



Nordiska kommissionen för Geodesi Nordic Geodetic Commission

Working Group for Geodynamics and Earth Observations
(WGGE0)

Draft of the Minutes of the 49th meeting of the Working Group for Geodynamics and Earth Observations, within the Nordic Geodetic Commission

The hybrid WGGE0 meeting was hosted by Kartverket on 11 and 12 March 2025. It was organized together with the hybrid meeting of the Working Group of Height and Geoid (WGHG) on 12 and 13 March 2025. WG meetings were held in Meeting room 1&2 at the new Kartverket office, Drammensveien 151, in Oslo, Norway. Combined National Reports for the WG meetings were given at the WGGE0 meeting, the InSAR session was part of the WGHG meeting (see these minutes for information).

Participants (46, 28 in person (p), 18 online (o), *Guests in italics*):

- Denmark Tim E. Jensen (p), Kristian Keller (o), Jonathan F. Kirby (p), Stefan Krebs Lange-Willman (p), Biao Lu (o), Aslak Meister (p), Gabriel Strykowski (p)
- Estonia Tarmo Kall (o), Karin Kollo (o), Aleksei Kupavõh (p), Tõnis Oja (o), Andres Rüdja (o), Sander Varbla (p)
- Faroe Islands Hergeir Teitsson (p)*
- Finland Mirjam Bilker-Koivula (p), Pasi Häkli (o), Jaakko Mäkinen (o), Maaria Nordman (p), Timo Saari (p), Aino Schulz (p)
- Germany Christian Gerlach (o)*
- Iceland Guðmundur Valsson (p)
- Latvia Jānis Sakne (p), Vents Zuševics (p)
- Norway Kristian Breili (Secretary, p), Clinton P. Conrad (o), Michael S. Dähnn (p), John Dehls (p), Halfdan Pascal Kierulf (p), Ove Christian Dahl Omang (p), Vegard Ophaug (p), Olav Vestøl (p)
- Poland Przemysław Dykowski (o), Kamil Łapiński (o), Małgorzata Szelachowska (p)*
- Sweden Jonas Ågren (p), Anders Alfredsson (p), Mohammad Bagherbandi (o), Andreas Engfeldt (p), Faramarz Nilfouroushan (p), Tobias Nilsson (o), Tong Ning (o), Per-Anders Olsson (o), Chrishan Puwakpitiya Gedara (o), Holger Steffen (Chair, p), Rebekka Steffen (o)

1. Introduction

The Chair welcomed all participants to the meeting.

The updated Agenda, version 7 March 2025, was approved unanimously.

The participants of the meeting were invited to comment on the Minutes from the previous 48th hybrid meeting hosted by Landmaelingar Íslands in conjunction with the NKG Science Week in Reykjavík on 14 March 2024. There were no comments and thus the Minutes were approved unanimously. The Chair uploaded the Minutes to the WG's website: <https://www.nordicgeodeticcommission.com/working-group-of-geodynamics/reports-and-documents/>

Kristian Breili (Norway) was appointed as Secretary. Next year, in the absence of members from Lithuania, it will be Sweden's turn.

The Chair repeated WGGEO's vision and goals, as well as its milestones for the 2022–2026 period. Regarding the latter, the agenda was adjusted to accommodate each milestone and sufficient time for discussion. The following news were forwarded from the NKG Presidium:

- The NKG Summer School 2025 is organized in Tartu, Estonia, with the theme “From Struve to the Space”. The meeting call has been distributed. More information and registration can be found here: <https://www.emu.ee/en/events/nkg-summer-school-from-struve-to-the-space>
- The next NKG General Assembly will be held in Lithuania in 2026.
- NKG Awards are coming. A designated WG discussed the nomination guidelines. The first NKG Young Scientist Award will be presented at the Summer School 2025. An announcement will be made in early April, likely with a deadline early May. The first “Lifetime Contribution” Award (name tbd) will be presented at the GA 2025.
- The Presidium discussed the matter of national points of contact for NKG. Presidium Members are national contact points. Each country can organize as it fits. Latvia, for example, founded a national NKG group with own bylaws.
- The Presidium acknowledged the good work of the WG.
- Next presidium meeting is planned tentatively in spring 2025, online.

2. Geodynamics

- Clinton P. Conrad (invited, online): “Rapid Ground Motion Driven by Deglaciation Above the Iceland Plume”

There is ongoing a rapid uplift along the coast of Greenland, i.e., more than 2 cm/a at several stations. Rapid deglaciation above low-viscosity mantle drives rapid uplift (several cm/a). Observations of Holocene sea level change may help us predict which coastlines will uplift rapidly in the future. Mantle complexity strongly impacts modelled GIA uplift.

- Mohammad Bagherbandi, Lars E. Sjöberg, Mahmoud Abd El Gelil and Ismael Foroughi (online): “Relationship between surface gravity and height changes due to glacial isostatic adjustment using GRACE and GRACE-FO in Fennoscandia and Canada”

The main motivation for this study was to investigate how accurate GRACE and GRACE-FO data are for determining \dot{g} / \dot{h} . Relative gravimetry measurements, absolute gravimeter observations, and monthly GRACE and GRACE-FO data provide consistent results for \dot{g} / \dot{h} in both Fennoscandia and Canada.

- Yohannes G. Ejigu and Maaria Nordman: “Improving GNSS Data Accuracy: Implementing Non-Tidal corrections at the observation-level in GNSS data”

Corrections to non-periodic atmosphere, ocean, and terrestrial water cycle effects were implemented at the observation-level in GNSS data, i.e., by modifying RINEX files. The observation-based corrections show clear advantages/improvements over the postprocessed corrections in the up component in terms of WRMS reduction. The results were based on PPP-solutions from the PRIDE software. For a presently unknown reason, it was not successful to apply the same method together with double differences processed with the GAMIT software.

- Aino Schulz: “Non-tidal loading in GPS time series in Dronning Maud Land, Antarctica”

This presentation focused on crustal movements in East Antarctica and presented results from the MoveAnt and DynEAnt projects. The study explored GNSS data from three stations in the east Antarctica and loading data from several sources. Non-tidal atmospheric loading seems to contribute most to the corrections, especially in the up component. There is a smaller contribution from non-tidal ocean loading, while hydrological loading does not seem to improve the results. There is presently no reliable hydrological model for Antarctica.

- Holger Steffen and Rebekka Steffen: “GIAMachine, GIAMIP and HOLSEA – what are they?”

Efforts are being done to create an online platform for accessing GIA products, i.e., the GIAMachine. This work is inspired by SubMachine, which is a collection of web-based tools for interactive visualization, analysis, and quantitative comparison of global-scale, volumetric data sets of the subsurface (see <https://users.earth.ox.ac.uk/~smachine/cgi/index.php>). The main advantage of the GIAMachine will be to have one website for accessing GIA-models. It will reduce the needs for doing Google searches and personal requests to get the models. Also, other projects will create outputs that can be housed on the GIAMachine. GIAMIP, the GIA model intercomparison project, will compare the output of different GIA models, that shall solve are certain input, to assess the model spread and potential uncertainty from GIA model output. It is not a benchmark. HOLSEA is an International Union for Quaternary Research (INQUA) sponsored project with the goal of determining the rates, mechanisms, and geographic variability of sea level over the past approximately 20.000 years. An Excel spreadsheet was developed to provide a uniform format for global RSL data. Many data were provided in the last decade. Now, a community is established on Zenodo and future data can be uploaded there. A web interface will be created that will be linked or included in GIAMachine.

Discussion

- Holger Steffen et al.: “BIFROST2025: Status March 2025”

BIFROST2025 will include GNSS data from northern Europe and northern central Europe over the period 1/1-2000 to 31/12-2024 reprocessed with the GipsyX, GAMIT, and Bernese software. The reprocessing will include more data, more stations, longer time series, and will be based on updated and refined processing standards. The main research objectives are to 1) verify the picture/shape of land uplift, 2) define location of the uplift maximum, 3) determine forebulge locations and subsidence, and 4) identify local anomalies. Uplift rates calculated from the BIFROST2025 solutions will be used as input to the next Nordic land-uplift model (NKG202XLU). There are still some questions to be discussed, e.g. who will analyze the Bernese result and which methods and software will be used for

time series analysis? The coming WGRF meeting in Gävle will likely provide answers. There will be several solutions (three software for GNSS processing and several software for time series analysis). It is to be determined which solution will be used in the new Nordic land-uplift model. It was questioned why Galileo and GLONASS observations are included in the Bernese solution, as this will create inconsistencies with respect to the GPS-only solutions of GAMIT and GipsyX. However, this choice is based on recommendations from the GNSS community.

- Holger Steffen et al.: “NKG2022GIA - Status March 2025”

The activity could not deliver a first test model yet because of computer problems at Lantmäteriet, which caused a delay of 6 months. They are solved for the time being. Among others, a new virtual machine will be tested in April 2025. If successful, it is expected that computer issues do not cause further delays. The model itself is working fine, but it was found that the theory on the rotational feedback and its implementation has some differences depending on the publication (equations with either plus or minus, for example), which can cause differences which are deemed too large compared to the uncertainty of observations. The problem is currently under discussion and will hopefully be solved at the GIA Workshop in Sidney. Apart from that, the activity is on track. Although a large observation dataset is already available to serve as constraint, updates are planned in GNSS (BIFROST processing), relative sea level (HOLSEA database expects update by summer) and the glacially induced faults (update is ongoing after the Postglacial Fault meeting 2024).

3. Gravimetry

- Jaakko Mäkinen, Ivars Liepiņš, Kalvis Salmiņš, Vents Zuševics, Jānis Kaminskis, Reinhard Falk and Mirjam Bilker-Koivula (online): “Repeated relative-gravity measurements down a silo 10 metres deep isolate the gravity effect of local hydrology at the Riga absolute-gravity station”

The objective of the study was to calculate the hydrological influence on gravity measurements at five different heights inside a 10 m deep silo located at Riga Botanic Garden (fundamental geodetic station in Latvia). The model can explain the influence amazingly well. Conclusion: The model is too good to be true.

- Andreas Engfeldt: “A new realization of RG 2000 - the Gravity Reference Frame of Sweden”

The new realization was presented. The updated RG 2000 has been partly realized as preparation to the new Nordic geoid model that will be calculated in 2026. Compared to the previous release of RG 2000, the new realization is based on more absolute and relative gravity measurements and includes some new sites. Many of the absolute gravity measurements were reprocessed with new gravity gradients. The new realization includes data observed between 1975 and 2024.

Discussion

NKG Absolute Gravity Database – Code of conduct: There have been, as expected, no updates in the AG database since the last meeting. A new draft of the agreement on AG data sharing was developed within a group led by Vegard Ophaug and has been presented to the Presidium. The draft was considered excellent, but a bit problematic from the legal perspective. As a less problematic solution, a code of conduct will hopefully be approved in the next presidium meeting. The change

from an agreement to a code of conduct will not have any practical implications. We will continue to share data, save it in the NKG archive, and encourage the instrument owners to submit data. It was questioned why we need this agreement and why we cannot keep the old contract as it is. It was also noted that the NKG AG database is not a real database and should be called a *data archive*.

AG comparison in Onsala 2022 – Status of the report: The report draft was distributed among participants and Mirjam received some comments. All except one major comment by Hans-Georg Scherneck are basically solved. An abstract to IAG 2025 in Rimini is planned and a later manuscript to the corresponding Symposium Series.

Relative gravity lines (“FLUGL”) – Status of the reports: Not much progress since the presentation at the Geodynamics and Earth Tide Symposium in Strasbourg end of August last year. However, a corresponding paper is planned in the Symposium’s special issue. Hence, work will be continued accordingly. Next update will be presented at the WGGE0 meeting 2026.

4. National Reports (WGGE0 and WGHG combined)

It was suggested to change the order of the presentations of the National Reports. It is presently ordered alphabetically. The WG meetings 2026 will have it “rolling”, thus Denmark is moved to the back, and we will begin with Estonia.

Denmark – Agency for Climate Data (Stefan Krebs)

The Danish Agency for Data Supply and Efficiency has changed its name to Agency for Climate Data, which better reflects the tasks the agency performs for the society. It is still the mapping authority of Denmark. A new Continuously Operating Reference Station (CORS) has been established at Jutland (HANK00DNK). There are also plans for installing InSAR corner reflectors near the CORS at Hanstholm and Bejerringbro. New guidelines for private GNSS positioning services providers have been published. The GNET at Greenland has been expanded by four stations at Ilulissat and two on the east coast.

Denmark – DTU (Gabriel Strykowski)

The precision gravity network of Denmark and several sites in the GNET at Greenland were observed with A10. The DTU has invested in a new tent for gravity measurements. A new uplift model from DTU (new GNSS, levelling, and tide gauge data) has been published. The DTU contributed to airborne gravity campaigns along the Norwegian coast and at Svalbard, Norway. As an airborne gravity campaign, DTU completed in 2024 the first science circumnavigation of Antarctica. Plans for 2025 include a new geoid model for Greenland, AQG measurements at KAGA GNET station in August 2025 together with Polish colleagues and more A10 measurements in Denmark.

Estonia – Tallinn University of Technology (Sander Varbla)

The BalMarGrav project has been finalized, aiming at rectifying historic marine gravity data. A new PhD-project deals with the examination of SWOT data for deriving the offshore geoid geometry. There is work in progress on determining a corrector surface for the European height reference surface.

Estonia – Land and spatial development board (Sander Varbla)

A new tool for real-time GNSS interference and quality monitoring of ESTPOS stations has been released. The 2025 NKG Summer School (“From Struve to the Space”) will be held in Tartu, Estonia, 25-29 August 2025.

Faroe Island – Faroese Environment Agency (Hergeir Teitsson)

The Faroese Environment Agency is responsible for mapping on land and sea and production of navigational charts. The Faroese geodetic infrastructure consists of the Faroe Islands Vertical Reference 2009, i.e., a local Faroese physical height system and realization of ETRS89 with the height zero in Tórshavn, one AG station plus land gravity measured from 1960-1970, and a GNSS-network with four CORS. There are plans to update and refine the Faroese geoid model, hopefully with new gravity measurements. The last update was in 2012.

Finland – National Land Survey of Finland (NLS) / Finnish Geospatial Research Institute (FGI) (Mirjam Bilker-Koivula)

The NLS has joined the Multilateral Memorandum of Understanding on Strengthening the Global Geodesy Supply Chain. New funded projects are ScanCloud, DynEAnt and EXQUALIBR (among others together with Aalto University). Precise levelling is ongoing for all FinnRef stations. Repeated AG measurements are performed at 20 stations with AG pillars. The stations are measured regularly every third year. In 2024, 7 were measured. The FG5X-221 is currently for regular maintenance at Micro-g. The Nummela Standard Baseline was successfully measured in September to October 2024. This was the 17th measurements since 1947. The baseline is very stable and is used for calibrating electronic distance measurement instruments. Updates to the EPSG registry and PROJ were made. The new project TarGeOp deals with “Levelling network and geoid model optimization for the future height system”. The objective is to do research and investigations as a basis for the decision on the renewal of the height system. At the Metsähovi observatory, the commissioning of the VGOS system is progressing. There is a contract with DiGOS GmbH to finalize the commissioning of the Metsähovi SLR telescope and SLR system – “on sky” tests are expected to start in Q3/2025.

Finland – Aalto University (Maaria Nordman)

Two master theses in geodesy were completed in 2024. There are five ongoing master theses and six ongoing doctoral theses at the Aalto University. Ongoing research projects deal with underground positioning and non-tidal loading in GNSS time series. Two research projects in Antarctica were funded, namely Crustal movements of the East Antarctica (MoveAnt) and Understanding the Dynamic Earth in East Antarctica with Multitechnique Geodetic Measurements (DynEAnt).

Iceland – Natural Science Institute of Iceland (Guðmundur Valsson)

The Natural Science Institute of Iceland (NSII) is currently the government agency responsible for mapping and geodesy in Iceland. Main projects in 2024 concerned the coordinated establishment of ground control points (GCP) for aerial photogrammetry. 390 points were established in 2023 and 150 points in 2024. The IceCORS stations have been updated with Trimble NetR9 receivers from the Norwegian Mapping Authority. A common reference frame for response and research was established. There is a need to update the ISN2016 and replace ISN93 in the Reykjanes peninsula. There have been

several eruptions in the Reykjanes peninsula in 2023-2025 deforming the reference frame significantly. Planned activities for 2025 include a new datum for Reykjanes and finalizing the GCP network. An InSAR study (including levelling and GNSS measurements) investigates if there is a sea-level rise or subsidence in the harbour area of Reykjavik. There is a need to establish a low tide coastline. The line is important for defining boundaries of properties, but the line has never been defined accurately.

Latvia – Latvia Geospatial Information Agency (Jānis Sakne)

Activities in 2024 included 43.45 km of levelling and deployment of corner reflectors. First test measurements in autumn 2024 indicated that reorientation of the reflectors is necessary. Eight new benchmarks were established in the great network of Latvia. More points are planned to be established in 2025. Geopotential measurements are done in a 4 km x 4 km grid. Gravimetric measurements were performed along the Baltic Sea with dedicated motorized equipment. Declination, inclination, and total intensity of the geomagnetic field in Latvia were measured for maps with scale 1:50.000.

Norway – Kartverket (Ove Omang)

No precise levelling has been done in 2024. This is the first year since 1972 without any levelling in Norway. Plans has been written for how a new vertical reference frame for Norway can be realized. A white paper was written addressing a two-(reference)frame solution for organizing and providing geospatial data in Norway. In cooperation with DTU, airborne gravity campaigns were accomplished at Svalbard and along the Norwegian coast. Approximately 6000 km were observed off the coast of southern Norway. The gimbal and telescope assembly for the SLR in Ny-Ålesund were installed in 2024. The plan is to install the laser in 2025.

Norway – The Norwegian University of Life Sciences (NMBU) (Vegard Ophaug)

Research activities include GIA and absolute gravimetry, glacier mass balance with gravimetry, geoid and height systems, and geodetic oceanography. The SEGREF-project deals with “Sea level, geoid, and geodetic reference frame for sustainable development along the Norwegian coast.” There is currently one PhD student working on this project.

Sweden – Lantmäteriet (Andreas Engfeldt)

Absolute gravity measurements were performed at 8 sites with FG5X-233. Lantmäteriet also took part in the EUREMET comparison in Wettzell. All FG5/FG5X observations have been reprocessed with new gradients Detailed gravity measurements included 885 new measurements. Seven more operators of the Scintrex CG5 have been trained. The plan is to do about 2000 detail gravity measurements in 2025 and include these points in the new NKG geoid model. A new version of RG 2000 was realized with reprocessed and new gravity data. Lantmäteriet has contributed to NKG work (NKG2022GIA, BIFROST2022 and NKG202XLU) and several other external studies. The first IAG Commission 3 (Earth Rotation and Geodynamics) Symposium “TIGER - Tracking and Investigating Geodynamics and Earth Rotation” will be organized in Gävle on 28 September – 1 October 2026 together with the GGOS Topical Meeting on Geohazards (1–2 October) and GGOS Days 2026 (5–7 October). Three corner reflectors were installed in 2024, and two more wait for permission. Two of the active transponders (CAT) broke in 2024, whereas one is still in Italy under repair. A new “Swedish-EGMS” Web service is under development (at SGI). Information on the CRs and CATs were submitted to

SARCalNet and are currently under review. Anders Alfredsson defended his licentiate thesis on 27 September 2024.

Sweden – University in Gävle and Onsala Space Observatory (Holger Steffen)

Mohammad Bagherbandi was excused, so the Chair forwarded that the University in Gävle focused on teaching in 2024. Regarding OSO, a successor for Maxime Mouyen has been found but no name was released yet. The new colleague is supposed to start in May. In the meantime, Hans-Georg Scherneck is taking care of the SG and is analyzing the data. We hope to get an OSO update at the next WGGE0 meeting.

5. Business Matters

Status of the NKG website and mailing list. The [NKG website](#) has been updated further. The NKG logo is back. The Presidium seeks pictures that can be shared. Sign up on the mailing list if you haven't already: https://www.freelists.org/list/nkg_wggeo. Meeting calls will only be distributed via the list. It is possible to post job advertisements!

6. Closing of the meeting

The next meeting in 2026 (week 11) will be held at Tallinn University of Technology (TalTech) in Estonia. Local organizer will be Artu Ellmann.

The Chair thanked the hosts and participants and closed the meeting.