



# Nordiska kommissionen för Geodesi Nordic Geodetic Commission

Working Group for Geodynamics and Earth Observations

## Draft of the minutes of the 46th meeting of the Working Group for Geodynamics and Earth Observations, within the Nordic Geodetic Commission

The hybrid meeting was hosted by Lantmäteriet in Gävle on 14 and 15 March 2022. It was organized together with the hybrid meeting of the Working Group of Future Height Systems and Geoid that took place in the Högskolan i Gävle on 15 and 16 March 2022. National reports for both meetings were given at the WGGEO meeting.

### Participants (56, 31 in person (p), 25 online (o)):

Denmark	Tim Enzlberger Jensen (o), Rene Forsberg (p), Kristian Keller (o), Joanna Balasis-Levinsen (p), Erik Lysdal (o), Aslak Meister (p), Gabriel Strykowski (Secretary) (p)
Estonia	Vahidreza Jahanmard (o), Tarmo Kall (o), Karin Kollo (o), Jaanus Metsar (o), Majid Mostafavi (o), Tõnis Oja (p), Andres Rüdja (o), Oliver Stimmer (p), Sander Varbla (o)
Finland	Mirjam Bilker-Koivula (p), Jaakko Mäkinen (o), Jyri Näränen (o), Maaria Nordman (o), Veikko Saaranen (o)
Germany	Lukas Ruesch (o), Joachim Schwabe (o)
Iceland	Thorarinn Sigurdsson (o), Guðmundur Valsson (o)
Latvia	Janis Kaminskis (o), Katerina Morozova (o), Ļubova Šuļakova (o), Madara Znotiņa (p), Vents Zuševics (p)
Netherlands	Jesse Reusen (p)
Norway	Kristian Breili (o), John Dehls (p), Halfdan Pascal Kierulf (p), Ove Christian Dahl Omang (p), Vegard Ophaug (o), Matt Simpson (p), Olav Vestøl (p)
Poland	Przemyslaw Dykowski (p), Małgorzata Szelachowska (p)
Sweden	Jonas Ågren (p), Anders Alfredsson (p), Hadi Amin (p), Mohammad Bagherbandi (p), Yiting Cai (p), Andreas Engfeldt (p), Nureldin Gido (p), Lotti Jivall (o), Martin Lidberg (p), Maxime Mouyen (p), Faramarz Nilfouroushan (p), Tobias Nilsson (p), Per-Anders Olsson (p), Holger Steffen (Chair) (p), Rebekka Steffen (p)
Switzerland	Fabio Crameri (invited)

## 1. Introduction

The chair welcomed all participants to the meeting.

The updated agenda, version 14 March 2022, was approved.

The participants of the meeting were invited to comment on the minutes from the previous 45<sup>th</sup> meeting hosted online by Högskolan i Gävle, 16 March 2020. There were no comments to the minutes. The chair therefore uploaded the Minutes to the WG's website: <https://www.nordicgeodeticcommission.com/working-group-of-geodynamics/reports-and-documents/>

Gabriel Strykowski (DTU Space, DK) was appointed as secretary. The chair noted again that the secretary duty should be shared among the countries. In 2023, Lithuania must nominate a secretary. In 2024, it will be Estonia's turn.

The chair informed the participants in brief about the most important input from the Presidium. Part of the Presidium worked last year on the new updated NKG bylaws that were approved by the Presidium for announcement and approval by the General Assembly 2022 (GA22) in Copenhagen subject to linguistic polishing. The two most important changes are (1) that the three Baltic countries (Estonia, Latvia, and Lithuania) will join officially as full NKG members and (2) that the bylaws are written in English. Holger went briefly through various details. Licensing of NKG-products is still in progress, CC-BY for all NKG products is recommended. Concerning the present working group, the Presidium wishes the WG should continue in the future and a new chair for WG should be suggested by the participants for approval at the GA22. Time slots for discussion was reserved during both meeting days, and it was also suggested, if necessary, to continue discussions in the WGFHSG meeting.

## 2. Outreach

- Fabio Cramerì “How to prevent misuse of of colour data processing and science communication” [(www.fabiocramerì.ch) “undertone design”]

Fabio Cramerì was invited to give a very inspiring talk about the use of colour maps in scientific communication. The main message is that the use of popular colour scales (like jet/rainbow) risk to emphasize certain data intervals while it suppresses others and may result in visual artefacts. In the scientific communication, use the scientific colour maps characterized by the uniform and ordered colour scales. The background matters. This was illustrated by several examples. Test your figures in B&W. Remind your peers and teach your students. One important property of scientific colour maps that was that some scientific colour maps (e.g., batlow) works in black and white in a way that is friendly to people with the colour vision deficiency. Visit the website for more information.

It was noted that colour maps in InSAR processing software still uses popular colour scales and thus should be changed. However, John Dehls wondered which one should be used and how to deal with them in B&W due to the continuous nature of the signal to be investigated. For topographic maps, popular colour maps can still be used.

## 3. Geodynamics

- Rebekka Steffen, Holger Steffen, Robert Weiss, Benoit S. Lecavalier, Glenn A. Milne, Sarah A. Woodroffe & Ole Bennike: “Earthquakes induced by ice-mass loss: A case example for southern Greenland”

Stresses are induced by ice loading. Depending on the size of the ice sheet, stresses migrate from mantle to the lithosphere under ice load. Deglaciation and GIA can trigger earthquakes. Stress

changes for southern Greenland (around Nanortalik) point to unstable conditions 10615 $\pm$ 250 a. Relative Sea Level (RSL) offset before 10,600 a was most likely due to an earthquake with a moment magnitude 8.4 (if it occurred in one event). Simulated earthquake moves RSL points in a range of possible 3D Earth models in combination with Huy3 ice model. Such earthquake must have triggered a tsunami along the coast of North Atlantic, but evidence of tsunami deposits is difficult to find. Matt Simpson had a remark about RSL modelling limitations. There seems to be a misfit between the known present-day ice model and the ice model used in the modelling. The latter is derived from observed RSL data and thus might be biased.

- Yiting Cai & Maxime Mouyen: “Non-tectonic-induced stress variation on active faults”

Yiting Cai is a PhD student from Chalmers with Maxime Mouyen as supervisor. Which stress sources can trigger earthquakes? Yiting presented a 2013 case study from the Kuril Fault in Kamchatka-Kuril Islands-Japan region. The considered monthly stress contributions were hydrological loading (GLDAS), atmospheric loading, non-tidal ocean loading. Each stress source contributes to Coulomb stress change significantly and thus influence stable/unstable conditions.

Vents Zuševics wondered how depth increments for the models are chosen. They are from a data centre in China which did not reveal such details. Rebekka Steffen remarked that magnitudes should be compared to the tectonic stress magnitude. Non-tectonic stress is possibly an extra trigger for the earthquake to happen. Faramarz Nilfouroushan suggested to have a look at the stress impact of volcanoes. Maxime Mouyen noted that tectonic stress is a background stress. It is in this sense that additional non-tectonic stress can trigger an earthquake. Holger Steffen noted that the used hydrological model GLDAS does not contain all hydrological components, thus details are missing. Use WGHM instead of GLDAS. Also, stress from postglacial rebound (PGR) is usually quickly released and any PGR-related stress build-up later concerns only a few regions in the world. Hence, stress calculated (converted) from GIA models might give you stresses that do no longer exist.

- Jesse Reusen, Bart Root, Wolfgang Szwillus, Javier Fulla & Wouter van der Wal: “Contribution of GIA and deep mantle to gravity field anomaly in North America”

Jesse Reusen is a PhD student from TU Delft who is a guest at Lantmäteriet this week. He considered two generic viscosity models in his investigation: stiff lower lithosphere (viscosity:  $> 10^{22}$  Pa s, low relaxation time, large deflection remaining) vs. easy flowing lithosphere (viscosity: between  $10^{21}$  Pa s and  $10^{22}$  Pa s, short relaxation time, small deflection remaining). A stiff mantle viscosity model has a bigger remaining effect on gravity. Case study: Hudson Bay, North America. Model assumption: vary stepwise within reasonable bounds the lower- and the upper mantle viscosity to get a density model corresponding to surface gravity signal that best approximate the observed regional gravity signal. Gravity field comprises signals associated with: GIA, crust/lithosphere, and mantle. The best viscosity model yields a mantle signal ( $<10$ mGal), GIA ( $\sim 40$ mGal) and crust ( $<15$  mGal). Holger Steffen noted that this study nicely confirms that lower mantle viscosity can be well studied in North America, but not in Fennoscandia.

- Yahya Allah Tavakoli, Hadi Amin, Hamidreza Bagheri & Mohammad Bagherbandi: “A new model of surface mass change detection from GRACE(-FO) gravity fields”

Presented by Hadi Amin, PhD student from University of Gävle. Level 2 GRACE(-FO) products are global time-variable spherical harmonic coefficients. These coefficients can be converted to the Total Water Storage (TWS) changes via an analytical model. Different models and their ellipsoidal corrections are discussed. The authors propose a new model which is a modification of a

corresponding spherical TWS model of (Wahr et al., 1998). The properties of the new model are: the mass redistribution is concentrated on the Earth's surface, the Earth's topography is not negligible, the Earth's shape is neither sphere nor ellipsoid, but approximated by a regular shape. The different analytical model responses were tested on global GMSL time series of sea-level changes from altimetry, the global barystatic sea-level time series and the thermostatic sea-level changes from ARGO products. Furthermore, the performance of the analytical models to model the ice-sheet mass changes in Greenland and Antarctica were studied. Finally, mass changes in three river basins (Amazonas, Mississippi, and Ob) were studied. The conclusion is that the proposed model performs better than both the spherical and ellipsoidal models in all three studied cases. Faramarz Nilfouroushan wondered if correlation or correlation coefficient is relevant. Holger Steffen noted that there are different versions of correlation coefficients which have different implications/mathematical nature. Perhaps they all should be calculated and evaluated if they show the same preferred model to get a complete picture.

- Halfdan P. Kierulf et al.: “Ice and snow loading in Svalbard recovered from observations”

The GGOS2020 goal is to have a reference frame with 1 mm accuracy and 0.1 mm/yr stability. The challenge: How to study geophysical processes when the reference frame is deformed by the same process? Here the case study is Svalbard. They used long (10-20 years) land uplift time series from 5 GNSS stations in Svalbard and 1 GNSS station outside Svalbard (Bjørnøya). Svalbard is exposed to elastic loading from atmosphere, non-tidal ocean loading, land water storage, ice and snow loading from a Climate Mass Balance, CMB, model. Bjørnøya is less affected by ice loading. The first result shows that the annual land uplift signal in GNSS results depend on GNSS processing strategy. Different and inconsistent annual signal results for Svalbard GNSS stations are obtained using different software and analysis strategy. Bjørnøya GNSS data can be used as a reference for common mode (CM) and load filtering in Svalbard. The uplift in Svalbard varies with time. The use of CM filtering yields consistent results for Svalbard stations also for different software and analysis methods. CM-filtered time series agree with seasonal signal from CMB models, but not with the inter-annual signal. In the Svalbard-project the authors use a new glacial model to recover inter-annual signal. Faramarz Nilfouroushan wonders why not a non-linear trend is use in the analysis.

## Discussion

- Holger Steffen et al.: “BIFROST2020 & NKG202XLU – status March 2022”

There is a place for improvement of the existing models (NKG2016LU and BIFROST2016). New data have been acquired, i.e., new levelling data from Germany and Poland, 7 more years of GNSS data (2015-2021) and more stations in Nordic and Baltic countries, especially in Finland and Lithuania. We can also add more GNSS data from Germany and Poland. Together with better knowledge about existing outliers (trees) (Lahtinen et al. 2019) and about elastic effect due to climate change related processes (Kierulf et al. 2021) we can improve trend calculation. For the new land uplift model, the background GIA model can be tuned with elastically corrected and updated GNSS data. Further, there are new spatially/temporally weighted RSL data. Modelling improvement gives us 3D spherical models with lateral heterogeneity and compressibility. The new land uplift model will be calculated in a one-step approach introduced in Vestøl et al. (2019).

Status March 2022 is that there were no additional meetings between since the one between BIFROST and GNSS AC in January 2021 because it was decided to await ITRF2020 (meanwhile released) before processing commences. Most data are in place, and we are ready to go then.

- Holger Steffen “NKG2022GIA activity status March 2022”

Last meeting of the group was in September. All observation data to tune the models are in place and were published in recent years open accessible. Focus is now on the new GIA model development, which will be a 3D spherical, compressible finite element model that solves the sea-level equation with moving coastlines and rotational feedback. It is planned to provide a first result at GA22. Benchmarks with other codes are promising. Vents Zuševics promised to be more active in this work in the future. Since the last WG meeting he was deeply involved in other activities (Latvian geoid and other important issues).

## 4. Gravimetry

- Maxime Mouyen: “Using models and local measurements to assess hydrological effects in gravity time series”

The study’s purpose is to model hydro-gravity signal in SG054 data in Onsala. SG054 is part of IGETS global network. The data used in the study are first preprocessed to level-3 IGETS data (1-min sampling) enhanced with dynamic ocean response to the air pressure. The author discussed 3 approaches to handle hydrological data: 1. Global hydrological models such as GLDAS, 2. local groundwater level data, 3. standard surface meteorological data without ground water data (air temperature, humidity, pressure, rainfall ... etc.). Global hydrological signals obtained by removing them from the total global effect (from different global models: ERA, GLDAS2, MERRA2 and “Ensamble”) on the SG station in the part associated with the pixel containing the SG station. Subsequently, the local part of the hydrological signal is restored using a more detailed local model from local groundwater level data. Local groundwater level data are measured since 2015. Deep learning (DL) was used to reconstruct missing ground water level data 2009-2016 from standard surface meteorological data (without groundwater data). Reasonable results are obtained by comparison with measured SG data. Przemyslaw Dykowski asked if the umbrella effect was considered as the SG is in a house with roof. The rainfall is not necessarily representative for local conditions in the vicinity of SG though.

- Przemyslaw Dykowski et al.: “IGiK contribution to the maintenance and realization of IGRF in Europe”

A short presentation of the Institute of Geodesy and Cartography, IgiK was given in the beginning. Next the IGiK gravimetric observatory in Borowa Góra (some 35 km north of Warsaw) and IGiK gravity activities both in Poland and abroad were presented. IGiK has since 2008 participated in several international comparison campaigns and conducted a number of surveys with their A10-020 gravimeter. This includes several surveys in the Nordic region (Finland, Sweden, Denmark and Norway) as well as in Ireland and Northern Ireland. Since 2016 the observatory operates a superconducting gravimeter iGrav-027. The long term comparisons of A10-020, FG5-230 (owned by the University of Warsaw) and iGrav-027 in Borowa Góra was discussed in some details as one of the activities of the observatory. In October 2021 the Absolute Quantum Gravimeter AQG-B07 was installed. The Absolute Quantum Gravimeter (no mechanical parts) operates with 4.5 million drops/month and a sampling frequency of ~2Hz. This new technology (independent) provides potentially a long term stability of the gravity reference. There is a “self calibration”-internal laser spectroscopy and rubidium atomic clock. Seismic noise compensation is made via an integrated accelerometer. AQG-B07 uncertainty budget and systematic effects are currently under evaluation. Preliminary results of monitoring continuous iGrav-027 with periodic AQG-027 show already after few months promising results comparable with FG5-230. These results are expected to improve

with time. Both A10-020 and AQG-B07 are under consideration to participate in the 2022 Nordic AG comparison. Holger Steffen and Maxime Mouyen asked questions about AQG operating practicalities. The answer was that it was not quite as easy and simple as the manufacturer claims, but there were definitely some advantages. Martin Lidberg wondered about AQG's relation of g-value to time and distance. FG5 has such a well defined relation. In the AQG, this is handled by the gravimeter design using quantum theory. Gabriel Strykowski asked what is the physical vertical level of the measured g-value referring to? Answer: The system determines the effect of height. So, it is well-defined.

## Discussion

- Andreas Engfeldt: "Nordic AG database update"

All members are strongly encouraged to send their AG data to Andreas Engfeldt ([andreas.engfeldt@lm.se](mailto:andreas.engfeldt@lm.se)) before the next meeting.

- Andreas Engfeldt, Mirjam Bilker-Koivula & Maxim Mouyen: "2022 Nordic AG comparison (NKG-CAG) in Onsala"

This was a short briefing about the comparison campaign to take place in 2022. International colleagues with 16 instruments agreed to visit Onsala from May to July.

- Jaakko Mäkinen & Andreas Engfeldt: "Status of the land uplift gravity lines publications"

Jaakko Mäkinen gave a short online presentation consisting of the data part and the scientific part. Meaningful results will be shown at GA22.

## 5. Academics

- Maaria Nordman: "Renewal of Bachelor education in Aalto Former Technical University of Helsinki."

The talk gave an overview of the transformation of the Bachelor education at Aalto in recent years to be more attractive and logical for students. Gabriel Strykowski asked if Master courses are given in English or Finnish. They are in English while Bachelor courses are in Finnish.

## 6. National Reports

**Denmark SDfE, Aslak Meister et al.:** Smidstrup permanent GNSS station is discontinued. A new GNSS station will be soon erected some 15 km north of the old one. Joanna Balasis-Levinsen has a presentation under WGFHSG on CATS and related activities. A high-resolution InSAR deformation map was produced of Copenhagen as well as nationwide InSAR deformation map for quality assessment. Comparing InSAR vs. GNSS class A, InSAR 2D is well referenced to geodetic reference frame. Quality assessment of InSAR vs. GNSS class B/C stations (independent stations) is performed. Updates on the TAPAS-project in Aarhus were given. Regarding the 5mm geoid of Denmark, there will be a WGFHSG presentation by Forsberg et al. Finally, some results of the Greenland REFGR/GR96 GNSS campaign 2021 were shown.

**Denmark DTU Space, Gabriel Strykowski et al.:** The report included the gravity program, the 5-mm geoid project (fill-in relative measurements on land), automated gravity surveys in Danish Waters (5 surveys in 2021), new airborne data, the A10-019 program in 2021 and plans for 2022.

Participation in NKG CAG 2022 in Onsala is anticipated with the A10-019. Geoid modelling dealt with the 5-mm geoid, the new FAMOS Baltic geoid and method development. Research and development focused last year on drone gravimetry in Denmark and a test in Wales. Greenland activities were GNET gravimetry with CG5/CG6 relative gravimeters and updates to the gravity database (new commercial data released). Greenland work also included geoid and height systems with a new geoid and transformations between old (ASIAQ) and new geoid based height systems.

**Estonia-Estonian Land Board Andres Rüdja et al. & TTE Sander Varbla:** The report focused on ESTPOS, the national GNSS satellite data center, the metrology of geodetic instruments and the Estonian-Latvian cooperation INTERREG V. Project «Harmonization of Estonian and Latvian geodetic systems in border areas» (GeoRefAct). The national geodetic network was assessed and the geodetic point database revised. 3D-Estonia shall cover the country. ESTHub was created as a national satellite data center. TTE contributes to Post-FAMOS geoid modelling activities (BSCD2000). Modelling accuracy of offshore areas will be presented by Sander Varbla in WGFHSG.

**Finland, National Land Survey, FGI, Mirjam Bilker-Koivula:** The report started with the National Land Survey's GNSS Network. FinnRef is the backbone of the Finnish reference system. The NKG GNSS AC as provided a cumulative GNSS solution (updated with 3.5 years: 1997-2020.5). Precise Levelling has been performed of FinnRef and RIMS station. In absolute gravimetry, all 20 AG stations have been measured. There is continuation planned with a 3-year cycle. There were also centering measurements of GNSS antennas. The Flex-EPOS project has SAR reflectors. Two reflectors are now installed in Metsähovi and Loviisa. KaRef deals with renewal of the Finnish national reference system. In Metsähovi, the development of VLBI and SLR continues. The new Metsähovi main building will be ready in May 2022. FGI's office moves to Otaniemi Campus at the Aalto University Campus. Joanna Balasis-Levinsen asked what is the motivation to install the corner reflectors. Answer is simply: new technique – we are learning.

**Iceland, National Land Survey of Iceland, Guðmundur Þór Valsson:** 2021 activities covered 5 new IceCORS stations (now 33 IceCORS stations in total; fully operational), a new Geodetic Map Viewer, a new InSAR map of Iceland for 2012-2020. There was an eruption in Reykjanes peninsula (a lot in the news). Processing of all CORS station data in Iceland from 1997 commenced with Bernese NKG AC style. A GNSS campaign was done for the National Power Company as well as GNSS levelling over Kjölur highland trespass. Planned 2022 activities focus on municipalities. Time series are generated for all CORS stations in Iceland from 1997 and testing accuracy of IceCORS. Use of IceCORS in farming is investigated. Gunnar H. Kristinsson will be new director general of National Land Survey of Iceland. There will likely be a new office in Akranes.

**Latvia, Latvian Geospatial Information Agency, Madara Znotiņa:** In 2021, a benchmark inventory in Vidzeme region (northeastern part of the country) was provided. There is a new State geodetic electronic network database (in Latvian). It includes benchmark base information, coordinates ... etc. Levelling was performed on 46 km in total in 2021. An overview of LatPos base stations in 2021 was shown. The GeoRef Act: cooperation between Estonia and Latvia on border regions was highlighted (see Estonian presentation). Plans for 2022 include benchmark inventory in Zemgale and Kurzeme region (western and southern part of the country), 47 km of levelling and relative gravimetric measurements in the border corridor.

**Norway, Kartverket, Ove Christian Dahl Omang:** Norway performed levelling to reduce the distance to nearest GNSS/levelling points from 15 to 10 km. IGS2014 is now realized in the active and passive network. An update of the nationwide separation models (mean sea level, geoid, chart datum, ellipsoid) was released. There is a Chart Datum relative to the ellipsoid via Mean Sea Level. The Norwegian tide gauge network is extended. Eight AG sites were measured with FG5-226 and

15 sites measured with A10-42. (Almost) all existing points in the old Norwegian first order gravity network are now observed with A10. Marine gravity focused on the coast of Norway and Svalbard area. Superconducting gravity is going well. 8777 gravity data were submitted to the NKG gravity database. The Quantifying Past and Future Sea Levels for Norway (QUANTSEA) project continued (Matt Simpson and Halfdan Kierulf are involved). The Ny-Ålesund Geodetic Observatory. Svalbard is equipped with VLBI and SLR. A new project, HyPos (National Hybrid Positioning Service for the Digital and Autonomous Societies of the Future), started. Andreas Engfeldt wondered what happened to the old sites from the old gravity network? - The plan is to revise the ones that were accessible and replace some sites along the coast.

**Sweden Lantmäteriet, Andreas Engfeldt et al.:** AG activities in 2021 and plans for 2022 were presented. The gravity lab was flooded in August at Lantmäteriet during heavy rainfall. Marine gravimetry on lakes (Lake Vättern) is planned for 2022 as well as relative gravity measurements for geoid modelling. Updates on NKG2022GIA status, Greenland Project status (Rebekka Steffen) and the IAG JSG3,1 Group (chair: Rebekka Steffen) were given. Finally, InSAR based Ground Motion Service of Sweden and InSAR activities were presented.

**Sweden HiG, Jonas Ågren et al.:** HiG Educational program related to Geodesy was introduced. A study program in Land Surveying over 5 years. There are currently 13 bachelor students, 10 master students and 3 PhD students. Gabriel Strykowski wondered if the students are from the local area and if there is overlap with KTH. Answer from Jonas Ågren was «Yes to both». There is some pessimism regarding the programs success, but there is still time to develop it as it just started during a pandemic.

**Sweden Chalmers, Maxime Mouyen:** status report on SG054 in Onsala. All is working smoothly.

## 7. Business matters

The following parts are a summary of discussion on Monday and Tuesday as two time slots were reserved for Business matters.

**New NKG bylaws:** They were prepared last year and are now written in English. A native speaker, Matt Simpson, will check the language before GA22. The most important addition to the new NKG bylaws is that the three Baltic countries (Estonia, Latvia, and Lithuania) will be full members of NKG. Holger went briefly through the new bylaws as they are now. The audience had only a small number of questions and remarks. Discussion focused on the following items: Open Data policy and NKG awards (see next item).

**NKG Awards:** The new bylaws allow the creation of dedicated NKG awards. There was a discussion about who exactly should be awarded with the new NKG award (honorary award, meritorious award, early career award, etc.). Consensus was very limited number of awards (1 or 2), early career is encouraged. There was input from an anonymous person: The idea is that it should not be given to the former members of the Presidium, but to a person who for a long time has done extraordinary service to NKG. The audience was in favour of this suggestion. The Chair will forward this suggestion to the Presidium.

**Future of WGGE0:** The WG will continue. There was some discussion about the name for the new WG, but the Chair suggests keeping the name. Audience approved. Vision and Goals for the next 4 years need to be revised. In general, the current topics should remain, some perhaps partly altered, but InSAR should be emphasized more.

The InSAR community supports the idea of having a forum for discussions and exchange of latest developments and best practices among them and (John Dehls) between them and geodesists,



especially the GNSS community. The latter is unique and missing in other InSAR-dedicated and -related meetings. It is decided to integrate the InSAR community into the WG. Audience approved. It was further discussed how this should be done best timewise. Currently, InSAR is in between WGGEO and WGFHSG as part of one WG's schedule, depending on which WG meets first (this is usually related to when most members of each group can attend a meeting). It is also noted that recently time for discussion has been reduced, thus implying a time constraint. The number of participants and presentations on the WG-meetings has increased and InSAR has been added as a new topic. It is therefore suggested that if the agenda seems to be tight it should be possible to extend the WG meetings from lunch-to-lunch-to-lunch meetings to lunch-to-lunch-to-afternoon meetings so that 2-3 more hours can be added. There was also discussion whether InSAR can be the first or last topic on the agenda of the meeting period (Andreas Engfeldt and Joana Balasis-Levinsen). There are pros and cons (Rene Forsberg). It is decided to test not having InSAR in between next year (Holger Steffen), then it will be briefly evaluated. Timewise it is also suggested to limit talks to always 15 minutes (Ove Omang) and perhaps have a poster session (Faramarz Nilfouroushan). We will test both options in future if opportunity arises. On another note, the one invited talk at the beginning of the meeting is warmly welcomed, so we will keep this. Maxime Mouyen notes that we (almost) always present finished work. We should encourage more "open question"-presentations.

Regarding absolute gravity, future comparisons might be an option, but at this stage rather be a vision and left as a goal for later if NKG-CAG-2022 is considered a success (Andreas Engfeldt and Mirjam Bilker-Koivula). We try to decide before GA22 how much another Nordic comparison should be part of the Vision and Goals. AG community agrees. Relative gravity lines shall be kept (Andreas Engfeldt).

Additional topics for Vision and Goals are BIFROST2020 and a new land uplift model (together with WGFHSG; Halfdan Kierulf, Olav Vestøl). Climate change and loading (Rene Forsberg), sea level and coupling/delivery to climate studies and projections (Matt Simpson) are also suggested, and region-wise Greenland, Svalbard and Iceland should be included (more) (Halfdan Kierulf). Jonas Ågren wonders if we should formulate projects as in old days project. The Chair is not font to have projects and the WG should not be forced by the Presidium to write such if not completely necessary. Administration should be as low as possible.

**Chairman proposal(s) for the next 4-yr period:** Holger Steffen announced that he is willing to continue. Lantmäteriet supports his decision. The audience approved his nomination and suggested that the Presidium forwards his nomination for approval at the GA22. Holger Steffen thanked the audience for their trust. He will inform the Presidium.

**NKG General Assembly 2022:** will be on 5-9 September in Copenhagen. The location is Ørestaden close to Copenhagen Airport.

**Status of the NKG website:** The website is up and running. Administration is done at the National Land Survey of Iceland. The chair has access to the website and will periodically add material to the WGGEO section of it. Latest documents (Minutes and Agendas of previous meetings) have been uploaded.

**Mailing list:** Members of the working group are urged register to the mailing list of the working group WGGEO under [https://www.freelists.org/list/nkg\\_wggeo](https://www.freelists.org/list/nkg_wggeo).

**Meeting registration:** Will be mandatory in future as has been done already this year.

## 8. Closing of the meeting

The chair thanked the participants and their active participation. Next meeting will be in 2023 in

Norway, likely in Oslo, in week 11 as usual.