NORDISKA KOMMISSIONEN FÖR GEODESI
Nordic Geodetic Commission, Working Group of Reference Frames
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NKG Working Group of Reference Frames

Minutes of the working group meeting in Oslo, Norway, April 19–20, 2018

Place: Kartverket
Storgata 33 A, Oslo

Participants:

Denmark	Kristian Evers, Thomas Knudsen
Estonia	Tarmo Kall, Karin Kollo
Finland	Pasi Häkli, Sonja Lahtinen (minutes)
Iceland	Gudmundur Valsson
Latvia	Ksenija Kosenko
Lithuania	Karolis Galinauskas
Norway	Michael Dähnn, Geir Arne Helle, Halfdan Kierulf, Jon-Petter Magnesson, Torbjørn Nørbech (19.4.), Karoline Skaar, Oddvar Tangen
Sweden	Lotti Jivall, Christina Kempe, Martin Lidberg

The slides of the presentations are available at the SDFE's FTP server.

Session 1: Scientific presentations

- **Karin, New Estonian height and gravity systems:** Karin presented the new Estonian height system (EH2000), gravity system (EG2000) and height correction surface (geoid). The aim has been to establish an integrated geodetic network, i.e. the same point is a reference point/site for coordinate, height and gravity frames. See the details from the presentation and from https://geoportaal.maaamet.ee/.
- **Kristian, NKG transformation in PROJ:** Kristian introduced new features of the new major version 5 of the PROJ library and the implementation of the NKG transformation in PROJ package. The NKG transformation has been implemented as a PROJ pipelines and it is available since the version 5.0.
- **Tarmo, Time series analysis of the Estonian stations:** Tarmo presented results of the comparison of the Bernese and Gipsy time series analysis of the Estonian stations. He has analysed the power spectra of both solutions using Hector software. See the slides for the results of the velocity and spectral differences and the best noise models.

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- **Martin, New Swedish gravity system:** Martin introduced the new Swedish gravity system RG2000. The definition, realisation, strategies, observations and computation of the system are described in the slides. New software was developed for the adjustment of the gravity data and it is available if needed.
- **Gudmundur, DRF Iceland status report:** Gudmundur presented the status of the NKG project Dynamic Reference Frame Iceland. Iceland has been processing an additional GNSS solution for the needs of the project including stations outside the NKG GNSS AC area.

Session 2: National reports

Denmark

- The financing of maintenance of the Greenland's GNSS network (GNET) in the future is under negotiation. The goal is to keep GNET running.
- The development of the motorised trigonometric levelling has continued.
- A new national height system is under consideration. The work for a 5 mm national geoid model has continued.
- A new dense GNSS/RTK network will be established in Aarhus for GNSS research in TAPAS (Testbed in Aarhus for precision positioning and autonomous systems) project. The aim is to reach 1 cm RTK positioning accuracy.
- The GNU Gama software will replace the old software for adjustment of levelling data.
- A lot of effort has been put to the development of PROJ.

Estonia

- The new height and gravity systems and the height correction surface were launched on Jan 1st, 2018.
- The first order GNSS stations have been re-measured.
- Absolute gravity measurements at four points have been carried out in 2017.
- The Väänä geodetic baseline has been reconstructed and measured in 2017.
- The tide gauge network has been used to analyse the mean sea level for coastline mapping and the stations will be connected to the first order levelling network.
- Maa-amet will organise the EUREF symposium in Tallinn in 2019.

Finland

- The FinnRef network will be densified to 50 stations for the NLS's operational use. Roughly half of the new stations have been already established and the rest will be done later this year. The FinnRef stations will also be connected to the national levelling network.

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- Measurement of GNSS levelling points has been done in 2016-17 and the data processing will be done during this year.
- The renewal of SLR in Metsähovi is going on. The system will be operational in 2019. The VGOS (VLBI Global Oberving System) will be installed in summer and complete system tests are expected in 2019.

Iceland

- The results of the national reference frame ISNET2016 has been published and the final report will be finalised.
- The GNSS core station network consists of 20 stations and two monitoring/testing receivers.
- The new national transformation service will be implemented using PROJ (see Session 5).
- New GNSS post-processing service is under development.

Latvia

- Latvia has continued their inventory of the geodetic points, which includes to find, mark and protect the points for the future use.
- The first order levelling benchmarks have been re-established in Daugavpils.
- The establishment of zero order permanent GNSS stations has continued. Three stations are operational, one will soon be operational and arrangements for the fifth station in Daugavpils is going on.
- The levelling and adjustment of the second order levelling has been finished.
- The geo-magnetism project (variometer station) is going on and new field equipment has been purchased.

Lithuania

- There are currently 31 LitPos stations in the network and five new stations will be released this year.
- Lithuania has started contributing to the operative work of NKG GNSS AC.

Norway

- New HREF and velocity model have been finished. The HREF is based on geoid and updated GNSS data. The velocity model bases on combination of GNSS velocities, levelling and GIA models.
- Dynamic reference frames are in focus in the new strategy of geodetic institute of the NMA.
- The modernising of SKTrans is going on. The PROJ library will be utilised (see Session 5).

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- The development of the Where software continues. The focus is now on the individual analysis of VLBI, SLR and GNSS. Aim is to become an operational IVS analysis centre.
- The opening ceremony of the new VLBI telescopes will be held in connection to the IVS conference in Ny Ålesund in June. A contract for SLR has been signed with NASA.
- Norway is active in UN GGIM although not anymore chairing it.
- Many other projects going on: reprocessing of passive networks, studies on common reference frame for on and off-shore use, visualisation of the sea level (VisHav), EGNOS monitoring, Galileo performance monitoring for GRC etc. (see more in slides).

Sweden

- The new strategy for geodesy in 2018-2025 will be released by the summer 2018.
- Galileo system has been included in SWEPOS services since Feb, 2018. Some hardware vs software incompatibilities have been encountered. Support for Beidou is planned for 2020 and the testing has been started.
- Densification of SWEPOS will be carried out in co-operation with municipalities based on the needs and socio-economic benefits.
- The computation of the transformation parameters between ITRF2014 and ETRS89 for the maritime applications is going on (note: report was published in May 4, 2018 and available at http://www.lantmateriet.se/en/Maps-and-geographic-information/GPS-and-geodetic-surveys/Geodesy/Transformations/ITRF---SWEREF-99/).
- New updates have been released in the series of the Handbook for surveying and mapping (HMK) in 2017.
- Many other projects/smaller tasks are going on or finished related to the national reference frames (see the slides).

Session 3: Project NKG GNSS AC

- **Major activities since the last meeting:** All LACs has finished the repro processing, and the combination of the solutions was finished in Dec, 2017. A test analysis of 40 stations was done in Feb, 2018 (see Lotti's slides) and the guidelines were prepared for the benchmark test step. The weekly operational work has continued with a 5 to 10 week delay. An article of the first results of the operational work was published in March in Journal of Geodetic Science by Lahtinen et al. (https://doi.org/10.1515/jogs-2018-0005)
- **Test analysis:** The test analysis with a subnet of 40 stations was carried out by LM, EST, ISS and FGI. The differences between the solutions were mostly small. The NKF03 solution was decided to be the main solution, and to be used in the national time series analysis. However, analysing also the ten degree solution may be useful to study the time series.

- **Benchmark test:** All LACs have finished the Tsview benchmark test. The results were mostly identical and the differences were mainly due to the different interpretation of the breaks in the time series.
- **Status of LACs**: All LACs have been regularly submitting the operational solutions during the period. Jon-Petter is new operator for the SK solutions (both operational and repro time series analysis). FGI will probably add roughly 25 new CORS stations to its subnet when they are operative. Part of the LACs have already started the Tsview analysis of the national stations.
- **Time series studies:** Lotti has analysed the Swedish twin stations. Oddvar has analysed the data quality of Norwegian stations, and tried to link them to the changes in HFS4 time series. He has studied also the effects of growing trees on time series, and similar patterns can be seen e.g. at the Finnish stations. Sonja has started working with Hector, and compared the velocities and uncertainties to the ones from Tsview. Karolis has compared the FODITS and Tsview results using the benchmark test stations (see slides in LIT national report). See the details from the presentations available at the FTP.
- **Next steps:**
    - The national analysis will be carried out by mid-summer, 2018, using the NKF03-solutions. Time-series analysis based on other solutions is optional. The LACs are encouraged to make the analysis and submit the results earlier if possible. Lotti will divide the EPN stations outside Nordic/Baltic countries to be analysed at least by one LAC.
    - The principle of the uncertainty analysis with Hector was discussed. It was decided that Tarmo will analyse in detail the power spectra of the benchmark test analysis stations (11 stations) by mid-summer. FGI and LM (possibly EST too) will analyse all the repro stations by mid-August using all four solution types. The default noise model was decided to be white noise plus flicker noise. The results will be compared before NKG GA.
    - FGI aims to complete the CATREF stacking before NKG GA. The EST LAC was also initially interested in participating in the work.
    - Martin and Lotti will make preparations for comparison of the final solution to the BIFROST solution before mid-summer (mainly checking the consistency between the used station names).
    - The presentations of the NKG GNSS AC for the NKG GA were discussed. Lotti will present the overview of the project. The other presentations will present the velocities, combined coordinates and uncertainty analysis. The exact division of the topics into presentations (oral, poster) will be discussed and fixed later but anyway before submitting the abstracts.
- **Planning of the next period:** The topics for the next period were discussed based on the overview of the plans of the whole NKG for the next period. The things to be discussed and studied will include:

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- Change towards global GNSS analysis instead of the current regional network: either adding a global solution to our regional solutions or processing stations with global coverage by ourselves.
- Producing cumulative solution (repro + operative) for the dynamic reference frame needs, rapid solutions may be a pre-requisite to provide DRF at current epoch to users as well.
- In-depth comparison between different software (Bernese, GAMIT, GIPSY).
- Follow the IGS work for the next ITRF (ITRF2020?): guidelines for the processing may be useful for our work as well, and follow the EPN's activities for repro projects.
- Troposphere products: are there needs or interests outside our group?

Session 4: ITRS-ETRS89 Transformation project

- **General:** Last year a questionnaire related to the needs of a new ETRS89 realisation (ETRF2014) was carried out by EUREF. Since then the ETRF2014 has been realised and transformation parameters to both ETRF2000 and ETRF2014 are now available. It is notable that the origin of the ETRF2014 coincides with that of the ITRF2014 resulting coordinate shifts up to 7cm between ETRF2014 and ETRF2000. The discussions on the conventional frame will be continued in the next period.

- **New models for transformations:** Gridded uncertainties for GIA models NKG2016GIA_prel0306 (used with vertical NKG2016LU model) and NKG2016GIA_prel0906 (to be used with horizontal LU model) and a vertical land uplift models NKG2016LU_abs/lev are available. Pasi is working on the horizontal land uplift model by fitting the NKG2016GIA_prel0906 velocities to the BIFROST horizontal velocities using least squares collocation technique. The estimation of the uncertainties for them could be done in the same manner as for the NKG2016LU_abs model. Together, the horizontal and vertical land uplift model will constitute a new 2D+1D PGR model NKG_RF17vel. The modelling should be finished before the NKG GA.

- **Next period:** The update of the NKG2008 transformation will be carried out. This includes incorporation of the new NKG_RF17vel model, new input coordinates in ITRF from the NKG AC project and update/review of the national ETRS89 coordinates to the NKG transformation, resulting a new improved set of national transformation parameters. Efforts to incorporate the transformations into (GIS) software was also considered an important task, see also session 5.

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Session 5: PROJ

- **General:** Thomas presented the background and activities of the PROJ study group since the last WGRF meeting (see also Kristian's presentation in session 1 for background information). The study group had a kick-off meeting in November 2017 where e.g. national transformation implementations were discussed. Most of the transformation tools are already in place in PROJ but also some tools are still missing. Some other highlighted topics were e.g. data licenses and "release early and often" strategy of geodetic material. The study group encouraged people to implement national transformation into PROJ.

- **Norwegian implementation:** Geir Arne presented the status of the implementation of the Norwegian transformations into PROJ. The PROJ library will replace the old library in use. The work will be finished during 2018. A wrapper will be offered to users to ease the transition from the old to the new library.

- **Icelandic implementation:** Gudmundur presented their implementation of the national transformations into PROJ. PROJ parameter file for Icelandic transformations was already under preparation. The old transformation program needs to be replaced, and the interface for the users will be similar to the one used by NOAA.

- **Technical aspects:** Kristian presented the tools related to the PROJ and GitHub platform for the development of the program. The PROJ project has a mailing list that is a good forum for asking questions. The subscription link is available at proj4.org.

- **Next steps:** The comparison of the NKG2008 and the national ITRF transformation will be carried out. An invitation to participate in the work will be sent to all by email. Thomas pointed out that the NKG parameter file needs regular maintenance. Every country was encouraged to implement their national transformations into PROJ. The need for a common coordinate file format was also discussed. The discussion will continue via email.

Session 6: Plans for the next period 2018-2022

- **General:** In spring 2018, the NKG Presidium had asked the working groups to come up with ideas for the next NKG period 2018-2022 and especially for the drafted focus areas by the Presidium (pwp presentation). In addition to the focus areas Pasi introduced some personal thoughts for the WGRF activities for coming period and requested ideas and comments from the WGRF members by email in spring. Based on the WGRF feedback and iteration in the Presidium meeting and DRF-Iceland project meeting Pasi presented NKG plans and views for our working group for the next period (see the slides). Both the GNSS AC and the transformation projects will continue as well as the work of the PROJ study group. See more detailed plans for each existing project/study group in the associated session (above). In addition to the ongoing work, it was considered important to study the topical scientific issues such as utilising the new

GNSS systems and signals in processing station coordinates and taking the advantage of the new possibilities. The utilising of the data quality information for the time series analysis was also considered as an interesting topic to study. These studies could be carried out within smaller (study) groups with people sharing the interest.

- **Next meeting:** The NKG WG chairs will be selected in September in NKG GA, and the next meeting will be agreed thereafter.

AOB

- **EPOS:** Martin demonstrated how to join the national EPN stations into EPOS network. An EPOS Data Supplier Letter needs to be signed and submitted to EPOS. The data from EPOS stations will be analysed by two EPOS analysis centres (Gipsy and GAMIT solutions). Martin also informed people about a request for submitting sitelogs related to the EPN densification.