

REPORT OF THE WG GEODYNAMICS AND EARTH OBSERVATION 2022-2026

NKG GENERAL ASSEMBLY 2026, VILNIUS, LITHUANIA

HOLGER STEFFEN & THE WG GEO MEMBERS

GEODYNAMICS AND EARTH OBSERVATION

Vision and goals

Improved understanding of the Earth and climate system is key to the interpretation and use of geodetic observations. Being of utmost importance in detecting environmental changes, geodetic observations are, in turn, often undesirably affected by them. The GIA process and ongoing climate-related changes such as glacial melting (especially in Greenland, Iceland, Svalbard, Norwegian glaciers) and hydrological changes are of particular importance for the countries within NKG, thus represent the core of our working group. We further investigate and study other geodynamic processes (e.g., plate tectonics, regional and local subsidence, erosion, sedimentary loading) important for our activities. In addition, we follow the progress of international programs such as the European Plate Observing System (EPOS).

1. We **develope and improve** GIA models as well as empirical **models of geophysical processes**. Our models are tested against the most up-to-date palaeo and geodetic data of international standard. We provide model uncertainties and further investigate GIA models with lateral changes in Earth's subsurface structure.
2. We cooperate on the **collection and analysis of absolute gravity data**. These data are used and made available for new studies of GIA and other geophysical processes. We constantly refine our analyses of the absolute gravity data by, for example, investigating and applying corrections for hydrological changes. We encourage periodic Nordic comparisons of absolute gravimeters.
3. We serve as Nordic and Baltic platform for **collaboration of geodesists and geophysicists within the InSAR community**. We investigate and validate the potential applications of InSAR data relevant for our WG, assist in the coordination of InSAR reflector installation in the NKG area and help connecting InSAR to GNSS.
4. We **investigate** and/or provide data for studies on and projections of **climate-related changes, sea level and different types of loading**.
5. We cooperate on the **analysis and preservation of data from existing relative gravity lines** and make them publicly available.
6. We **make NKG products**, i.e data, models and codes, **available to users and the scientific community** at regular intervals. We encourage continued collaboration with universities and other institutions and participation in funding proposals.

GEODYNAMICS AND EARTH OBSERVATION

Keywords

Glacial isostatic adjustment, Plate tectonics, Environmental effects, Climatic Changes, Ice melt, Sea-level changes, Gravity measurements, InSAR, Modelling, Education

Milestones 2022-2026

1. NKG2022GIA: Deliverables are modelled output of land motion, gravity, sea level, and stress field changes over time, i.e., from the past glacial, to today, and in the near future (max. 1000 years), together with their uncertainty estimates.
2. BIFROST2022: New 3D velocities for a largely extended time series (+7 years) and GNSS station network (500+) that includes the forebulge area will be calculated with three different software. Cooperation with WGHG and WGRF (NKG GNSS AC).
3. NKG202XLU: Based on BIFROST2022, NKG2022GIA and an extended levelling dataset a new land uplift model will be generated in a one-step approach. Cooperation with WGHG.
4. Report on findings of investigations on
 - a) how the national geodetic infrastructures can add value to an InSAR-based deformation monitoring, such as the European Ground Motion Service (EGMS), and
 - b) applications of InSAR data for maintaining and developing the national geodetic infrastructures.Cooperation with WGHG.
5. Relative gravity lines: Joint NKG publications on data and results from the relative gravity lines.

WGGEO OBJECTIVES FOR 2022-2026

- Work on our Milestones
- Welcome Baltic countries officially as members
- Continue the excellent cooperation and back-to-back meetings with VGHG
- Continue with hybrid meetings
- Continue with one invited talk per meeting to give WG members some outside perspectives and helpful advice $\Rightarrow$ depends on the meeting frame
- Keep the # of scientific talks and # of participants in WG meetings
- Keep the InSAR community engaged
- Have an eye on international developments such as AI, quantum techniques, international projects and geodetic supply chain threads
- Update the NKG website
- Celebrate the 50th WG meeting with a dinner speech that people from SDFE, I mean SDFI, no, wait, KDS, well, I guess DMI-KOG... will never forget

REPORT ITEMS

1. Collaboration with the InSAR community - Status of the InSAR report (**talk #2**)
2. Model development - Status of BIFROST2025, NKG202XGIA, NKG2026LU (**talk #3**)
3. Relative gravity lines – Status of publications (**talk #5**)
4. AG data code of conduct
5. Cooperation and meeting organization with WGHG
6. Invited talks
7. # of scientific talks and # of participants in WG meetings
8. The next period 2026-2030

COLLABORATION WITH THE INSAR COMMUNITY

- As per resolution from the NKG GA 2018 in Helsinki
- Started in the 2019 WGGE0 meeting with 3 invited InSAR presentations
- InSAR now a major part of WGGE0/WGHG meetings (up to half day with many discussions), though interest ceased a little in the last period
- Two reports were planned to be prepared during the last period
- Already reduced to one for practical reasons:



- Input was delivered by all NKG countries, which is truly appreciated
- Faramarz Nilfouroushan et al. will summarize it in the next talk (#2)
- WG members appreciate a continuation of the InSAR session

DEVELOPING AND IMPROVING GEODYNAMIC MODELS

NKG202XGIA model:

- Observation data for identifying the best model are in place since the last GA (velocity field, relative sea-level data, gravity data, glacially induced faults), but updates have been incorporated, such as BIFROST2025 test data
- Ice models were delivered by Lev Tarasov in fall 2023 and identification of best ice model combination was performed with the ID modelling software ICEAGE in summer 2026
- 3D earth models were prepared
- New 3D spherical method FEMIBSF:
 - Combination of FE software Abaqus with Python/Fortran scripts; compressible and 3D Earth parameters possible
 - Sea-level equation, rotational feedback, degree-I correction and no-net mantle rotation correction included
 - Benchmark with ID models successful, more benchmarks are part of international efforts under the IAG umbrella
 - Implemented at LM computers with increased modelling power and GPUs
- More in talk #3

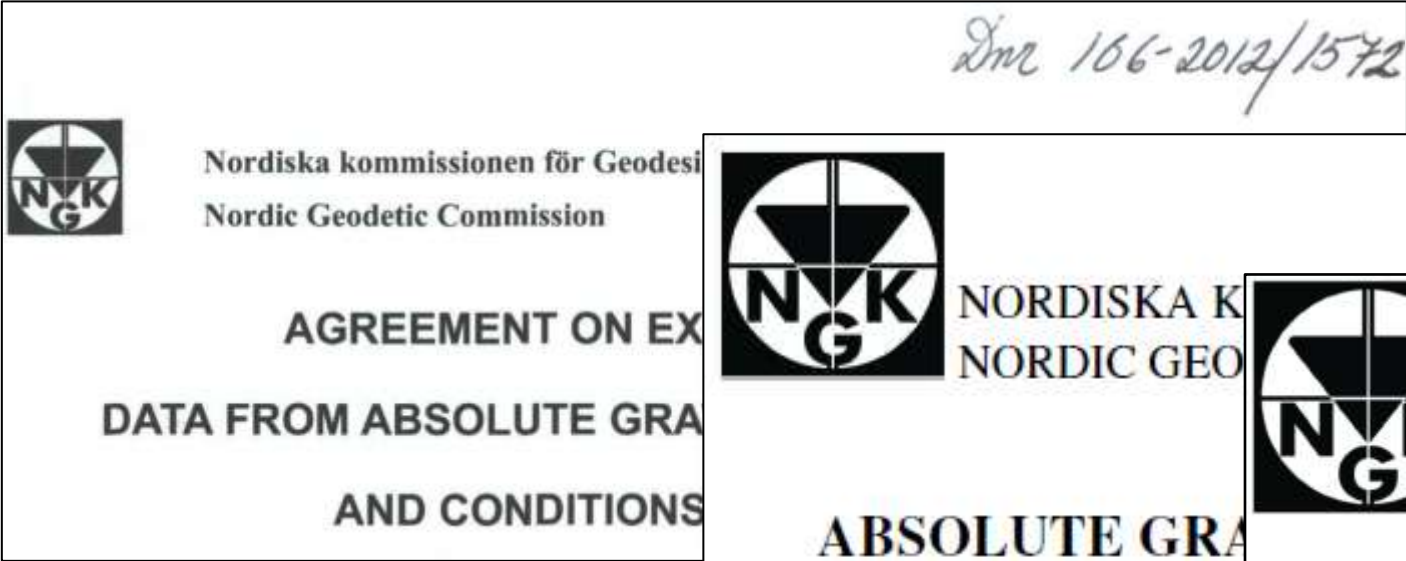
DEVELOPING AND IMPROVING GEODYNAMIC MODELS

- BIFROST2025 and NKG202XLU activity:
 - Four different processings with three different software (GAMIT, GipsyX, Bernese)
 - NKG GNSS AC will prepare two solutions (Standard Repro-2 and one specified for BIFROST)
 - Timespan of data January 2000 - December 2024
 - Area includes common NKG area with extension to the Faroe Islands in the west
 - Results will feed into NKG202XLU and NKG_RFxxvel
 - Cooperation of WGs GEO, HG and RF, and NKG with Polish colleagues
- Status:
 - GAMIT processing finished in June 2026
 - GipsyX processing almost finished (just a few additional Swedish stations)
 - Bernese processing finished in August 2026
 - Preliminary results without UK & Faroe Islands were shown in an invited presentation at IAG Scientific Assembly in Rimini
- More in talk #3

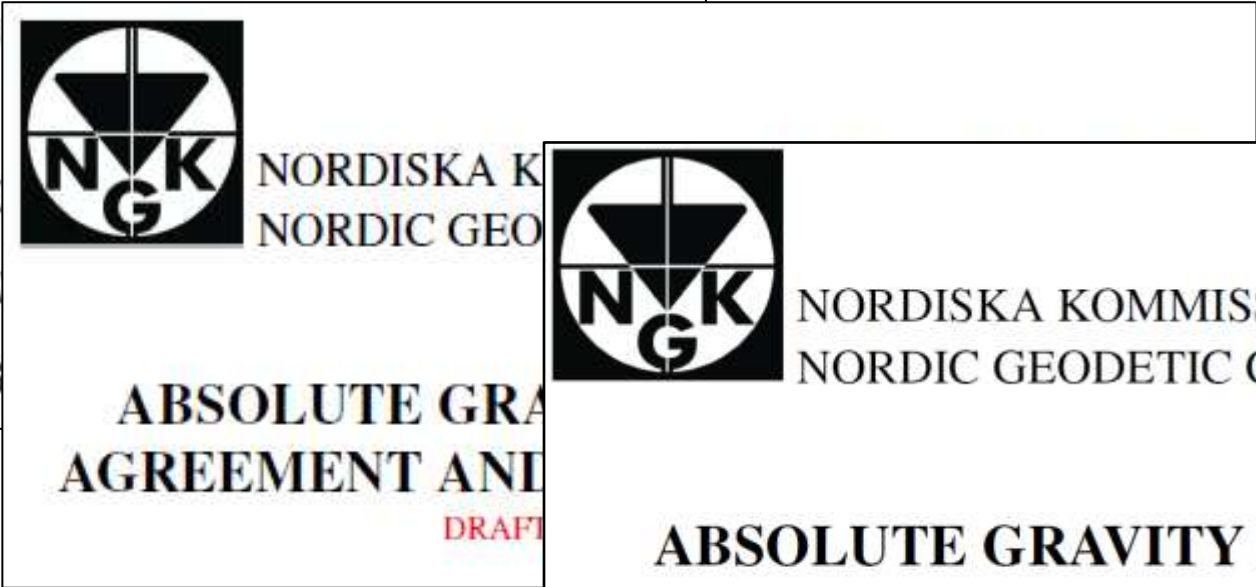
ANALYSIS AND PRESERVATION OF DATA FROM EXISTING RELATIVE GRAVITY LINES

- As per decision during the NKG GA 2018 in Helsinki
- 2-3 publications are planned regarding the relative gravity lines (Jaakko Mäkinen & Andreas Engfeldt)
 - Steady progress of rescuing, publishing, and reprocessing the measurement data, especially during the pandemic
 - Jaakko sent majority (~90%) of the data and preliminary analysis to Andreas
 - Perhaps only 2 publications (one report and one scientific paper)
 - Work in progress
- More later in the talk #5 by Jaakko Mäkinen et al.

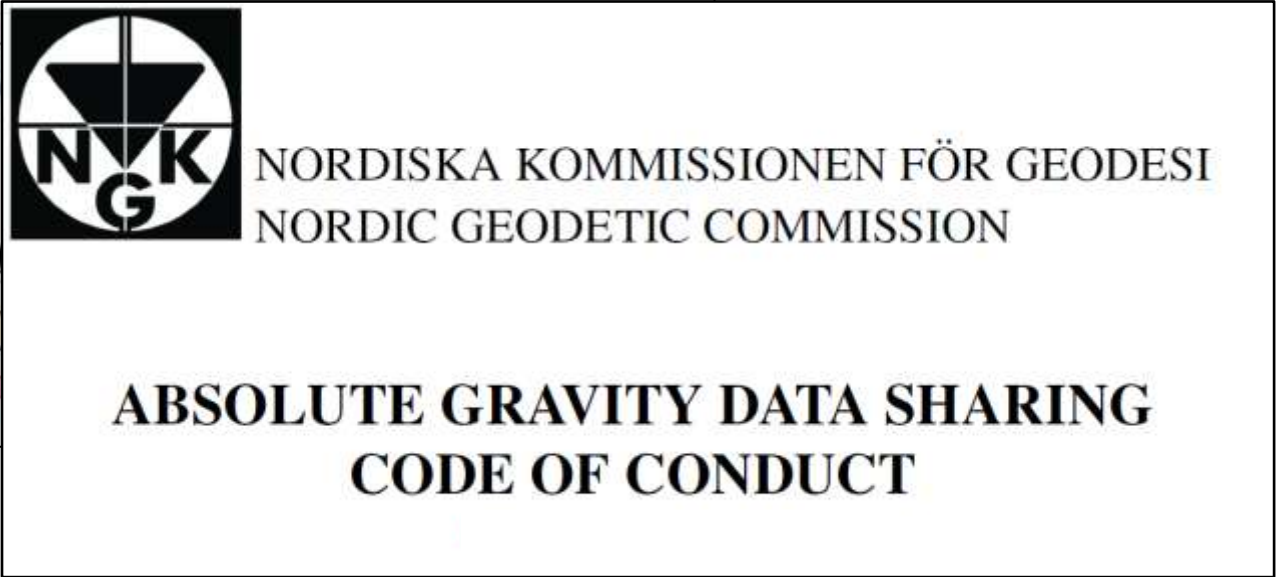
NKG AG DATABASE



Old signed agreement
Not practical



New draft
A bit problematic from
the legal perspective



Solution
Approved by the Presidium in November 2025

COOPERATION AND MEETING ORGANIZATION WITH WGHG

1st day, afternoon – WGHG presentations & discussions

2nd day, morning – **National reports** & WGHG cont.

2nd day, afternoon – WGGE0 **InSAR**

3rd, morning – WGGE0 presentations & discussions

1st day, afternoon – WGGE0 presentations & discussions

2nd day, morning – **National reports** & WGGE0 cont.

2nd day, afternoon – WGHG **InSAR**

3rd, morning – WGHG presentations & discussions



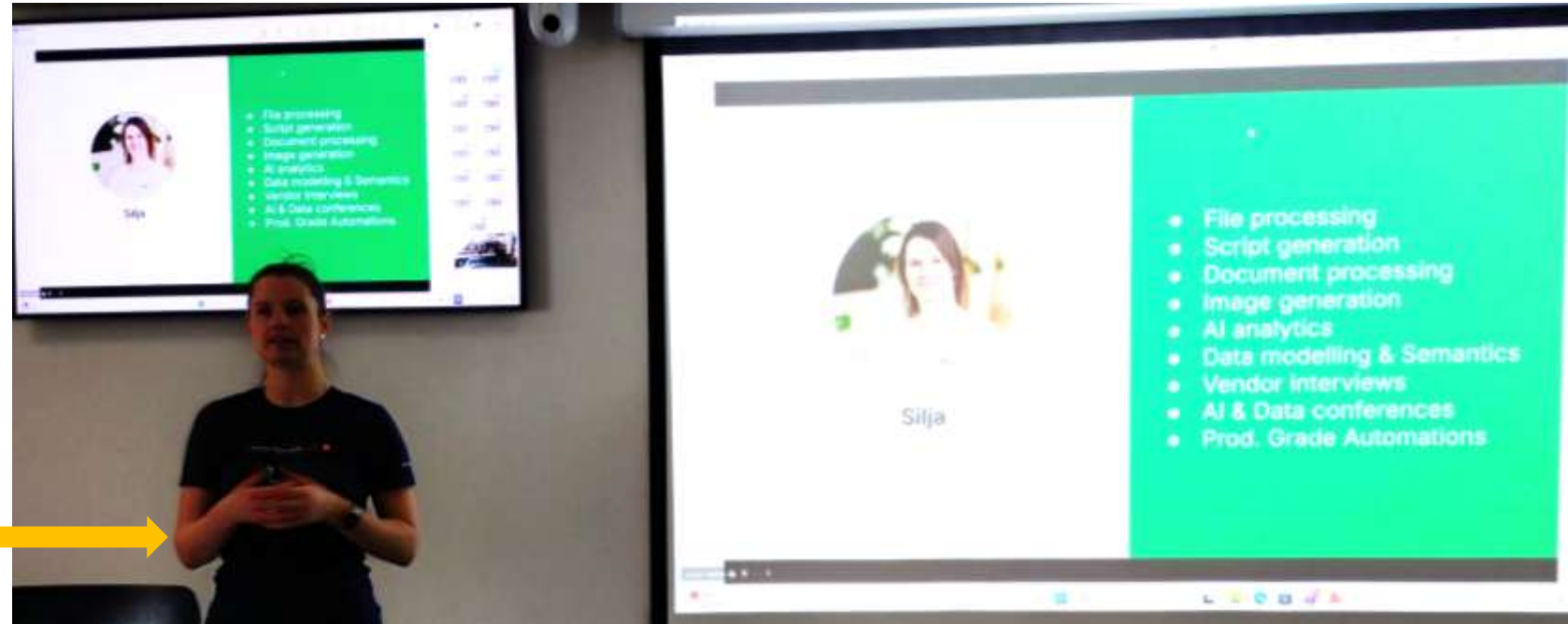
Oslo 2025



Tallinn 2026

INVITED TALKS

- 2023: SAR workshop in Otaniemi, Finland
- 2024: "Science Week" in Reykjavik, Iceland
- 2025: Invited geodynamics presentation by Clint Conrad (University of Oslo, Norway)
- 2026: Invited AI presentation by Silja Märdla (Bolt, Estonia)



NUMBERS

Year	Location	Participants In pers.+online	Countries	Scientific presentations	Other presentations
2019	Lyngby, DK	36+0	8	8	6
2020 ^{a,b}	Reykjavik, ISL	18+2	8	6	7
2021 ^c	Online	0+72	11	11	6
2022	Gävle, S	31+25	11	8	6
2023 ^d	Helsinki, FIN	35+12	11	8	4
2024 ^a	Reykjavik, ISL	26+25	11	9	4
2025 ^e	Oslo, N	28+18	10	7	2
2026 ^f	Tallinn, EST	32+25	11	11	6

a Science Week

b Pandemic-influenced

c Open link distribution

d Together with SAR workshop

e Faroe Islands join the meeting in person

f UK joins the meeting in person



GEODYNAMICS AND EARTH OBSERVATION

2026-2030

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GEODYNAMICS AND EARTH OBSERVATION

2026-2030

Goals

1. We **develope and improve 3D models of geophysical processes, most notably GIA**, affecting the NKG and adjacent areas (e.g., Greenland). Our models are benchmarked, can explain the most up-to-date observations of the process, and are provided with uncertainties.
2. We collect, quality-control, share and use different types of observation data to **investigate geophysical processes** in the NKG and adjacent areas. This includes, among others, **absolute and relative gravity, GNSS, levelling and InSAR data**. We constantly refine our data analyses and share latest developments.
3. We follow new developments in geodetic instrumentation, such as **satellite and quantum gravimetry**, and geodetic methods.
4. We serve as the Nordic and Baltic platform for **collaboration of geodesists and geophysicists working with InSAR**.
5. We undertake periodic (Nordic) comparisons of absolute gravimeters.
6. We **investigate** and/or provide data for studies on and projections of **climate-related changes, sea level and different types of loading**.
7. We **make NKG products**, i.e data, models and codes, **available to users and the scientific community** at regular intervals and according to FAIR principles. We support international activities from, e.g., EPOS and GGOS.
8. We foster continued collaboration with universities and other institutions and participation in funding proposals.

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2026-2030

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3. NKG2026LU: Based on BIFROST2025, NKG2026GIA and an extended levelling dataset that includes Germany and Poland, a new land uplift model will be generated in a one-step approach. Cooperation with WGHG.
4. Relative gravity lines: Joint NKG publications on data and results from the relative gravity lines.

Chair proposal: Holger Steffen (Lantmäteriet, Sweden) – last term