[20] U. Riccardi, J. Hinderer, K. Zahran, E. Issawy, S. Rosat, F. Littel, and S. Mohamed. A First Reliable Gravity Tidal Model for Lake Nasser Region (Egypt). *Pure Appl. Geophys.*, 180:661–682, 2023. doi:10.1007/s00024-022-03087-9.

[21] Y. Rogister, J. Hinderer, U. Riccardi, and S. Rosat. Subsurface tidal gravity variation and gravimetric factor. *Geophys. J. Int.*, 238:848–859, 2024. doi:10.1093/gji/ggae196.

[22] E. Seidel, H. Steffen, R. Steffen, N. Ahlrichs, and C. Hübscher. Drivers of glacially induced fault reactivation in the Baltic Sea sector of the Tornquist Fan. *Boreas*, 54(2):220–245, Apr 2025. doi:10.1111/bor.12689.

[23] H. Steffen and R. Steffen. Temporal Behavior of Glacially Induced Stresses and Strains at Potential Sites for Long-Term Storage of Used Nuclear Fuel in Canada. *Journal of Geophysical Research: Earth Surface*, 129(9), 2024. doi:10.1029/2024jf007705.

[24] R. Steffen, H. Steffen, A. Kenyeres, T. Nilsson, and M. Lidberg. EuVeM2022—a European three-dimensional GNSS velocity model based on least-squares collocation. *Geophysical Journal International*, 241(1):437–453, Feb 2025. doi:10.1093/gji/ggaf052.

[25] L. Tunini, A. Magrin, G. Rossi, and D. Zuliani. Global Navigation Satellite System (GNSS) time series and velocities about a slowly convergent margin processed on high-performance computing (HPC) clusters: products and robustness evaluation. *Earth System Science Data*, 16(2):1083–1106, 2024. doi:10.5194/essd-16-1083-2024.

[26] P. Vajda, J. Bódi, A. G. Camacho, J. Fernández, R. Pašteka, P. Zahorec, and J. Papčo. Gravimetric inversion based on model exploration with growing source bodies (Growth) in diverse earth science disciplines. *AIMS Mathematics*, 9(5):11735–11761, 2024. doi:10.3934/math.2024575.

[27] P. Vajda, A. G. Camacho, and J. Fernández. Benefits and Limitations of the Growth Inversion Approach in Volcano Gravimetry Demonstrated on the Revisited 2004–2005 Tenerife Unrest. *Surveys in Geophysics*, 44(2):527–554, 2023. doi:10.1007/s10712-022-09738-9.

[28] P. Varga, E. Győri, C. Fodor, and G. Timár. An Attempt to Determine the Magnitudes and Epicenters of Significant Historical Earthquakes in the Pannonian Basin. *Seismological Research Letters*, 2023. doi:10.1785/0220220161.

[29] P. Varga, E. Győri, C. Fodor, and G. Timár. The Tragic TURKISH–SYRIAN Earthquakes of 6 February 2023 and the Importance of Research of Historical Seismological Events. *Magyar Tudomány*, 2023. doi:10.1556/2065.184.2023.11.10.

[30] V. Volkov, M. Dubrov, I. Larionov, J. Mrlina, V. Polak, D. Aleksandrov, and S. Golovachev. Atmosphere and Lithosphere Interaction Could Triggered the 2023 Mw 7.8 Turkey Earthquake. *Springer Proceedings in Earth and Environmental Sciences*, pages 121–130, 2023. doi:10.1007/978-3-031-50248-4_13.

[31] M. Weigelt, A. Jäggi, U. Meyer, D. Arnold, T. Mayer-Gürr, F. Öhlinger, K. Sośnica, S. Ebadi, S. Schön, and H. Steffen. Bridging the gap between GRACE and GRACE Follow-On by combining high–low satellite-to-satellite tracking data and satellite laser ranging. *Journal of Geodesy*, 98(9), 2024. doi:10.1007/s00190-024-01888-5.

[32] L. Xiang, H. Steffen, and H. Wang. Comparison of Terrestrial Water Storage Changes in the Tibetan Plateau and Its Surroundings Derived from Gravity Recovery and Climate Experiment (GRACE) Solutions of Different Processing Centers. *Remote Sensing*, 15(22):5417, 2023. doi:10.3390/rs15225417.

[33] L. Xiang, H. Wang, H. Steffen, L. Jiang, Q. Shen, L. Jia, Z. Su, W. Wang, F. Deng, B. Qiao, H. Cui, and P. Gao. Two Decades of Terrestrial Water Storage Changes in the Tibetan Plateau and Its Surroundings Revealed through GRACE/GRACE-FO. *Remote Sensing*, 15(14):3505, 2023. doi:10.3390/rs15143505.

4 Sub-commission 3.2: Volcano Geodesy

(joint with IAVCEI)
Chair: Susanna Ebmeier (UK)
Vice-Chair: Matthew Head (USA)

https://geodesy.science/com3/structure/sub-commissions/sc-3-2/

Activities during the period 2023-2025

2025 marks the first decade of the European Space Agency's Sentinel-1 mission. This open and systematically acquired imagery has facilitated advances in the way that SAR, and especially InSAR, can support volcano monitoring. Volcano observatories are increasingly using InSAR data as part of their monitoring streams, especially to measure deformation at high magma flux basaltic systems. Emerging themes in volcano geodesy research, in part driven by an abundance of reliable data, include automation of InSAR processing and analysis, and the continued development of machine learning applications for detection and classification. Long term deformation time series have also motivated research into the impacts of poro(visco)elastic rheologies on deformation. Significant events for the volcano geodesy community over the past two years have included the continuation of unrest and eruption on the Reykjanes Peninsula, unrest at Santorini and a major dyke intrusion near Fentale, Ethiopia. Our focus as a sub-commission over the coming year will be the development of a decadal plan for volcano geodesy. We aim for this to be a collaborative community effort that will motivate discussion and collaboration for both researchers and volcano observatory scientists.

Meetings and Special Sessions

- **IAVCEI Assembly, Rotorua, New Zealand, February 2023:** "Geodetic attractions: Observations and interpretations of deformation and gravity change at active volcanoes"
- **IAVCEI Assembly, Rotorua, New Zealand, February 2023:** "Global applications of volcano geodesy"
- **EGU General Assembly, Vienna, Austria, April 2023:** "Volcanic processes: Tectonics, deformation, geodesy, unrest (20-year anniversary)" – 20 oral presentations, 19 poster presentations;
- **IUGG Meeting, Berlin, Germany, July 2023:** "Studying and monitoring volcanic processes through volcano geodesy techniques, approaches and realistic modelling" - 12 oral presentations, 10 poster presentations;
- **AGU Fall Meeting, San Francisco, USA, December 2023:** "Global applications of volcano geodesy" – 7 oral presentations, 16 eLightning presentations, 13 poster presentations;
- **Cities on Volcanoes, Antigua, Guatemala, February 2024:** "Multi-scale and multi-parametric geodetic monitoring and modelling for studying and forecasting volcanic activity" - 9 oral presentations, 18 poster presentations;

- **EGU General Assembly, Vienna, Austria, April 2024:** "Volcanic processes: Tectonics, deformation, geodesy, unrest" – 20 oral presentations, 24 poster presentations
- **AGU Fall Meeting, Washington DC, USA, December 2024 :** "Global applications of volcano geodesy" – 9 oral presentations, 13 poster presentations;
- **EGU General Assembly, Vienna, Austria, April 2025:** "Volcanic processes: Tectonics, deformation, geodesy, unrest" – 14 oral presentations, 16 poster presentations
- **IAVCEI Assembly, Geneva, Switzerland, June/July 2025:** "Movin' on up: Volcano geodesy applications and advances"

Peer-reviewed Publications

[1] M. Abdallah, X. Ding, S. Younis, and S. Wu. A novel lightweight 3d cnn for accurate deformation time series retrieval in mt-insar. *Science of Remote Sensing*, 11:100206, 2025.

[2] M. Abdallah, S. Younis, S. Wu, and X. Ding. Automated deformation detection and interpretation using insar data and a multi-task vit model. *International Journal of Applied Earth Observation and Geoinformation*, 128:103758, 2024.

[3] B. Ahadov, E. Fielding, and F. Kadirov. Far-field earthquake-induced crustal deformation and mud volcano activity in azerbaijan based on the insar technique. *Remote Sensing*, 17(8):1421, 2025.

[4] F. Albino, S. Gremion, V. Pinel, P. Bouygues, A. Peltier, F. Beauducel, J.-L. Froger, and Agus Budi Santoso. Benefits of gnss local observations compared to global weather-based models for insar tropospheric corrections over tropical volcanoes: Case studies of piton de la fournaise and merapi. *Journal of Geophysical Research: Solid Earth*, 130(4):e2024J, 2025. B028898.

[5] J. A. Albright and P. M. Gregg. Building a better forecast: Reformulating the ensemble kalman filter for improved applications to volcano deformation. *Earth and Space Science*, 10(1):e2022E, 2023. A002522.

[6] R. Alshembari, J. Hickey, K. Pascal, and R. Syers. Declining magma supply to a poroelastic magma mush explains long-term deformation at soufriere hills volcano. *Earth and Planetary Science Letters*, 631:118624, 2024.

[7] K. R. Anderson and M. Gu. Computationally efficient emulation of spheroidal elastic deformation sources using machine learning models: A gaussian-process-based approach. *Journal of Geophysical Research: Machine Learning and Computation*, 1(3):e2024J, 2024. H000161.

[8] K. R. Anderson, T. Shea, K. J. Lynn, E. K. Montgomery-Brown, D. A. Swanson, M. R. Patrick, others, and C. A. Neal. The 2018 eruption of kīlauea: Insights, puzzles, and opportunities for volcano science. *Annual Review of Earth and Planetary Sciences*, 52, 2024.

[9] M. Angarita, R. Grapenthin, S. Henderson, M. Christoffersen, and K. R. Anderson. Versatile modeling of deformation (vmod) inversion framework: Application to 20 years of observations at westdahl volcano and fisher caldera, alaska, us. geochemistry, geophysics, geosystems, 25(4), e2023gc011341. 2024.

[10] Y. Aoki. Forecasting the fate of vertically propagating dikes from geodetic data. *Earth, Planets and Space*, 76(1):65, 2024.

[11] Y. Aoki. Measuring volcano deformation with gnss. In Y. Aoki and C. Kreemer, editors, *GNSS Monitoring of the Terrestrial Environment*, chapter 7, pages 129–159. Elsevier, 2024.

[12] A. Astort, E. Trasatti, L. Caricchi, M. Polcari, P. De Martino, V. Acocella, and M. A. Di Vito. Tracking the 2007–2023 magma-driven unrest at campi flegrei caldera (italy). *Communications Earth & Environment*, 5(1):506, 2024.

[13] P. A. E. Bedón, S. K. Ebmeier, J. R. Elliott, T. J. Wright, P. Mothes, V. Cayol, others, and D. Andrade. Co-eruptive, endogenous edifice growth, uplift during 4 years of eruption at sangay volcano, ecuador. *Journal of Volcanology and Geothermal Research*, 454:108147, 2024.

[14] T. Beker, H. Ansari, S. Montazeri, Q. Song, and X. X. Zhu. Deep learning for subtle volcanic deformation detection with insar data in central volcanic zone. *IEEE Transactions on Geoscience and Remote Sensing*, 61:1–20, 2023.

[15] M. J. Bemelmans, J. Biggs, M. Poland, J. Wookey, S. K. Ebmeier, A. K. Diefenbach, and D. Syahbana. High-resolution insar reveals localized pre-eruptive deformation inside the crater of agung volcano, indonesia. *Journal of Geophysical Research: Solid Earth*, 128(5):e2022J, 2023. B025669.

[16] M. B. Benito, G. E. Alvarado, M. Marchamalo, J. G. Rejas, P. Murphy, R. Franco, others, and J. Sanchez. Temporal and spatial evolution of the 2021 eruption in the tajogaite volcano (cumbre vieja rift zone, la palma, canary islands) from geophysical and geodetic parameter analyses. *Natural Hazards*, 118(3):2245–2284, 2023.

[17] A. Bevilacqua, A. Neri, P. De Martino, F. Giudicepietro, G. Macedonio, and P. Ricciolino. Accelerating upper crustal deformation and seismicity of campi flegrei caldera (italy), during the 2000–2023 unrest. *Communications Earth & Environment*, 5(1):1–14, 2024.

[18] A. Bonforte, G. Aiesi, F. Calvagna, S. Consoli, L. Pruiti, A. Rubonello, and B. Saraceno. Real-time mobile gnss network data acquired during the 2021–2022 unrest at vulcano island. *Bulletin of Volcanology*, 86(4):36, 2024.

[19] A. Bonforte, S. Gambino, R. Velardita, and L. Privitera. Review of early ground deformation observations by electronic distance measurements (edm) on active sicilian volcanoes: valuable data and information for long-term analyses. *Journal of Geodesy*, 98(6):60, 2024.

[20] C. Braitenberg. Monitoring the hunga volcano (kingdom of tonga) starting from the unrests of 2014/2015 to the 2021/2022 explosion with the sentinel 1-2 and landsat 8-9 satellites. *Frontiers in Earth Science*, 12(1373539):13, 2024.

[21] V. Bruno, B. Di Lieto, S. Gambino, M. Mattia, D. Messina, L. Privitera, P. Romano, and M. Rossi. Thirty years of ground deformation monitoring at stromboli volcano. *Scientific Data*, 12(1):534, 2025.

[22] L. Cabrera, A. Ardid, I. Melchor, S. Ruiz, B. Symmes-Lopetegui, J. Carlos Báez, others, and S. Cronin. Eruption forecasting model for copahue volcano (southern andes) using seismic data and machine learning: A joint interpretation with geodetic data (gnss and insar). *Seismological Research Letters*, 95(5):2595–2610, 2024.

[23] M. Camejo-Harry, K. Pascal, P. Euillades, R. Grandin, I. Hamling, L. Euillades, others, and M. Jo. Monitoring volcano deformation at la soufrière, st vincent

during the 2020–21 eruption with insights into its magma plumbing system architecture. *Geological Society, London, Special Publications*, 539(1):41–62, 2024.

[24] D. Carbone, F. Cannavò, C. P. Montagna, and F. Greco. Gas buffering of magma chamber contraction during persistent explosive activity at mt. etna volcano. *Communications Earth & Environment*, 4(1):471, 2023.

[25] Y. Cheng and R. Grapenthin. The alaska makushin volcano 2016–2018 inflation and its potential relation to the 2020 earthquake swarm, from gnss observations. *Journal of Volcanology and Geothermal Research*, 446:108010, 2024.

[26] M. S. Christoffersen, R. Grapenthin, M. Angarita, R. C. Aster, J. Chaput, and P. R. Kyle. Inferring eruption dynamics from seismometer tilt: A case study of erebus and augustine volcanoes. *Journal of Geophysical Research: Solid Earth*, 130(4):e2024J, 2025. B030657.

[27] M. Clunes, J. Browning, C. Marquardt, J. Cortez, K. Drymoni, and J. Kavanagh. Inclination and heterogeneity of layered geological sequences influence dike-induced ground deformation. *Geology*, 51(3):278–283, 2023.

[28] J. Crozier, L. Karlstrom, E. Montgomery-Brown, M. Angarita, V. Cayol, M. G. Bato, others, and Y. Zhan. Understanding the drivers of volcano deformation through geodetic model verification and validation. *Bulletin of Volcanology*, 85(12):74, 2023.

[29] N. Daud, D. S. Stamps, K. H. Ji, E. Saria, M. H. Huang, and A. Adams. Detecting transient uplift at the active volcano ol doinyo lengai in tanzania with the tzvolcano network. *Geophysical Research Letters*, 51(13):e2023G, 2024. L108097.

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5 Sub-commission 3.3: Earth Rotation and Geophysical Fluids

Chair: Sigrid Böhm (Austria)
Vice-Chair: Christopher Dieck (USA)

https://geodesy.science/com3/structure/sub-commissions/sc-3-3/

Activities during the period 2023–2025

Members and affiliates of Sub-commission 3.3 have been involved in the organization of scientific meetings and workshops related to Earth rotation and/or geophysical fluids:

- **EGU General Assembly 2023, Vienna, Austria, 23–28 April 2023**
  Session G2.3: Global Geodetic Observing System with a special focus on Earth Rotation. Conveners: Kosuke Heki, Florian Seitz, Alberto Escapa, David Salstein, Allison Craddock, Helene Wolf (Sigrid Böhm was involved in the session organization but is not listed as a convener due to session merging).
- **26th European VLBI Group for Geodesy and Astrometry (EVGA) Working Meeting, Bad Kötzting, Germany, 11–15 June 2023**
  Scientific organizing committee: Simone Bernhart, Sigrid Böhm, Susana Garcia-Espada, Rüdiger Haas, Karine Le Bail, Daniela Thaller, Vincenza Tornatore, Nataliya Zubko.
- **IUGG 2023, Berlin, Germany, 11–20 July 2023**
  G04: Earth Rotation and Geodynamics. Conveners: Janusz Bogusz, Chengli Huang, Severine Rosat, Michael Schindelegger.
- **EGU General Assembly 2024, Vienna, Austria, 14–19 April 2024**
  Session G3.3: Earth Rotation: Theoretical aspects, temporal variability, physical interpretation, and prediction. Conveners: Justyna Śliwińska-Bronowicz, Sigrid Böhm, Alberto Escapa, David Salstein, Florian Seitz.
- **27th European VLBI Group for Geodesy and Astrometry (EVGA) Working Meeting, Matera, Italy, 6–11 April 2025**
  Scientific organizing committee: Simone Bernhart, Sigrid Böhm, Susana Garcia-Espada, Rüdiger Haas, Maria Karbon, Karine Le Bail, Vincenza Tornatore, Nataliya Zubko.
- **EGU General Assembly 2025, Vienna, Austria, 27 April–2 May 2025**
  Session G3.2: Earth Rotation: Theoretical aspects, temporal variability, physical interpretation, and prediction. Conveners: Florian Seitz, Sigrid Böhm, Alberto Escapa, Justyna Śliwińska-Bronowicz, David Salstein.
- **IAG Scientific Assembly 2025, Rimini, Italy, 1–5 September 2025**
  Session G04-3: Monitoring and Modelling of Earth Orientation Parameters Across Temporal Scales. Conveners: Henryk Dobslaw, Sigrid Böhm, Sadegh Modiri, Jolanta Nastula, Chengli Huang

Selected peer-reviewed publications

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6 Sub-commission 3.4: Cryospheric Deformation

(joint with IACS)
Chair (IAG): Karen Simon (Canada)
Chair (IACS): Matthias Willen (Germany)
Vice-Chair: Carsten Ludwigsen (Denmark)

https://geodesy.science/com3/structure/sub-commissions/sc3-4/
https://cryosphericsciences.org/activities/joint-commissions/

Activities during the period 2023-2025

Co-organizing workshop on Glacial Isostatic Adjustment

Subcommission 3.4 members have been actively involved in the organization of an international workshop on GIA, to take place in Sidney, BC, Canada, from June 2-June 6, 2025. The workshop hosted 88 in-person and more than 70 virtual attendees from a variety of international, national, and local institutions, and followed a format of talks, posters, mini-workshops, and a one-day field trip. Almost two-thirds of the attendees were early career scientists, and one-third identified themselves as non-male. The Scientific Organizing Committee consists of several collaborators from various institutions, and they have been contributing to the organization of the meeting (https://polenet.org/2025-gia-workshop/). Funding for early career scientists to attend the workshop was made possible by various organisations, e. g., IUGG. Support is also expected from the joint partner of sub-commission 3.4, IACS, which will include IACS co-sponsoring of a social meet up event specifically for early career researchers. A summary of activities/outcomes will be made available on the workshop website after the meeting has concluded.

Online seminar Series "Talks on GIA"

In summer 2024, an online seminar series was re-initiated together with SCAR INSTANT and PALSEA, with the chairs of SC3.4 in charge of organizing the seminars. The online seminar series “Talks on GIA” aims to be a low-barrier online exchange format for the highly multifaceted community around GIA. The seminar series is community driven and not, like other online seminars, organized by a specific institution. The seminar series builds on earlier seminar series that were initiated during the Covid pandemic. Today, this format complements the return of in-person exchange formats such as conferences and workshops. The online seminars are an offer for the entire global community and allow the community to exchange without financial barriers. The design of the individual seminars was chosen in such a way that, wherever possible, a tandem of a more experienced researchers and an early career scientists give a coordinated presentation. This makes it possible to offer a stage to early career researchers to present their work and put it up for discussion, alongside people who are already better known in the community. In addition, the presentations in this format allow aspects to be presented in more detail than is possible, for example, with oral presentations at conferences. Presentations by the tandems usually lasted

around 40 minutes, followed by 10 to 20 minutes of discussion. Around 30 to 40 people have attended online each of the previous seminars. The seminars were recorded and the recordings were made available to the community for asynchronous viewing. The number of views of the recordings spreads from 61 to 224.

- 2024-06-20: Mirko Scheinert and Eric Buchta
  "Three decades of continent-wide geodetic GNSS observations to support GIA and geodynamic research in Antarctica"
  Link to the recording
- 2024-10-24: Meike Bagge and Volker Klemann
  "Motives to model GIA – foci, ingredients and current research directions"
  Link to the recording
- 2024-11-19: Sophie Coulson and Roland Bürgmann
  "Climate-Driven Solid-Earth Deformation and Earthquake Activity: The Case for GIA-Modulation of Recent Seismicity along the Northern Mid-Atlantic Ridge"
  Link to the recording
- 2025-01-29: Lambert Caron
  "Modeling mantle rheology between the seismic and post-glacial rebound time scales: the Extended Burgers Material"
  Link to the recording
- 2025-02-25: Valentina R. Barletta and Danjal L. Berg
  "GNSS constraints for GIA in Greenland"
  Link to the recording
- 2025-05-22: Wouter van der Wal and Caroline van Calcar
  "Antarctic mantle viscosity" and "Bedrock uplift reduces Antarctica's future contribution to sea level rise when using 3D mantle viscosity maps"
  Link to the recording

Collaboration with other community efforts and IAG activities

As a crucial point of the subcommission's ToR is to improve the accessibility of GIA modeling results and GIA-related observational data. There is currently no central repository for this and researchers have to invest a lot of effort in gathering all the ingredients to pursue studies related to GIA. We see this as a major barrier for investigating GIA-related topics in the future. Roger Creel and other researchers from the GIA community, including the subcommission chairs, have therefore launched the 'GIAMachine' initiative, analogous to 'SubMachine' or 'BedMachine', i.e. a model and data archive. Chairs of the subcommission have attended preparatory meetings and are co-organizing a mini-workshop at the workshop on Glacial Isostatic Adjustment (see above), where further specific steps will be coordinated within the community in order to become this initiative reality.

One of the sub-commission chairs, is a member of the IAG JWG C10 Tailored Parameterization Strategies for Climate Applications of Satellite Gravimetry. A key challenge in evaluating satellite gravimetry data is the consideration of effects due to GIA. Previous modeling results still differ significantly and the uncertainty about GIA propagates to GRACE-based estimates of ocean mass contributions to sea level. The

subcommission explicitly endorses novel concepts for the parameterization of GIA effects. The sub-commission chair has already given a presentation on GIA parametrization strategies at a meeting of the JWG C10 on the 2025-04-30. In addition, one of the subcommission chairs is a member of the IAG JWG 1.2.3, which has some themes that are complementary to those of the sub-commission.

Several topics related to the subcommission's ToR are closely related to the objectives of the JSG 3.1 on "Model representation and geodetic signature of solid-Earth rheology in surface loading problems". We carry out many activities (e.g., session organization) in collaboration with the chairs of the JSG.

Co-organizing sessions at international conferences

As a sub-commission, we were also actively involved in organizing sessions at the General Assembly of the European Geoscience Union (EGU) in spring 2024 and spring 2025. In order to have enough contributions to realize oral presentations, we cooperated with partners. In 2024, this was with the community around deformation of the solid Earth, e.g. by tides. In 2025, we joined forces with the hydrogeodesy community dealing with solid-Earth deformation due to hydrological variations. In addition to the EGU sessions that have already taken place, we are co-organizing a session on GIA topics at IAG2025 in Rimini.

- EGU 2024 (G3.4, co-organized by CR5/GD7)
  "Leveraging Glacial Isostatic Adjustment and other Solid-Earth Deformation Processes for Exploring Earth's Interior"
  Conveners: Holger Steffen, Hilary Martens, Hugo Boulze, Federico Daniel Munch, Anastasia Consorzi, Jun'ichi Okuno, Matthias O. Willen
  Presentations: 10 oral and 15 posters
- EGU 2025 (G3.4, co-organized by HS13)
  "Measuring and modelling solid-Earth deformation induced by changing loads from liquid and frozen water"
  Conveners: Mohammad J. Tourian, Matthias O. Willen, Joëlle Nicolas, Makan Karegar, Francesca Silverii, Holger Steffen, Caroline van Calcar
  Presentations: 10 oral and 16 posters

7 Sub-commission 3.5: Seismogeodesy

(joint with IASPEI)
Chair: Jean-Mathieu Nocquet (France)
Vice-Chair: Masayuki Kano (Japan)

https://geodesy.science/com3/structure/sub-commissions/sc-3-5/

Activities during the period 2023–2025

As a joint Sub-commission between the IAG and IASPEI, SC 3.5 promotes research integrating geodesy and seismology to better understand the behavior of seismic faults and the earthquake cycle. During the 2023–2025 period, the following scientific activities were organized:

- **IASPEI-IAG Joint Symposium "Seismo–Geodesy"**, held during the IUGG General Assembly 2023, was co-convened by Takuya Nishimura (Japan, IASPEI) and Jean-Mathieu Nocquet (France, IAG). The session included three oral sessions (15 talks) and one poster session (7 posters), and highlighted several important research directions:
  - High-resolution kinematics and strain rate mapping of the Earth's crust through the integration of InSAR, GNSS, and field observations
  - Time-dependent deformation and earthquake cycle modeling
  - Emerging sea-floor geodesy experiments to detect slow slip events at offshore faults
  - Investigations of fluid–fault interactions and slip dynamics
  - Machine learning approaches to signal separation
  - Low-cost GNSS deployments and high-rate, real-time applications
- **ESC 2024 Session, Corfu, Greece: "Integrating Geodesy, Seismology and Tectonics"**, convened by Athanassios Ganas (IASPEI) and Jean-Mathieu Nocquet (IAG), focused on quantifying strain accumulation and fault slip throughout the seismic cycle. The session featured 12 oral presentations and 7 posters, with an emphasis on the geodetic data to monitor faults behaviour before, during and after earthquakes.
- **IAG Scientific Assembly 2025, Symposium J03: "Geohazard Monitoring through Geodesy"**, co-organized with IAG/IAVCEI SC 3.2, ICCT, and the GGOS Focus Area on Geohazards, will showcase the role of geodesy in multi-hazard monitoring and early warning systems. Conveners: T. Melbourne, S. Ebmeier, J.-M. Nocquet, M. Kano, and M. Ravanelli.

20th WEGENER Assembly, Sousse, Tunisia (October 2023)

WEGENER Assemblies bring together every two years geoscientists working on crustal deformation and tectonics in the Mediterranean region. The 20th edition was hosted by the Office National des Mines in Sousse, Tunisia, and attracted over 60 participants. A total of 57 abstracts were presented, with strong participation from North African institutions, reflecting growing regional engagement in geodetic monitoring and seismic hazard assessment.

Preparation of the 21st WEGENER Assembly, Tirana, Albania (October 2026)

Preparations are underway for the 21st WEGENER Assembly, to be held in Tirana, Albania. The event will be organized by the Institute of GeoSciences, Polytechnic University of Tirana, under the umbrella of SC 3.5.

The Sub-commission continues to promote the integration of geodetic and seismic observations to advance our understanding of fault mechanics and to support natural hazard mitigation efforts.

8 Working Group 3.1: Hydrologic signature in geodetic observations

Chair: Carla Braitenberg (Italy)
Vice-Chair: Grace Carlson (USA)

https://geodesy.science/com3/structure/wg-3-1/

Activities during the period 2023-2025

1) **Objectives subthemes definition**
   We have commenced to approach the four objectives. In particular we have identified the themes into which the objectives are broken:
   - Obj 1: Define the physical mechanisms that generate hydrologic signals in geodetic observations.
     a) Loading of the crust through the added mass
     b) Deformation through poro-elastic deformation
     c) Deformation through overpressure as occurrs in Karstic underground water channels.
     d) Change in groundwater head - Example Amatrice 2016 earthquake
   - Obj 2: Define best practices for forward modeling of hydrologic effects that may be present in geodetic observations. To be defined
   - Obj 3: Identify spatiotemporal scales at which geodetic observation may be sensitive to different hydrologic processes. Geodetic observations which could be affected:
     a) Space-geodetic observation of Deformation
     b) Terrestrial deformation measurements (tiltmeters, extensometers).
     c) Gravity measurements terrestrial
     d) Gravity measurements from space
   - Obj 4: Identify pitfalls to prevent the wrong identification of signals as for instance earthquake precursors or differentiating signals of man-made from natural fluid fluxes.
     a) L'Aquila 2009 earthquake- precursor versus hydrologic induced deformation

2) **Relevant publications**
   We have started assembling relevant publications. The existing literature is our starting point to set a framework for the best practices correcting hydrologic effects in geodetic observations. We plan to set up a website including
   a) List of relevant publications
   b) List of relevant software
3) **Participation in Meetings**
   Active participation of Members of the Working group to meetings as: 20th International Symposium on Geodynamics and Earth Tides (G-ETS) held on August 25-30, 2024 in Strasbourg, France. IAG Scientific Assembly 2025, Rimini, Italy, 1–5 September 2025
4) **Install Survey Form**
   We set up a Survey form which is intended for WG 3.1 members and interested scientists in which we ask to present recommended modeling tools and publications relevant for the topic of hydrologic effects in deformation and gravity. We also ask to present names of interested scientists to present at a fall seminar series on the topic of WG 3.1.

9 Joint Working Group 3.1: Consistent improvement of the Earth's rotation theory

(joint with IAU)
Chair: José M. Ferrándiz (Spain)
Vice-Chair: Chengli Huang (China)

https://geodesy.science/com3/structure/jwg-3-1/

Activities during the period 2023-2025

The formal approval of the JWG 3.1 by the A2 Commission of the International Astronomical Union (IAU) finally took place in March 2025, quite late compared to the usual because instead of discontinuing the previous JWG 3.1 (ITMER) at the same time as the IAG did at the 2023 General Assembly, the A2 Organizing Committee decided to wait until the IAU General Assembly in August 2024 to finalize it and start the approval process for the new one. In the IAU structure, Chengli Huang is the Chair and José Ferrándiz the Vice-Chair, IAU members are considered as JWG members and non-IAU members as associate members. Naturally, these formal differences do not affect the operation of the JWG.

In order to publicize the purposes and structure of the JWG, as well as its activities, the most recent advances in a selection of its fundamental objectives have been presented at major congresses, such as the IAU General Assembly of 2024, the 2024 Fall Meeting of the American Geophysical Union, the European VLBI General Assembly (EVGA) of 2025, and the General Assemblies of 2024 and 2025 of the European Geosciences Union (EGU). Our members have also collaborated in the organization of sessions of these scientific meetings with IAU Commission A2, with GGOS and of

course with our IAG parent, this Commission 3. We can also highlight that there have been invited and regular presentations on some of the most relevant working topics for the group in these congresses as well as in the future IAU Symposium 401 to be held in August 2025 in Argentina.

Among the scientific advances of this period we can highlight the research on the effects of changes of terrestrial reference frames on the Earth Orientation Parameters (EOP), whose study has been almost obligatory because in December 2024 the extension of the ITRF 2020 was published and because the effects of the study of celestial reference frames constructed from the observation of sources at different wavelengths is a hot topic. A new CRF including proper motions of sources has also been developed and some novel effects such as the impact of correlation of VLBI data on EOP solutions have been deepened. Temporal densification of these solutions is important to advance the understanding of the current definitions of polar motion (PM) and precession/nutation. Although once the development of VGOS is sufficiently advanced, the technique will allow EOPs to be determined with a daily or higher cadence, this is still quite some years away due to the insufficient number of operational stations and their geographical distribution, and the need to adequately augment other complementary infrastructures, e.g. those for correlation of observations.

On the other hand, among the more theoretical aspects from the dynamical point of view, better approximations of the equations relating the PM to its excitation functions have been developed, which of course increase consistency and are promising, although it is still too early to assess its practical impact on the accuracy. Another remarkable advance is that all the important elements for renewing the theory of precession, both first and second order effects, are now sufficiently well studied as well as the fitting of the main precession parameters to the observations. An important element that appears as a result of the study of precession is the need to revise the standard models of the dynamic ellipticity or flattening H, which also has a direct impact on nutation since H is a factor of its amplitude. Decisions on such a revision are desirable to be taken in consensus with the IAU Commissions A2 and A3, and of course with the IERS and the GGOS Bureau of Products and Standards (BPS).

The upcoming 2026 IERS/GGOS Unified Analysis Workshop (UAW) may be a place to begin to establish such consensuses. Making an early decision on the future model of dynamical ellipticity is important, since at present H is considered a constant in nutation theory, a linear function in precession theory, and fits a quadratic function from J2 observations. Maintaining different models for H would mean maintaining inconsistencies between precession and nutation and thus systematic errors.

Some models of the Earth's interior have also been refined. From a practical point of view, it is important to note the improvement of the theoretical determination of the Chandler period, which is the most important free wobble of the Earth's rotation axis. The difference between the theoretical explained value and the observed one, which used to reach several tens of days, has been considerably reduced. Many other advances in the modeling of the Earth's interior have so far not had such a clear evaluable impact on the observed EOPs and it seems we will have to wait longer before they can be implemented as standards in operations.

Progress has also been made in the semi-empirical correction of the official nutation models and of the Free Core Nutation (FCN) models. Briefly we can say that the

WRMS of the time series of each Celestial Pole Offset (CPO) can be drastically reduced by correcting the precession linear component and the amplitudes of a few terms of the lunisolar forced nutation and planetary forced nutation, together with using a consistent FCN model, the WRMS value decreasing from about 180 microarcseconds to about 80 in the IVS series along the interval 1984-2024. It should also be noted that part of this improvement is achieved by introducing purely theoretical corrections for planetary nutations of a non-rigid earth. So far the theoretical amplitudes of the planetary terms have not be fitted to the observations and therefore only a very restricted part of the planetary terms whose amplitudes cannot be empirically fitted because of the proximity of their frequencies to that of the FCN have been used.

As the SC 3.3 section of this report contains a very complete list of references, we have considered that it is not appropriate to include a publication list in this section.

10 Joint Study Group 3.1: Model representation and geodetic signature of solid-Earth rheology in surface loading problems

(joint with Commission 1 and Commission 2)
Chair: Lambert Caron (USA)
Vice-Chair: Rebekka Steffen (Sweden)

https://geodesy.science/com3/structure/jsg-3-1/

Activities during the period 2023-2025

Benchmarking Initiatives

A significant focus for the activities of the JSG group was to kickstart the development and coordination of benchmarking activities aimed at advancing geophysical modeling standards and facilitating the validation of new and existing codes in the community. Initial efforts focused on community engagement, culminating in the collection of preliminary feedback and the compilation of a confirmed list of participant groups. A first draft of benchmark tasks and associated evaluation metrics was established, laying the foundation for standardized comparative analysis. Notably, synergistic collaboration with the SCAR-INSTANT program allowed us to harmonize benchmark protocols for compressible and transient rheology models with ongoing efforts for three-dimensional Earth simulations. This collaborative framework aims to ensure consistency and comparability across benchmarking efforts within the GIA community. To engage with more scientists, the JSG co-organized a thematic workshop on this topic as part of the GIA 2025 meeting in Sidney, BC, Canada.

GIAmachine Development

Results of GIA models and benchmarks are rarely open accessible, which makes a comparison and usage of the datasets very difficult. To overcome this challenge, this

JSG, the SC3.4 and the PALSEA-Next (PALeo constraints on SEA level rise) group have joined forces to create a database that will allow the distribution of GIA modelling results with the entire scientific community. The database is called GIAmachine and will have a graphic interface to plot the results as well as to be able to download the data. All GIA modellers are invited to contribute to the database with their own data.

Community Engagement and Leadership

Community outreach and scientific leadership has been realized through the organization and support of scientific sessions at international conferences. Noteworthy activities include:

- Chairing the session "Interaction Between Geodynamic, Surface, and Climate Processes Through Space and Time" at the 2024 American Geophysical Union (AGU) Fall Meeting.
- Co-organization of the IAG 2025 session titled "Geodetic Constraints and Modeling of Glacial Isostatic Adjustment and Cryospheric Deformation Across Time Scales."
- Co-organization of the 2025 Glacial Isostatic Adjustment (GIA) Workshop held in Sidney, British Columbia (https://polenet.org/2025-gia-workshop/). See Activities listed in the report of SC3.4.

These activities have facilitated interdisciplinary dialogue, fostered collaboration across research communities, and promoted the integration of geodetic, geodynamic, and cryospheric research.