



NLS
FINNISH GEOSPATIAL
RESEARCH INSTITUTE
FGI

NKG Working Group of Reference Frames (WGRF)

Status report

NKG General Assembly 5-9 September 2022

Pasi Häkli (Chairman of the Working Group of Reference Frames)

+all participants of the WG

Working Group of Reference Frames (WGRF) 2018-2022

WG meetings (1-1.5 days):

- 2019/03/25–26: Copenhagen
- 2020/03/10–11: Reykjavik
- 2021/03/22–23: Online
- 2022/05/19–20: Riga + online (hybrid)

Minutes, presentations (partly) available in the [NKG webpage](#)

People in the meetings:

- DK: Kristian Evers, Mette Weber, Thomas Knudsen, Aslak Meister, Per Knudsen, Majbritt Sørensen
- EE: Karin Kollo, Tarmo Kall, Jaanus Metsar, Andres Rüdja
- FI: Pasi Häkli, Sonja Lahtinen, Markku Poutanen
- IS: Dalia Prizginiene, Guðmundur Valsson, Þórarinn Sigurðsson
- LV: Ksenija Kosenko, Inese Vārna, Ivars Liepins, Jānis Kaminskis, Aigars Keiselis
- LT: Karolis Galinauskas, Simonas Valotka, Eimuntas Paršeliūnas
- NO: Michael Dähnn, Hans-Sverre Smalø, Karoline Skaar, Sveinung Himle, Per Christian Bratheim, Oddvar Bråvold Tangen, Arnlaug Høgås Skjæveland
- SE: Lotti Jivall, Martin Lidberg, Tina Kempe, Holger Steffen, Faramarz Nilfouroushan, Christina Lilje, Per-Anders Olsson, Tong Ning, Tobias Nilsson, Rebekka Steffen, Henrik Bryskhe

Input from the NKG General Assembly 2018

- NKG focus areas: ... Positioning services and **dynamic reference frames** stands out as particularly important areas for the period. ...
- Resolution 1: ...recommends NKG to **continue the DRF activities** in close cooperation with the NKG working groups and further make recommendations for future dynamic reference frames in the NKG area of interest.
 - WGRF activities were planned with the NKG DRF project and agreed in the Presidium, see next slide

WGRF plan 2018-2022:

- **Service: NKG GNSS Analysis Centre** (NKG GNSS AC)
 - Operational GNSS processing: local analysis (centres) and combination (centres) → daily ITRF position solutions
 - **Project: NKG GNSS Analysis Centre** (NKG GNSS AC)
 - NKG reprocessing (repro)
 - Implementation of Galileo and RINEX3 in operational processing
 - Contribution to EUREF and EPN activities
 - Cumulative solutions based on Repro1 and operational solutions
 - **Project: ITRS-ETRS89 Transformations**
 - Velocity field DRF-Fennoscandia v1.0: Compiling existing deformation models for the NKG-area and customize them for DRF and semi-DRF use
 - Finalizing ongoing update of the NKG transformations
 - **NKG PROJ Study group**
 - Completed its work and closed in 2019
- + close co-operation with:
- other NKG working groups
 - NKG project: Dynamic Reference Frame in Iceland (DRF-Iceland)

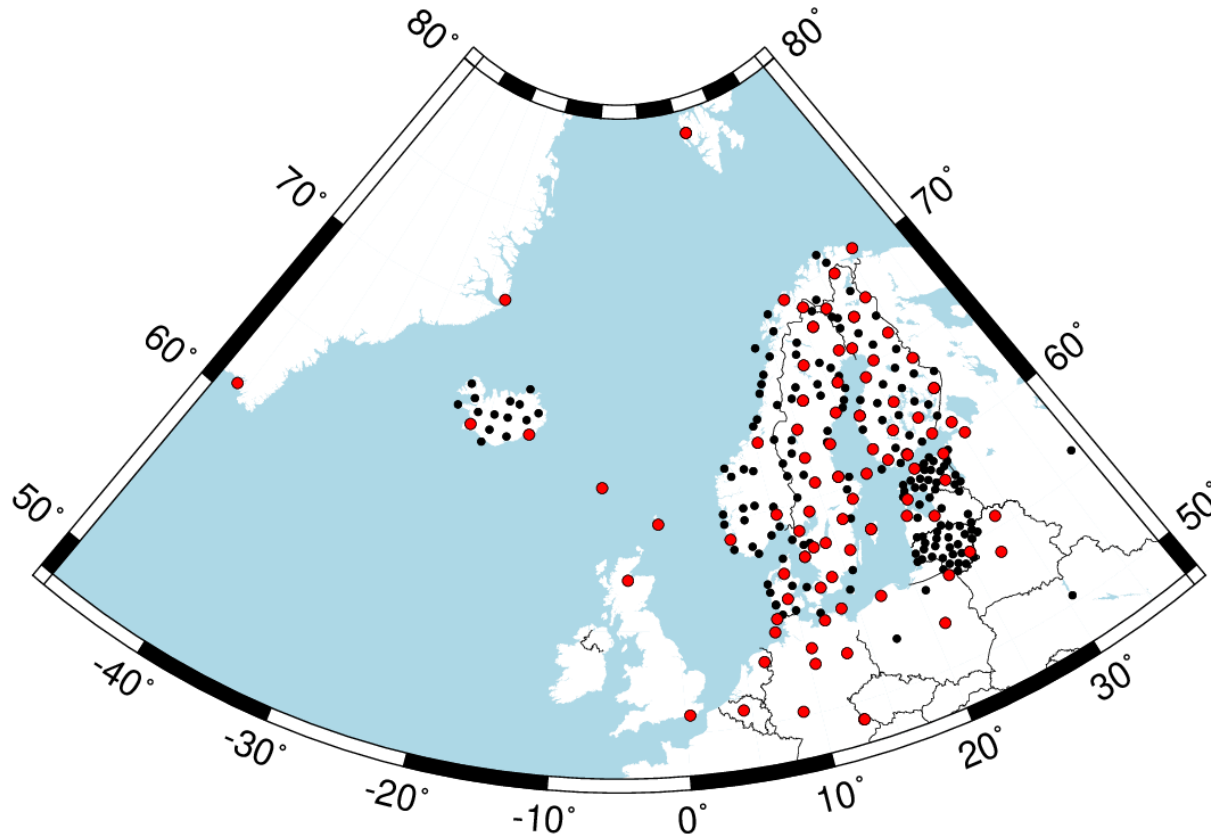


NKG GNSS AC

Project leader: Lotti Jivall (-2022), Sonja Lahtinen (2022-)



NKG GNSS AC: operational solutions



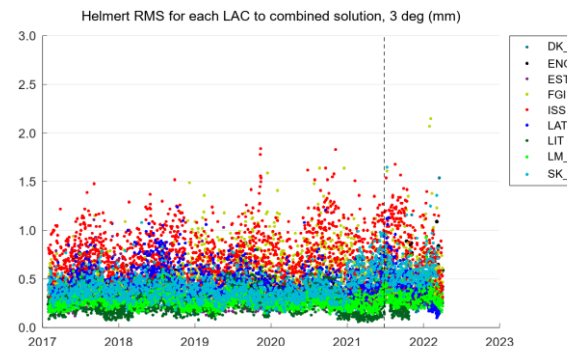
NKG AC network: Red dots are EPN-stations included in the NKG EPN-solution.

Totally 293 stations

- New stations in Belarus added (EPN_NKG) + more
- EPN_NKG (ENG) as backbone (105 stns) + 4 other EPN stn + 8 national subnetworks (184 stn)

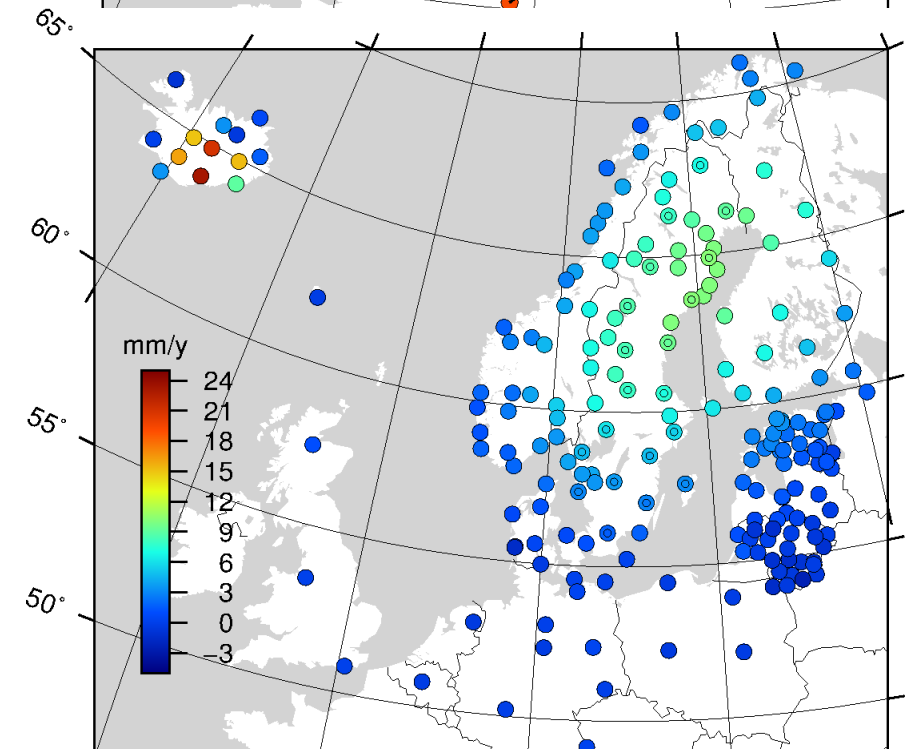
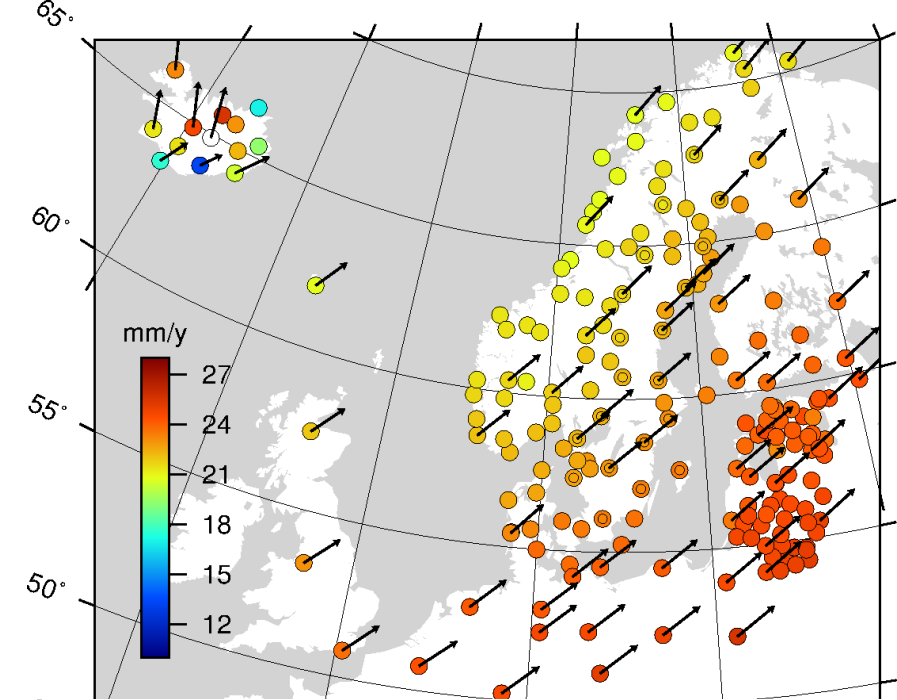
Operational processing:

- Inclusion of RINEX3 and Galileo in operational solutions since week 2055 (last week in May 2019) - Benchmark test week 2055.
- Contribution to EUREFWGs:
 - EPN Densification project: by each LAC, after Repro I and continuously with operational solutions.
 - EUREF dense velocities: NKG_RF17vel intraplate velocity model submitted



NKG GNSS AC: Repr01

- **Reprocessing** RINEX data **1997.0–2017.1**
 - Daily solutions with 3 and 10 degree cut-off angle
- Combination of subnets into daily solutions (CATREF)
- **National pre-analysis** mainly manually utilising Tsview software (time series analysis)
 - 8 analysis centres with local knowledge
 - Bad data (e.g. systematics due to snow), discontinuities
 - Rejections into daily SNX files before combination
- Cumulative solution using CATREF
 - Both **positions and velocities in ITRF2014**
 - Constraints between co-located stations (twin stations)
- **Uncertainties** for velocities using Hector
- Coordinate and velocity solution from [NKG Repr01](#) released in **2019**



NKG GNSS AC: cumulative solutions

NKG Repro 1 (1997-2017jan)
GPS, I08.atx


+

Operational (2017jan – 2020jun)
GPS+GLO (GAL from 2019may), I14.atx

- **Update** with additional 3.5 year of data: **1997-2020.5** → crd+vel in **IGb14**
 - Updated guidelines
 - Cleaned input data incl. I08.atx → I14.atx conversion
 - National pre-analysis
 - Focus on **automatization of the time series analysis**
 - Combination: CATREF, uncertainties: Hector
- [NKG Repro1 update2020](#) released in 2021
 - See more details in presentation by Lahtinen

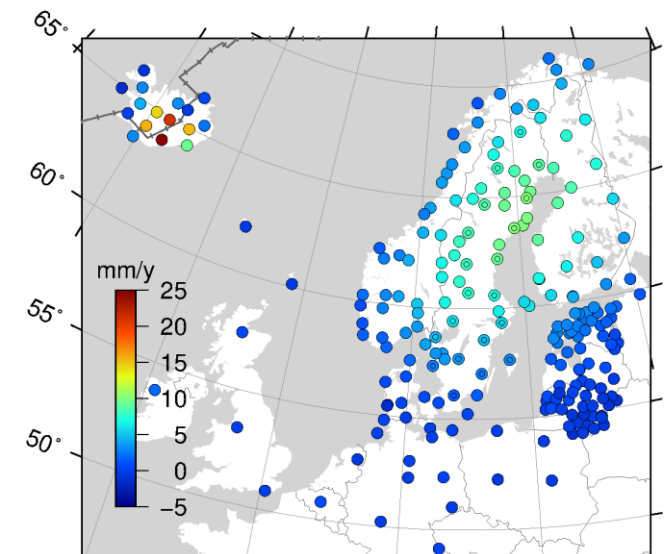
[Original Article](#) | [Open Access](#) | [Published: 01 November 2021](#)

Updated GNSS velocity solution in the Nordic and Baltic countries with a semi-automatic offset detection method

[Sonja Lahtinen](#)  [Lotti Jivall](#), [Pasi Häkli](#) & [Maaria Nordman](#)

[GPS Solutions](#) **26**, Article number: 9 (2022) | [Cite this article](#)

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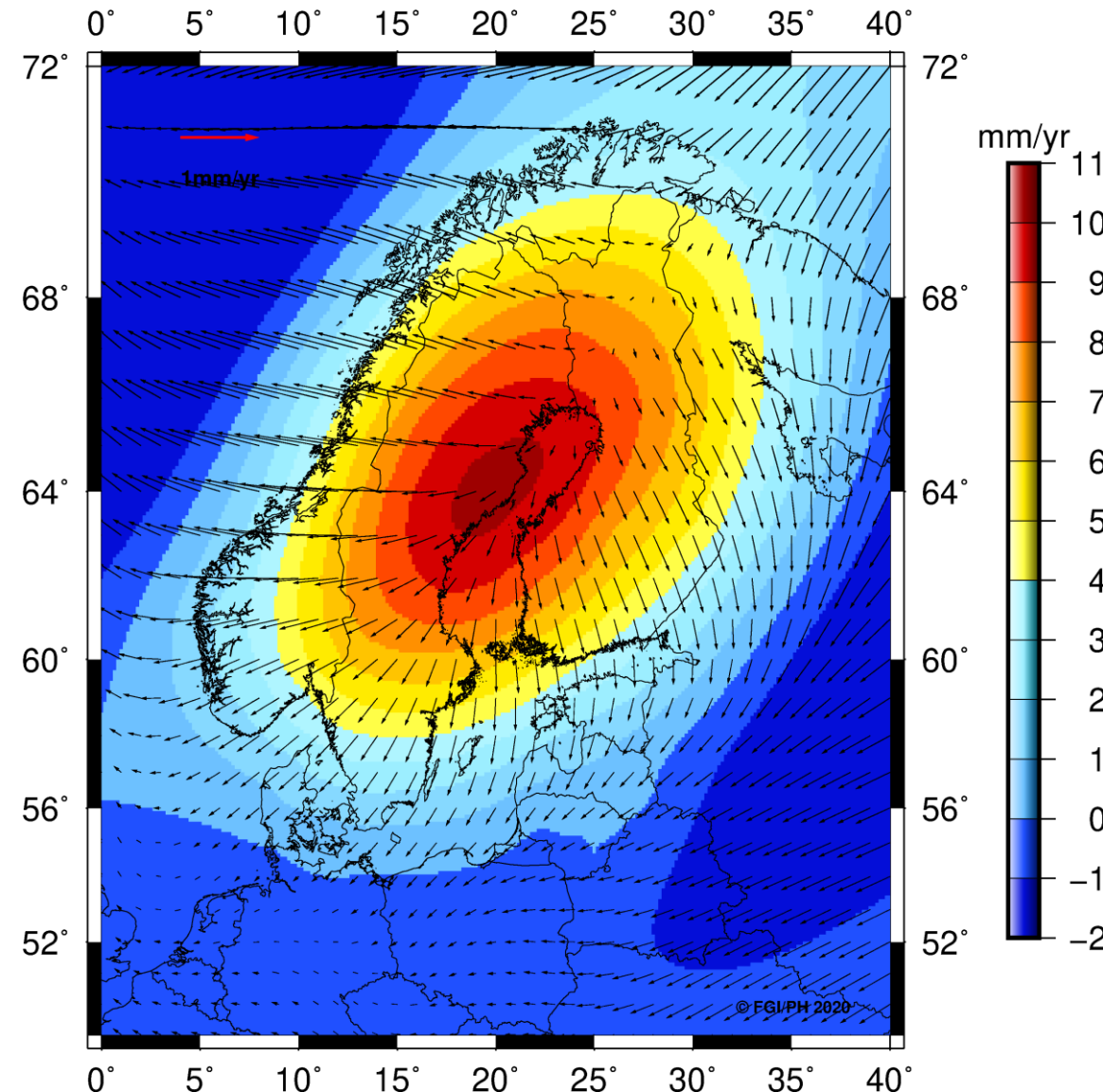


NKG transformations

Project leader: Pasi Häkli

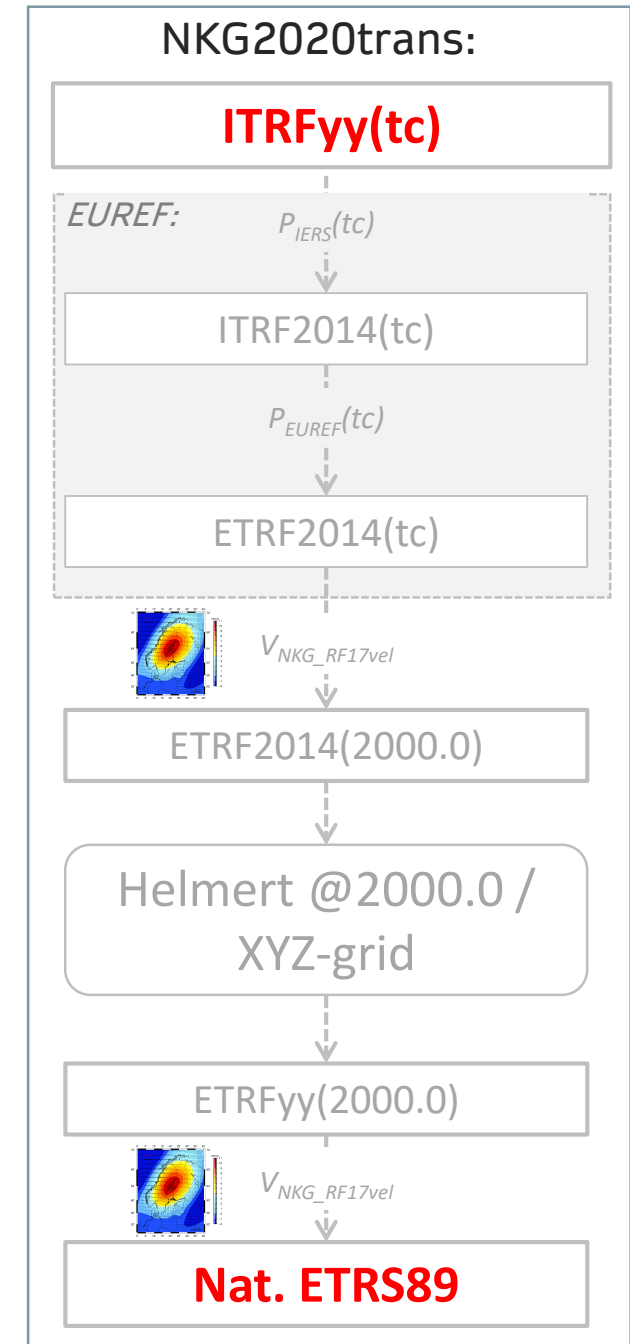
NKG transformations: NKG_RF17vel model

- NKG_RF17vel: **2D+1D** land uplift model
 - Horizontal velocities: WGRF, see below
 - Vertical velocities: equal to [NKG2016LU_abs](#) (WGGeo+WGFHSG)
- **Horizontal velocities:**
 - Based on **least-squares collocation** of GNSS velocities and uncertainties (NKG Repro1 and BIFROST) and NKG2016GIA_prel0907 model
 - Own collocation routines developed – comparisons with different collocation parameters and software conducted
 - A lot of effort used to **clean/filter the data** – GNSS velocity solution cleaned based on collocation results and feedback from the Nordic-Baltic countries
 - **Final model velocities released in 2019-12-16**
 - Still to be done: model uncertainties and documentation
- NKG_RF17vel used in the NKG2020 transformation



NKG transformation: NKG2020

- **NKG2020: Updated NKG transformation**
 - Follows previous [NKG transformation methodology](#)
 - All input data updated/revised (ITRF2014 and national ETRS89 coordinates and NKG_RF17vel model)
 - Transformation **results (residuals) checked and approved** by all countries
 - New **NKG2020** transformation **released in 12/2020**
- **Implemented in PROJ 7.2.1** (Jan 1 2021) except Norwegian part in PROJ 8.0.1 (May 5 2021)
 - Metadata reviewed by each country
 - Licensing: CC-BY4.0
 - Standardized data formats (GeoTiff)
 - EUREF tutorial on PROJ in 2019
- See more details in poster: Häkli et al.



Publications:

- Lahtinen S., Jivall L., Häkli P., Kall T., Kollo K., Kosenko K., Galinauskas K., Prizginiene D., Tangen O., Weber M., Nordman M. (2019): **ITRF2014 Densification for the Nordic and Baltic Countries**. GPS Solutions (2019) 23:95, <https://doi.org/10.1007/s10291-019-0886-3>
- Häkli P., Lidberg M., Jivall L., Steffen H., Kierulf H.P., Ågren J., Vestøl O., Lahtinen S., Steffen R., and Tarasov L. (2019): **New horizontal intraplate velocity model for Nordic and Baltic countries**. In FIG Working Week 2019 Proceedings: Geospatial information for a smarter life and environmental resilience, Hanoi, Vietnam, 22 – 26 April 2019. (http://fig.net/resources/monthly_articles/2019/Pasi_etal_November_2019.asp).
- Knudsen T., Evers K., Hjelle G.A., Valsson G., Lidberg M., Häkli P. (2019): **The bricks and mortar for contemporary reimplementations of legacy Nordic transformations**. Geophysica (2019), 54(1), 107–116. (http://www.geophysica.fi/pdf/geophysica_2019_54_knudsen.pdf)
- Kierulf H.P., Valsson G., Evers K., Lidberg M., Häkli P., Prizginiene D., Hjelle G.A., Vestøl O., Håkansson M., Knudsen P., Poutanen M. (2019): **Towards a Dynamic Reference Frame in Iceland**. Geophysica (2019), 54(1), 3–17. (https://www.geophysica.fi/pdf/geophysica_2019_54_1_003_kierulf.pdf).
- Lahtinen S., Jivall L., Häkli P., Nordman M. (2022): **Updated GNSS velocity solution in the Nordic and Baltic countries with a semi-automatic offset detection method**. GPS Solutions 26, 9 (2022). <https://doi.org/10.1007/s10291-021-01194-z>

BIG Thanks to all who participated to the
work of the WGRF!

... and thanks for your attention!

