NATIONAL REPORT OF FINLAND

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P. Rouhiainen, V. Saaranen, T. Saari, M. Turunen and many others.

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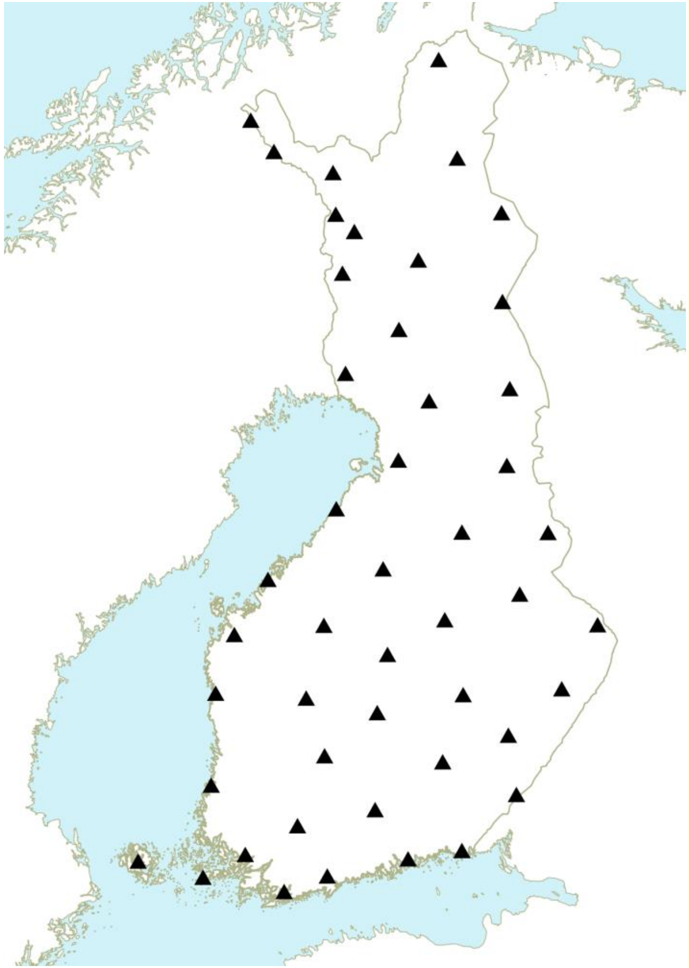
FINNISH GEOSPATIAL RESEARCH INSTITUTE
FGI

NKG Working Group of Reference Frames (jointly with WGFP)
Reykjavik, Iceland, March 10, 2020

FINPOS

- NLS positioning service operating on data from FinnRef stations (47)
- Services
  - Open access DGNSS & RINEX
  - Limited access NRTK
  - Limited access station raw data streams
- Runs on Geo++ GNSMART
  - GNSMART1 (GPS+GLO, GNNET) since 2014
  - GNSMART2 (GPS+GLO+GAL+BDS) since 2020?



FINPOS – ACTIVITIES

- 2019 summer: Test GNSMART, Trimble Pivot, Leica Spider, Topcon TopNet simultaneously on FinnRef data
- 2020 spring: Station raw data streams for sale
- 2020 spring/summer: Provided open services GNSMART1 → GNSMART2
- 2020: NRTK as open service?
- 2020: More stations
- 2021 summer: NLS production work (cadastral etc.) to use FINPOS

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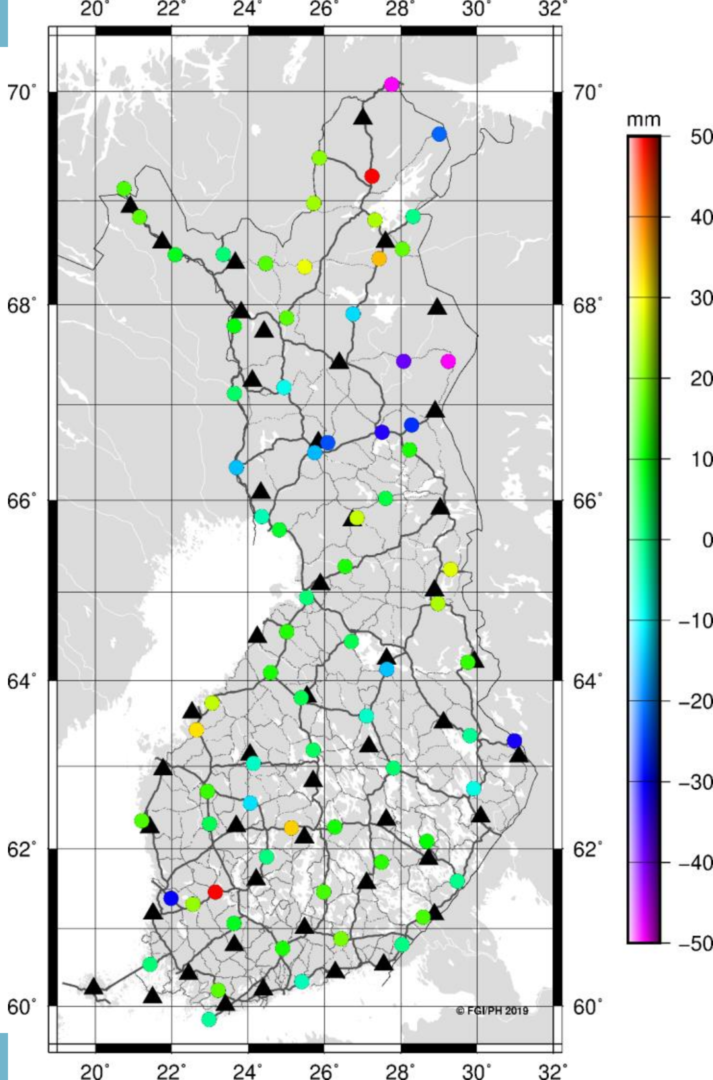
PRECISE LEVELLING IN FINLAND

- In 2019 , FinnRef (permanent GNSS) stations Haapajärvi, Kajaani, Maaninka, Suomussalmi and Virrat were connected to the precise levelling network. Sum of the distances from the nodal points was 24.5 km (49 km double run precise levelling).
  - Goal is to have all or most FinnRef stations connected to precise levelling network by the end of 2025.
- Precise levelling for the Finnish tide gauges were performed. The measurements are performed every third year.
- 3rd order levelling 222 km. Including 11 connections to water level stations of the Finnish Environment Institute (SYKE). There are still 15 water level stations in the measuring plan for the next years.
- Rod/system calibrations were continued and as a part of the FGI moving project the planning of premises for a new rod comparator was started.

GPS/LEVELLING 2016-17: PRELIMINARY ANALYSIS

- New GPS/levelling data set measured in 2016-2017
- Processing of GPS data in ITRF and transformed to EUREF-FIN with NKG transformation
- No thorough check of data yet → preliminary results
- Comparison: ΔN=N(data)-N(FIN2005N00)
- Four outliers to be checked (about 10-20cm)
- Statistics after excluding the outliers in the table below
    - Results express an update to the accuracy of the currently used height transformation surface (”geoid model”) FIN2005N00

ΔN=N(data)-N(FIN2005N00)	2016	2017
Number of points	40	33
Min (mm)	-31.80	-38.50
Max (mm)	33.70	35.20
Mean (mm)	6.27	4.46
Stdev (mm)	14.29	19.21
rms (mm)	15.44	19.43
95% (mm)	31.82	33.88



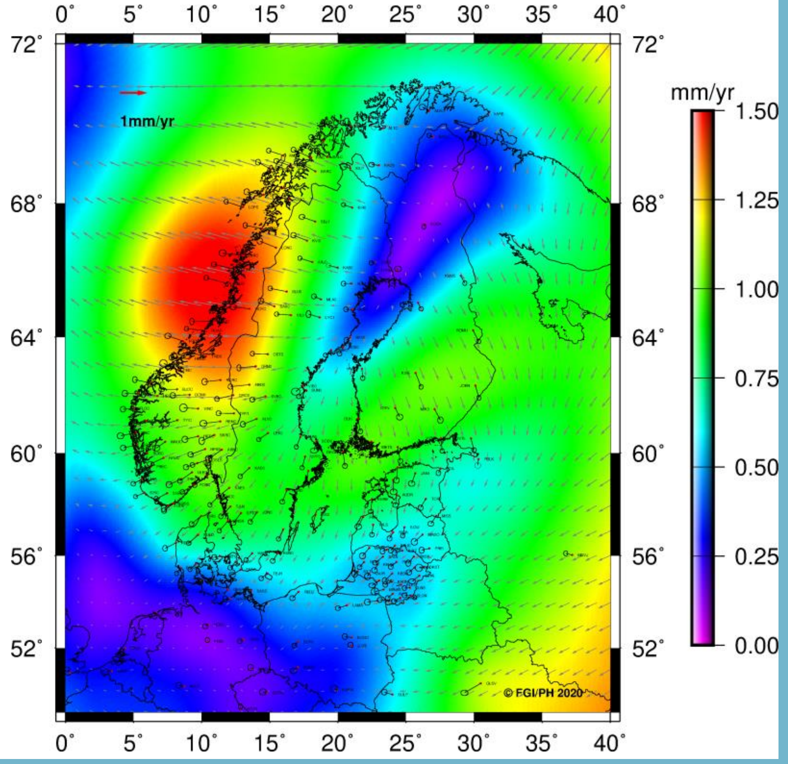
HORIZONTAL INTRAPLATE VELOCITIES OF THE NKG_RF17VEL MODEL

- Based on collocation of GNSS velocities and uncertainties (NKG Repro1 and BIFROST) and NKG2016GIA_prel0907 model
- A lot of effort used to clean/filter the data – GNSS velocity solution cleaned based on collocation results and feedback from Nordic-Baltic countries
- Also thorough testing of collocation routines and parameters conducted

→ **Final model velocities released in 2019-12-16**

- Still to be done: model uncertainties and documentation

Horizontal intraplate velocities in ETRF2014

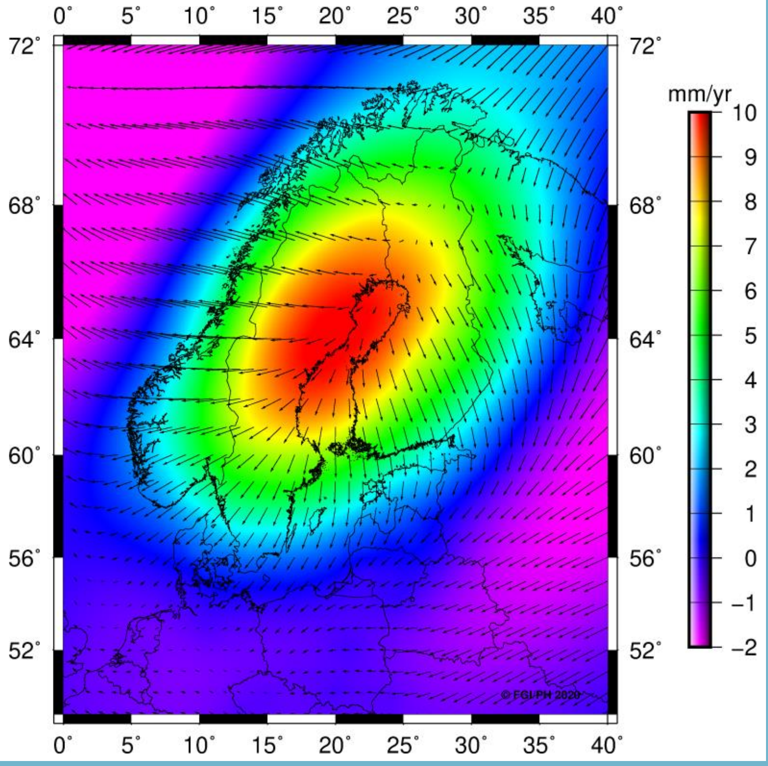


Gridded vel: grey vectors (magnitude: colormap), GNSS stn vel: black vectors

NKG_RF17VEL MODEL (2D+1D)

- Combining horizontal and vertical models to obtain crustal motion model (2D+1D) for 3D applications
  - Up component (WGGHS+WGG): NKG2016LU_abs completed in 2016 (uncertainties in 2019)
  - Horizontal component (WGRF): **completed in the end of 2019**
- Utilized for example in the NKG transformations (from global reference frames to national ETRS89 realizations)

NKG_RF17vel velocities (up component: NKG2016LU_abs)



Horizontal vel: black vectors, vertical vel: colormap

ITRFyy(t_c), e.g. ITRF2014(2020.188)

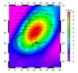
EUREF:

P_{IERS}(2020.188)

ITRF2014(2020.188)

P_{EUREF}(2020.188)

ETRF2014(2020.188)

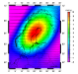


$V_{NKG\_RF17vel}$

ETRF2014(2000.0)

Helmert @2000.0

ETRFyy(2000.0)



$V_{NKG\_RF17vel}$

NKG transformation (updated/completed 3/2020):

- Method to transform 3D (4D) coordinates from global dynamic reference frames to static Nordic/Baltic ETRS89 realizations – can be considered as an implementation of a semi-dynamic reference frame.
    - Extension to the EUREF transformation that corrects for intra-plate deformations – can be used to transform from/to any ITRFyy and epoch
    - A combination of similarity (14-parameter Helmert) transformation and deformation corrections
- National transformation residuals from a few mm to about 1 cm
- Making available to users → to be implemented in PROJ

National ETRS89 realizations (epoch: t_r)

- DK: ETRF92(1994.704)
- FI: ETRF96(1997.0)
- LV: ETRF89(1992.75)
- SE: ETRF97(1999.5)
- EE: ETRF96(1997.56)
- LT: ETRF2000(2003.75)
- NO: ETRF93(1995.0)

ITRFyy(t_c), e.g. ITRF2014(2020.188)

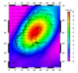
EUREF:

P_{IERS}(2020.188)

ITRF2014(2020.188)

P_{EUREF}(2020.188)

ETRF2014(2020.188)

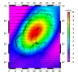


$V_{NKG\_RF17vel}$

ETRF2014(2000.0)

Helmert @2000.0

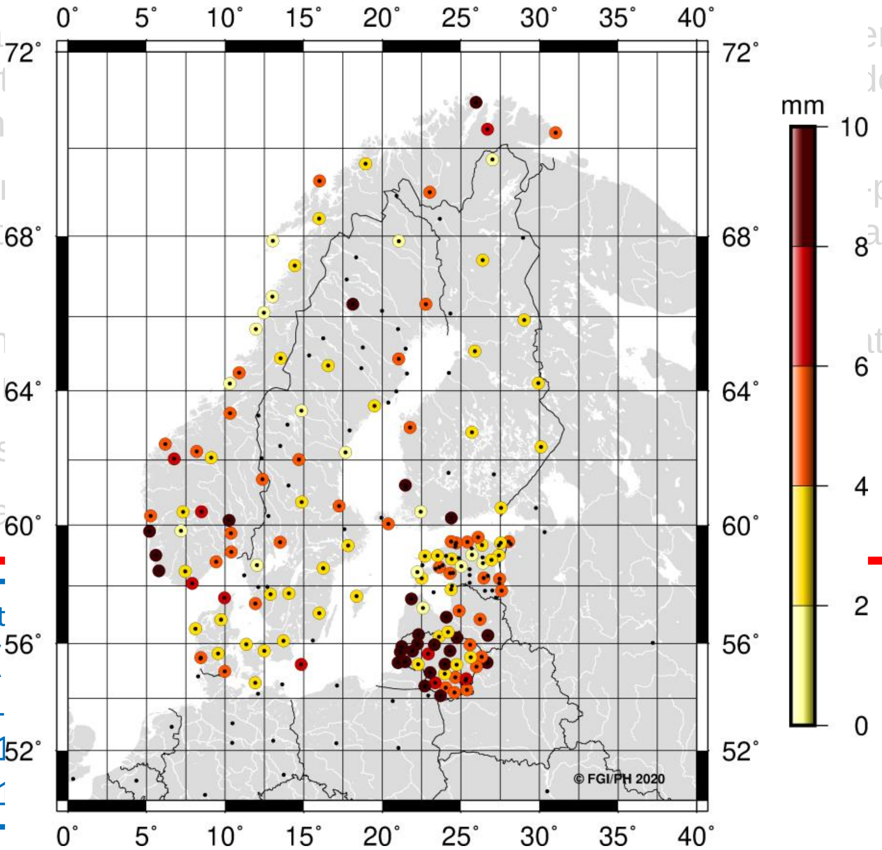
ETRFyy(2000.0)



$V_{NKG\_RF17vel}$

NKG transformation residuals:

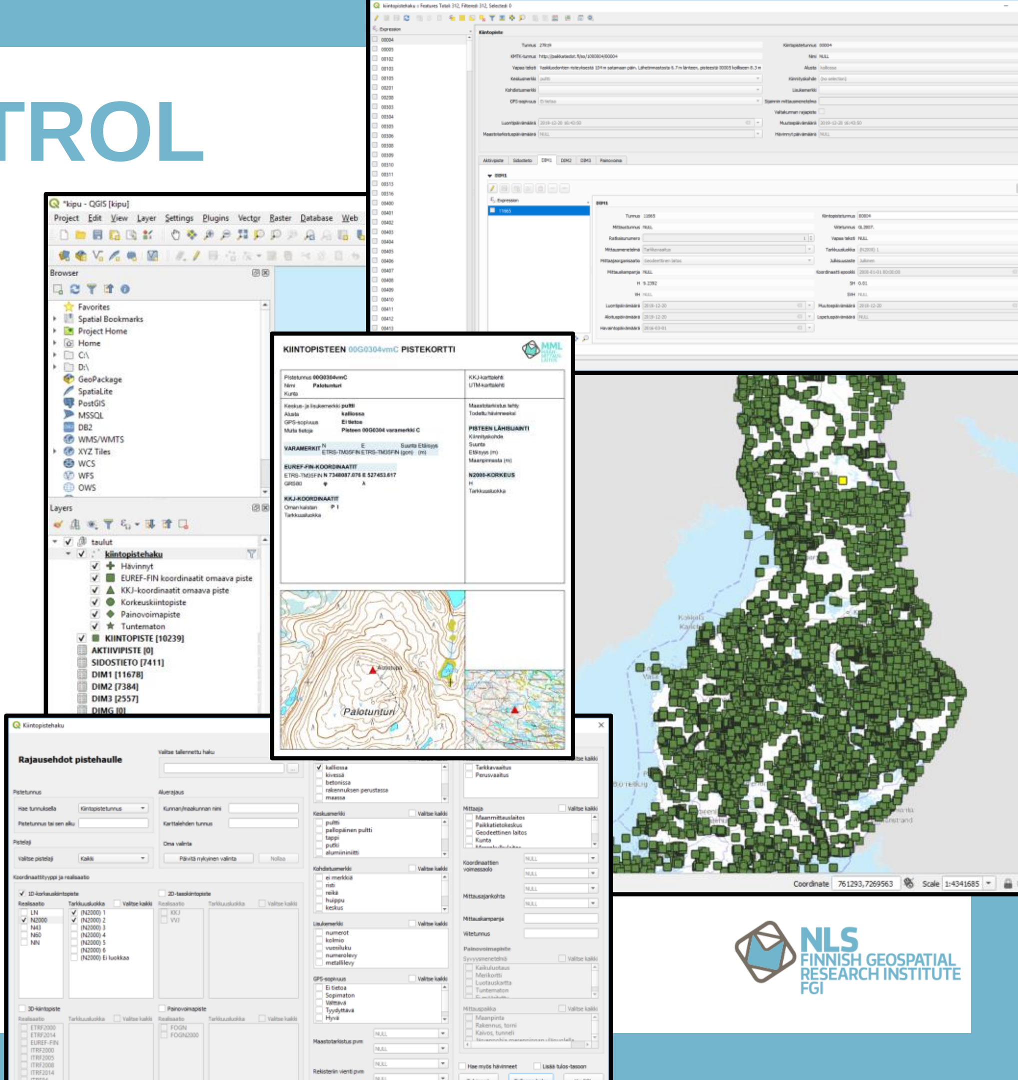
- Method to tra… frames to stat… as an implem… …erence …dered
  - Extensio… deformat… epoch …plate …and
  - A combin… and defo… …tion
- National trans…
- Making availa…



Nat…
- DK: ETRF92(…
- FI: ETRF96(1…
- LV: ETRF89(1…
- SE: ETRF97(…

RENEWAL OF CONTROL POINT REGISTRY

- Includes/handles:
  - Traditional passive benchmarks
  - Active benchmarks (permanent GNSS stations)
  - Gravity benchmarks
  - Supports velocity, uncertainty and time information and validity of coordinates (time windows) and global reference frames
- GUI built on QGIS
  - Uses mostly native QGIS tools
  - Search tool (form), import, export, printing of point information ”card”
  - Currently uses NLS transformation interface (internal) for transforming and converting coordinates but maybe PROJ in the future



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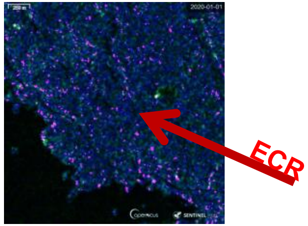
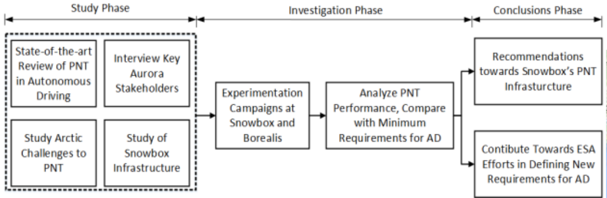




SOME OTHER PROJECTS

Arctic-PNT finished autumn (2 yr project)

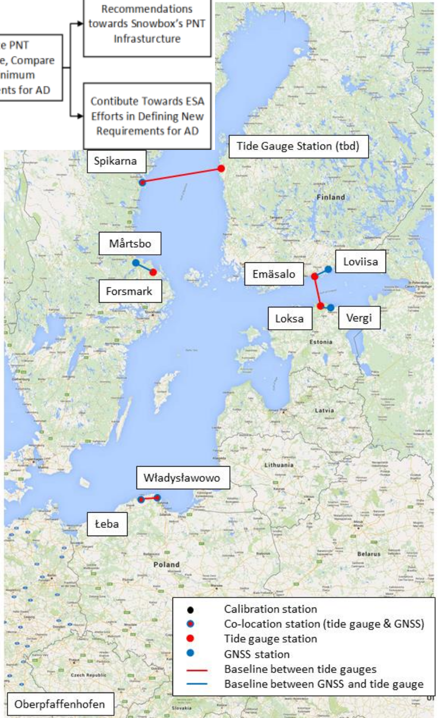
identify and analyze the role of Aurora SNOWBOX as a key infrastructure … especially with regards to positioning and navigation needs for autonomous driving in Arctic conditions

SAMK-ISTLAB (2 yr project)

The goal of the project is to build a jointly used laboratory and innovation environment for the study and development of smart maritime transport

SAR-HSU (2 yr Project)

The goals of the project are: (1) Connecting the tide gauge markers with the GNSS network geometrically in order to determine the relative vertical motion and to correct the tide gauge readings. Geodetic SAR (Sentinel 1) is used for connecting tide gauges to the GNSS network. (2) Determine a GOCE based high resolution geoid at tide gauge stations in order to deliver absolute heights of tide gauges with respect to a global equipotential surface as reference. (3) Joint analysis of geometrical and physical reference frames to make them compatible, and to determine corrections to be applied for combined analysis of geometric and physical heights.



THANK YOU!

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