NORDISKA KOMMISSIONEN FÖR GEODESI

NKG Working Group of Height and Geoid (WGHG)
- aka Future Height Systems and Geoid

Draft of the Minutes of the 48th meeting of the Working Group for Height and Geoid, within the Nordic Geodetic Commission.

The hybrid WGGEO meeting was hosted by Landmaelingar Íslands in conjunction with the NKG Science Week on 13 March 2024. It was organized together with the hybrid Workshop on “Geodesy Redefined? - Quantum & AI Insights” on 12 March 2024 and the hybrid meeting of the Working Group of Geodynamics and Earth Observation (WGGEO) on 14 March 2024. WG meetings were held in room Hvammur at the Hotel Reykjavík Grand in Reykjavík, Iceland. Combined InSAR session for the WG meetings were given at the WGGEO meeting.

Date: March 13, 2024
Location: Hotel Reykjavik Grand, Reykjavik, Iceland (Hybrid Meeting)
Chair: Ove Christian Dahl Omang
Secretary: Guðmundur Valsson

---

1. Welcome and Opening

- Chair Ove Christian Dahl Omang welcomed the attendees.
- **Approval of the agenda**.
    1. Agenda approved
- **Review and approval of the previous meeting minutes** (Aalto 2023).
    1. Correction of typos by Mariaa Norman.
- **NKG Awards Update**
    1. Work in progress for NKG Young Scientist Award and NKG Lifetime Achievement Award.
    2. First awards will be given at Summer School 2025.
- **Visions and Goals: Milestones 2022–2026**
    1. Effective use of Nordic/Baltic realizations of EVRS and IHRS.
    2. Study and development of height systems accounting for land uplift.
    3. Improvement of geoid models, aiming for 5 mm uncertainty.
    4. Research on optical lattice clocks and their applications in geodesy.
- **Input from NKG Science Week**
    1. Discussion on the role of AI and Quantum Sensors in Geodesy.

2. Scientific Presentations & Discussions

Quantum and Geoid

Presentation: *Quantum Survey in Iceland and Nuuk and the Danish One cm Geoid* *– René Forsberg (DTU Space)*.

- **Key Points:**
  - Overview of airborne gravimetry advancements and quantum gravimetry.
  - Demonstration of cold atom gravimetry (GIRAFE system) in Greenland and Iceland.
  - Potential use in high-precision geoid models and navigation without GNSS.
- **Discussion:**
  - No specific questions raised.

Presentation: *FIN2023N2000 - The New Height Conversion Surface for Finland* *– Mirjam Bilker-Koivula et al*.

- **Key Points:**
  - New geoid FIN2023N2000 replaces FIN2005N00.
  - Integrates GOCE & GRACE gravity satellite data, new GPS-levelling points, and marine gravity data.
  - Accuracy improvement: From ~1.87 cm to 1.38 cm RMSE.
- **Discussion:**
  - **Cause of errors?** Levelling data or gravity data? Need for clocks to control this.

Levelling

Presentation: *Heights on Svalbard – Report from a Levelling Campaign* *2023 – Olav Vestøl*.

- **Key Points:**
  1. Poor vertical reference in Longyearbyen and Ny-Ålesund.
  2. GNSS and levelling data were harmonized for a consistent reference frame.
  3. Tested four geoid models (ARCGP-2006, EIGEN-6C4, EGG2015, XGM2019e).
- **Discussion:**
  1. Corrections for tides and land uplift?
  2. Degree of XGM2019e model used?
  3. Doubts about XGM2019e's ability to replace gravity data with topography.

Presentation: *On the Contribution of Precise Levelling for Regional Realizations of* *IHRS – Anders Alfredsson*.

- **Key Points:**
  1. Use of precise levelling to strengthen IHRS/IHRF realization.
  2. Three approaches: Constrained, Weighted, Variance Component Estimation (VCE).
  3. Best accuracy achieved using VCE method (~4.8 mm standard uncertainty).
- **Discussion:**
  1. Why is it not easy to add points?
  2. Combination of Gravity and GNSS Data for enhanced height determination.

Marine Gravity

Presentation: *Homogenized Marine Gravity Maps of Southern and Eastern Baltic Sea for 3D Geodesy (BalMarGrav Project*) *– Monika Wilde-Piórko*.

- **Key Points:**
  - Revitalization of historical marine gravity data from the 1960s–1990s.
  - New modern shipborne gravity surveys for data validation.
  - Integration into Baltic Gravity Database (BalMarGrav DB).
- **Discussion:**
  - Gabriel Strykowski: Encouraged further participation and funding.

Presentation: *BalMarGrav-Project: 2023 "Nawigator XXI" Marine Gravity Survey* *– Gabriel Strykowski*.

- **Key Points:**
  - New shipborne gravity survey (June 2023) in the Southern Baltic Sea.
  - Comparison with historical datasets and modern validation.
  - Investigation of sea state influence on gravity measurements.
- **Discussion:**
  - Crossover surveys? Verification against pre-existing marine gravity data.
  - Biao Lu (DTU Space): Drift corrections necessary after bad weather.
  - René Forsberg: Sea state significantly impacts gravity measurements.
  - Joachim Schwabe: Could compute some corrections due to weather. Up to 1mGal.

Relative Gravity

Presentation: *Relative Gravity in Latvia 2022-2023* *– Vents Zuševics*.

- **Key Points:**
  - Part of BalMarGrav 2023, including new terrestrial gravity surveys.
  - Validation against historic marine datasets.
  - Cross-over surveys identified biased runs.
- **Discussion:**
  - No questions raised.

Airborne Gravity

Presentation: *Processing of Strapdown Gravimetry Using the Direct Method in NMA2023 Airborne Gravimetry Campaign* *– Bjørnar Dale (DTU Space)*

- **Key Points:**
  1. Development of DroneSOM for drone-based gravimetry.
  2. Overview of NMA2023 gravimetry campaign: 19 flight lines, 600m altitude, Cessna 208B Caravan aircraft.
  3. MATLAB-based direct gravity processing for improved resolution.
  4. Validation against DTU21MSS and GNSS-derived heights.
- **Discussion:**
  1. No questions raised.

NKG Gravity Database

Presentation: *Status of NKG Gravity Database – BalMarGrav License & Developments* *– Gabriel Strykowski (DTU Space)*.

- **Key Points:**
  - Migration from old 80-character input format to a CSV-based system for easier data management.
  - Improved security, SQL-based access control, and unique data source IDs for each dataset.
  - Integration of BalMarGrav-license for marine gravity surveys.
- **Discussion:**
  - Clarification of new data submission guidelines.
  - Ensuring consistency with historical gravity records.

GRACE and Land Uplift Model

Presentation: *Preliminary Results of GRACE and GRACE-FO Derived Land Uplift Model in Fennoscandia* *– Mohammad Bagherbandi (University of Gävle & KTH)*.

- **Key Points:**
  - Land uplift rates derived from GRACE/GRACE-FO (2003-2023).
  - Incorporation of hydrological loading effects for improved accuracy.
  - Comparison with GNSS velocity fields, ICE-6G, and NKG2016LU uplift models.
- **Discussion:**
  - Olav Vestøl: Questions about the RMS 0.7 in the GRACE and GRACE-FO land uplift rate comparison with other models. Are there some local errors?
  - Mirjam Bilker-Koivula: Questions about the hydrological models, some big signals in Finland.

NKG Geoid 2026

Presentation: *Status of New NKG Geoid 2026* *– Ove Christian Dahl Omang (Norwegian Mapping Authority)*.

- **Key Points:**
  - New computation strategy integrating bathymetry, ice thickness, and lake depth models.
  - Plan to start calculations after next meeting.
  - EGM202X model delay may impact results.
- **Discussion:**
  - René Forsberg: Suggested an ITHR version of the geoid.
  - Joachim Schwabe: Recommended including bathymetry data, especially near shorelines.
  - How to handle uncertainties? Proposal to generate an error grid.
  - Look at Canadian and Australian geoid approaches for reference.

3. National Reports

Denmark – ***Kristian Keller (DTU Space & SDFE)***

- Quantum gravimetry campaigns in Greenland and Iceland.
- Validation of marine gravity surveys with BalMarGrav data.
- GNSS interference monitoring and real-time corrections.

Estonia – ***Karin Kollo (Estonian Land Board***)

- GNSS station upgrades with Beidou support.
- Validation of commercial networks against ESTPOS.
- Refinement of marine geoid models using dynamic topography.

Finland – *Mirjam Bilker-Koivula & Maaria Nordman (NLS & Aalto University)*

- Reorganization of the Geodesy and Geodynamics department.
- FinnRef: 47 stations, precise levelling completed at 36 stations.
- Gravimetry: Absolute gravity measured at 7 stations, Otaniemi-Vihti calibration line update.
- Metsähovi Geodetic Research Station: SLR operational by end of 2024.
- 2023/2024 Antarctic campaign: GNSS upgrades, absolute gravity, local tie measurements.

Iceland – *Guðmundur Þór Valsson (National Land Survey of Iceland)*

- Monitoring of volcanic unrest in Reykjanes Peninsula using GNSS and INSAR.
- GCP network for aerial photogrammetry: 600+ points established.
- Establishment of a common reference frame for emergency response and research.
- New aerial photogrammetric system operational since October 2023.
- Upcoming INSAR study in Reykjavik for subsidence analysis.
-

Latvia – *Jānis Sakne (LGIA)*

- Benchmark inventory: 442 benchmarks checked, 14 destroyed.
- Levelling campaign: 7.2 km levelling for gravimetric benchmarks.
- The Great Network Project: 62 benchmarks for datum maintenance.
- Transitioning to passive reflectors due to license delays.

NKG Latvian National Group- *Vents Zuševics*.

Established in 2023 with the goal of enhancing geodetic collaboration within Latvia.

- Functions include disseminating NKG-related information, fostering international cooperation, and promoting geodesy.
- Chairman: *Vents Zuševics* (LGIA), with 9 founding members.
- Active in GNSS network monitoring and marine gravity research.

Lithuania – *Darius Popovas & Eimuntas Paršeliūnas (National Land Service, Vilnius Technical University)*

- Second re-measurement of 1st-order vertical network (2000 km, 2022-2026).
- Baltic Sea gravity surveys under BalMarGrav project (2021-2023, ~3000 km planned for 2024).
- Participation in FAMOS (Baltic Motorways of the Sea project).

Norway – *Ove Christian Dahl Omang (Kartverket)*

- Minimal precise levelling, 20 km completed in Svalbard.
- Marine gravity: Equipment breakdown (TAGS-6 and BGM-3).
- Ny-Ålesund Geodetic Observatory: Upgrades to VLBI and SLR, full co-location by 2026.
- QUANTSEA project: GIA modeling for sea level projections.
- New transformation services in Proj: Seamless transformation between land and ocean vertical datums.

Norway (NMBU) – *Geomatics Department*

- HYDROGRAV project: Gravity trend analysis linked to groundwater depletion.
- SEGREF project: Geoid models and reference frames for sustainable coastal development.
- ICESat-2 study: Coastal MSS improvements using satellite altimetry.

Sweden – Holger Steffern (*Lantmäteriet)*

- Absolute gravity campaigns: New calibration of RG2000, gradient measurements ongoing.
- Marine gravity measurements: Collaboration with Latvia and Lithuania.
- Greenland GIA project: New models incorporating compressibility and moving coastlines.
- SAR transponder & corner reflector installation: Expanding geodetic observation network.

Sweden -Mohammad Bagherbandi (HiG)

- *Mohammad Bagherbandi* discussed education program restructuring at Gävle.
    - Moving to 3+2 format (BSc + MSc).
    - BSc program under revision for better funding optimization.

4. Business Matters

NKG Website and Communication

- Need for improved event updates and structured archive of presentations.
- Mailing list

---

5. Future Meetings & Events

- **NKG Summer School 2025** will be held in **Estonia.**
- **Next NKG WGHG Meeting: Norway, Week 11, 2025.**