REVIEW AND UPDATE OF SWEREF 99

EUREF SYMPOSIUM 2021 ONLINE FROM SLOVENIA

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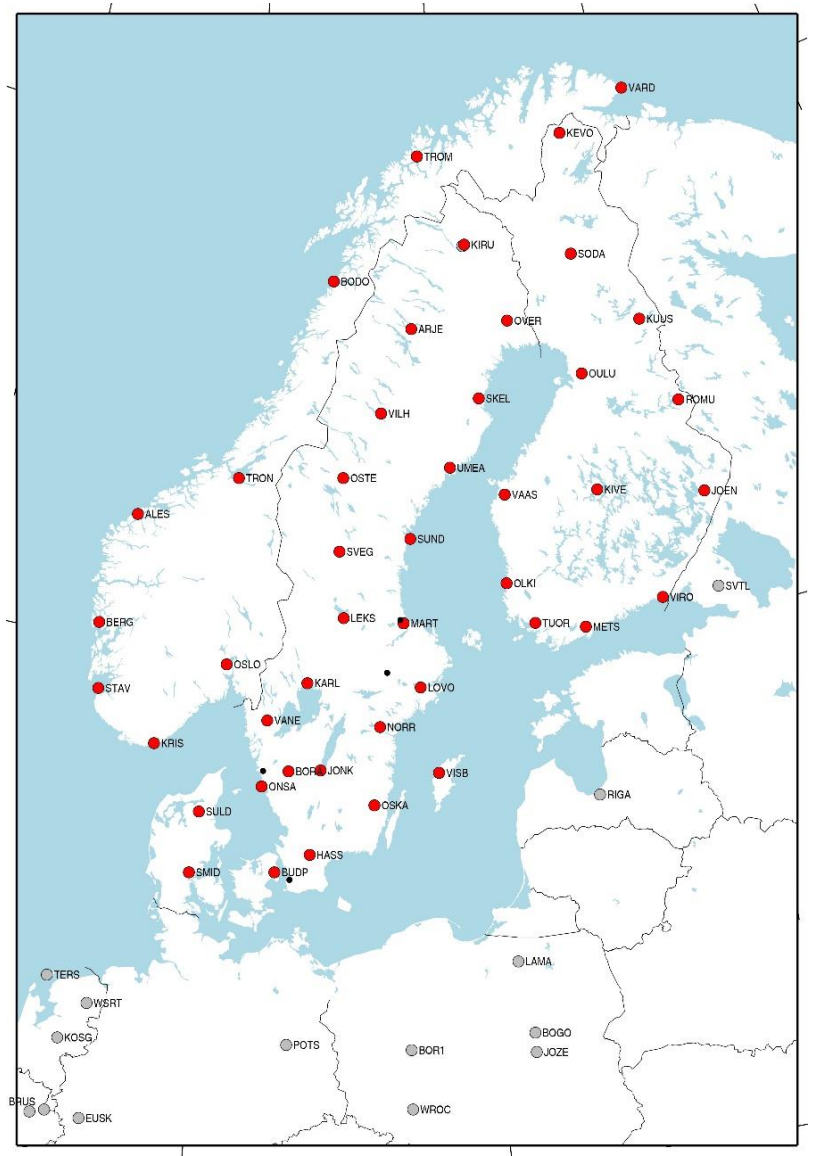
BACKGROUND

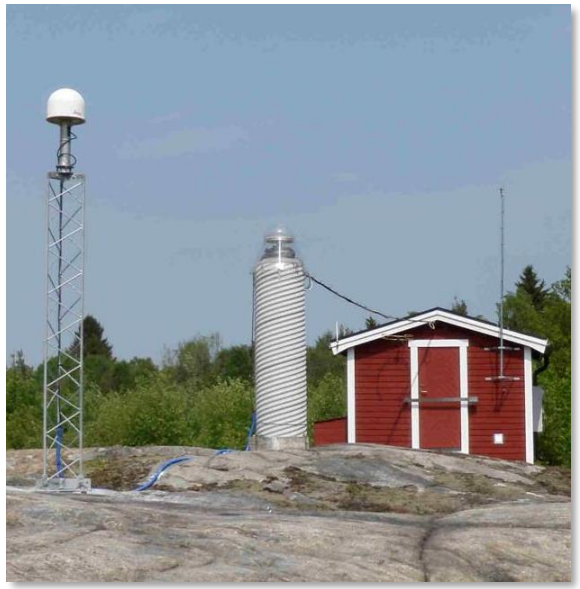
SWEREF 99, ETRS 89 IN SWEDEN, EPOCH 1999.5



Defined by **fundamental permanent GNSS-stations** in Sweden, Norway, Denmark and Finland. SWEREF 99 is mainly accessed through Swepos services (realtime or post processing)

6 weeks in the summer of 1999

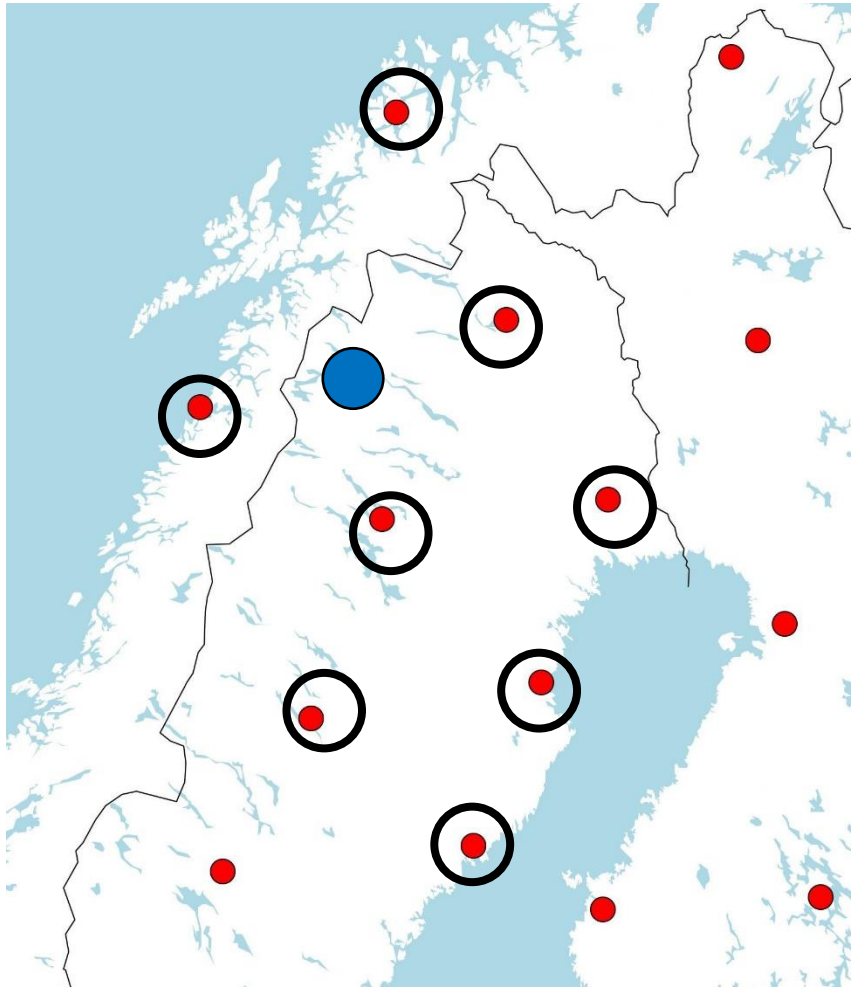
- ITRF 97
- Bernese GNSS Software ver 4.2
- igs_01.atx (relative antenna models)
- 15° elevation cut-off
- DM Chokering antennas



SINCE 1999

- Relative deformations within Sweden up to 4 cm in north and east and 20 cm in height
- Antenna changes in Denmark and Norway soon after the campaign in 1999 (but Finnish stations remained until 2016)
- Antenna changes
- Antenna model changes (relative → 108 → 114)
- Elevation cut-off 15° → 10° → 3°
- Other model changes for the processing
- Glonass and later Galileo were added

METHOD FOR NEW SWEREF 99-COORDINATES



Concept of ”local alignment” to the closest fundamental stations

- 3D Helmert 6-8 SWEPOS stations
- Additional foreign stations
- Reduction for landup-lift before the fit

SWEPOS-stations (new or changes)
3 weeks of SWEPOS-processing combined with NKG GNSS AC-solutions

Passive points
2 x 24 h

MOTIVATION AND OBJECTIVE

- Degradation and increasing demands on the precision from the SWEPOS-services
- **Review**: Analyse the ”present” SWEREF99 coordinates and quantify the uncertainty from different contributors
- **Update**: Compute a new set of coordinates for all stations used in SWEPOS services and for the definition of SWEREF 99

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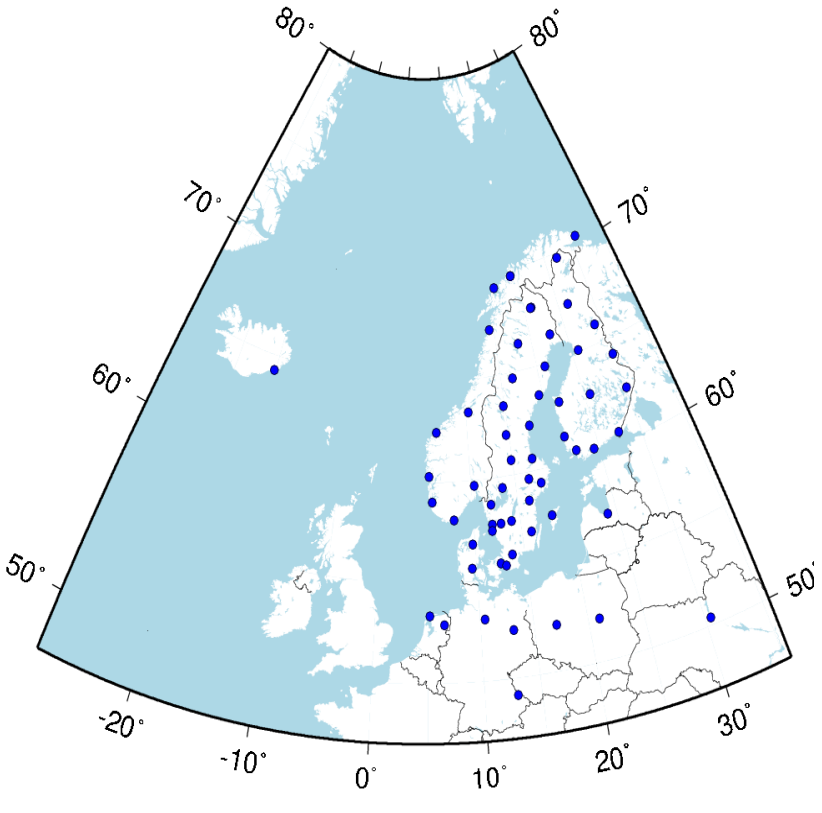
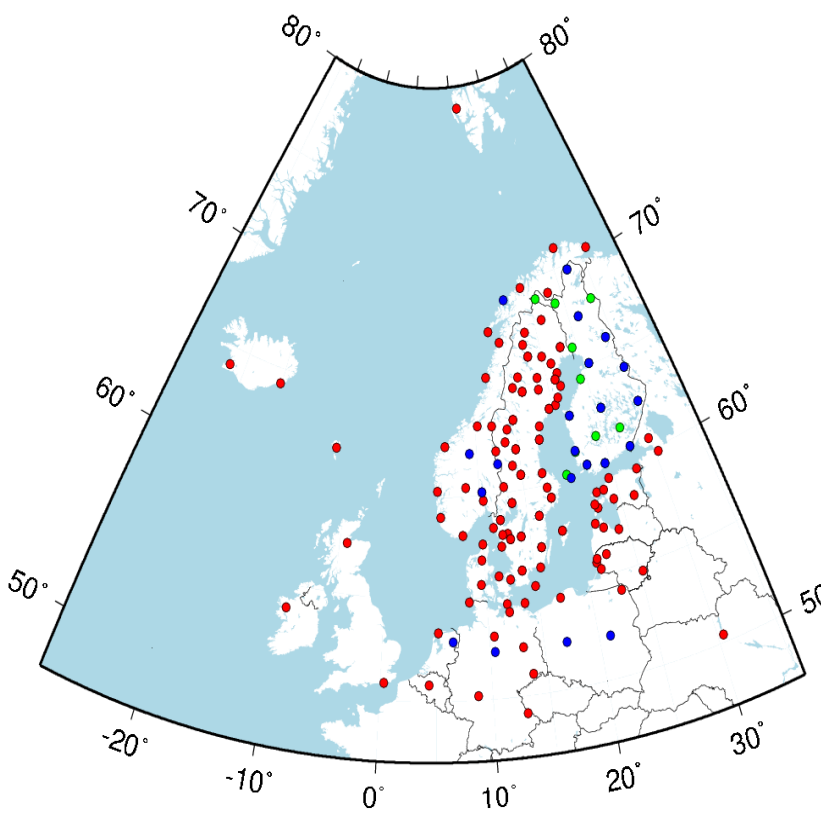
WORK DONE

THREE CAMPAIGNS

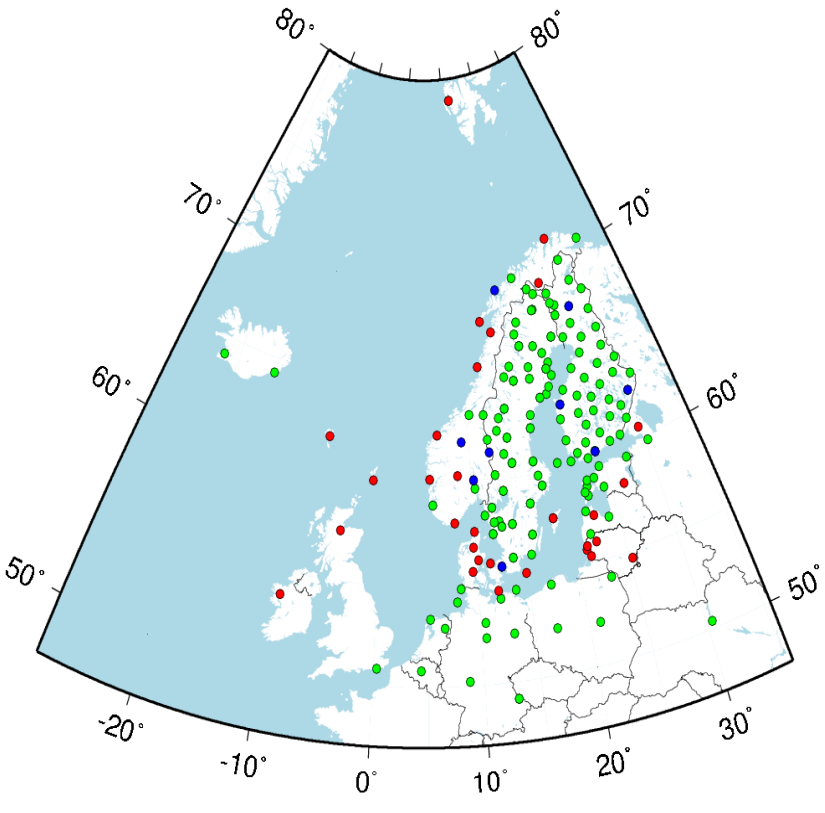
1999



2015



2019



= GPS = GPS+GLO = GPS+GLO+GAL

COMPUTED SOLUTIONS

Solution type	1999		2015		2019	
	I08	I14	I08	I14	I08	I14
Campaign GPS	S08_99_G	S14_99_G	S08_15_G	S14_15_G	S08_19_G	S14_19_G
Campaign GPS/GLO			S08_15_GR	S14_15_GR	S08_19_GR	S14_19_GR
Campaign GPS/GLO/GAL				S14_15_GRE		S14_19_GRE
NKG GPS	N08_99		N08_15R			
NKG GPS/GLO			N08_15O			
NKG GPS/GLO/GAL						N14_19_3v/9v

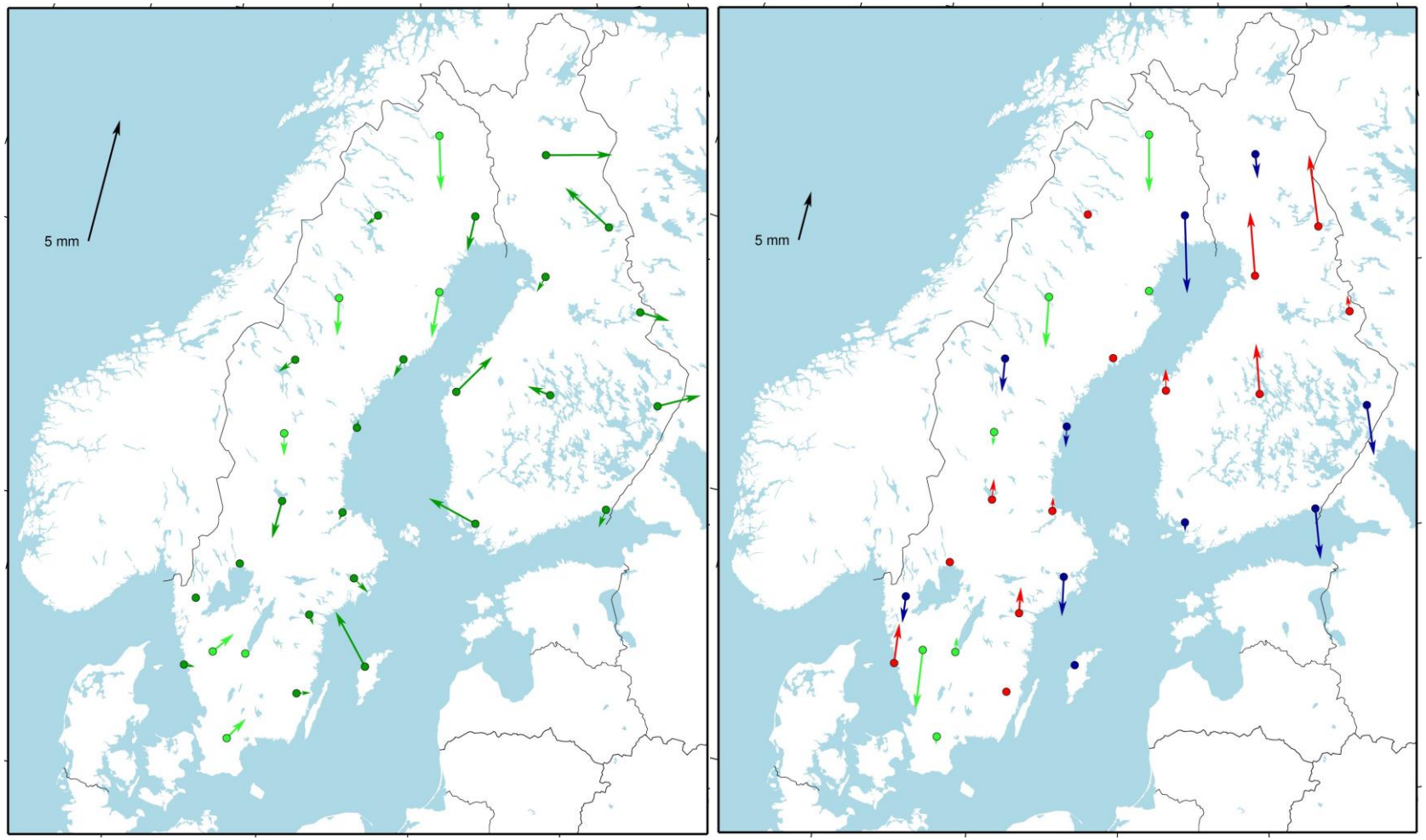
16x2 = 32 solutions
3° and 10° grader

+ time series analysis based on NKG
(repro1 and operational)

UNCERTAINTIES (STANDARD UNCERTAINTIES NE/U)

contributor \ cut-off angle	3°	10°
Net/cluster/baselines	0.2 / 0.8 mm	0.2 / 0.8 mm
GPS – GPS+GLO	0.7 / 1.5 mm	0.8 / 2.1 mm
GPS+GLO – GPS+GLO+GRE	0.3 / 1.1 mm	0.3 / 1.2 mm
I08-I14	max 4 / 21 mm	max 4 / 24 mm
I08-I14 vs IGN-korr	0.5 / 1.8 mm	0.5 / 1.6 mm
1999 – 2019 17 stn (N/E/U) 1999 – 2015 28 stn (N/E/U)	1.3 / 1.0 / 4.4 mm 1.2 / 0.7 / 4.0 mm	1.3 / 1.1 / 4.5 mm 1.2 / 0.7 / 4.2 mm

1999 CAMPAIGN FITTED TO OFFICIAL SWEREF 99 (114, EP1999.5)



Light green arrows for stations with antenna changes

SWEREF 99 (114) from coord. DB (epoch 1999.5) minus S14_99_G (1999,114, GPS, 3°)

Totally 30 stations:
RMS 0.9 1.0 3.7 mm in N E U

23 unchanged:
RMS 0.9 1.0 3.8 mm in N E U

Residuals depend on:

- Uncertanties of corrections rel → 108 → 114
- Model differences (trop, elev.cut off)
- Uncertanties of antenna changes

NEW COORDINATE SET: SWEREF 99 UPDATE 2021

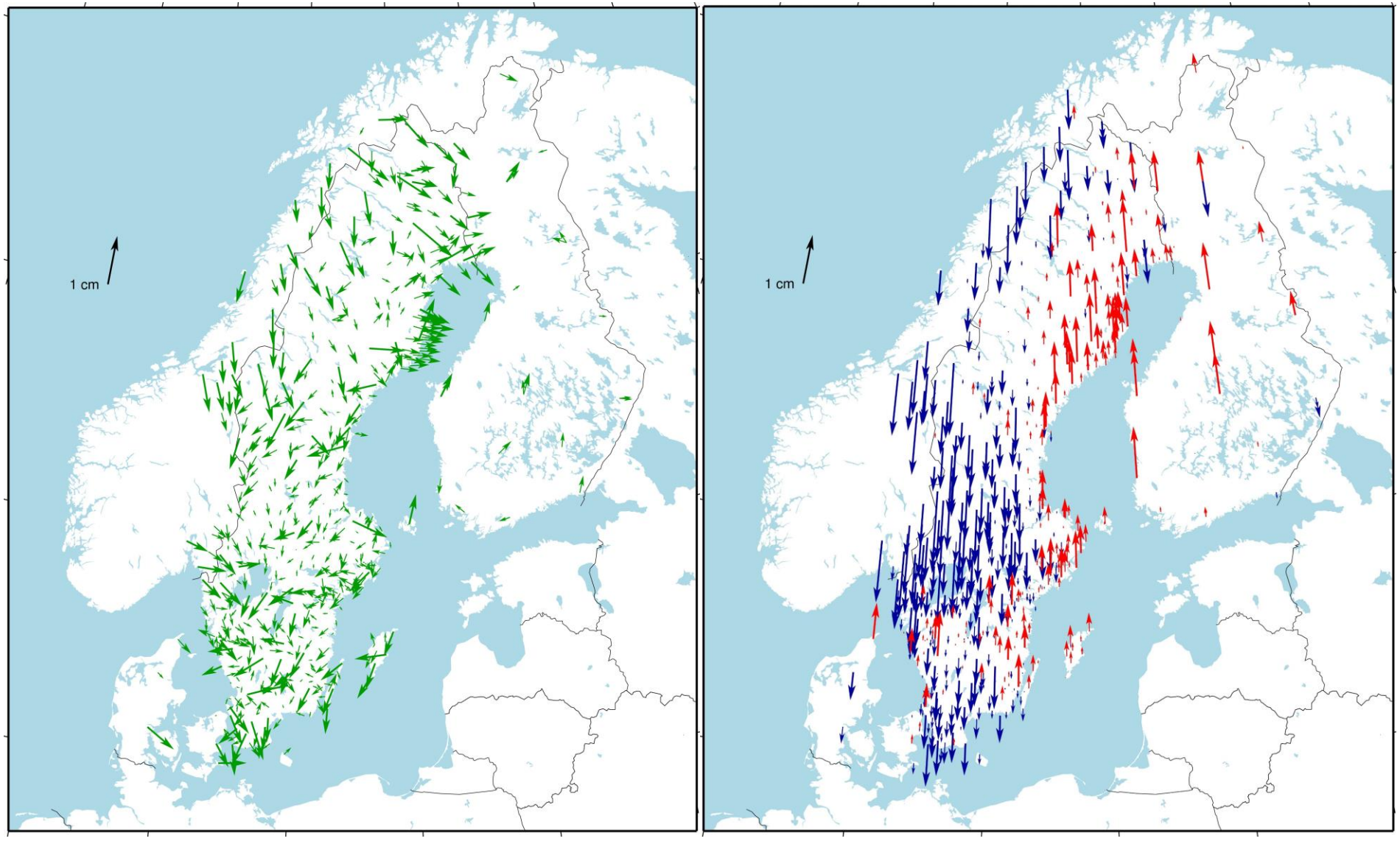
- Consistent with present observations and processsing models
- Agree with present coordinates within the uncertainty limits of the SWEPOS services

NEW COORDINATE SET

- Based on the 2019 campaign, 114, GPS+GLO+GAL (S19_14_GRE)
- 3°, more consistent solutions than 10°, standard in EPN/EUREF
- Add all other stations used in the Swepos services

- Fit to the ”present” official SWEREF 99 (in the coordinate DB)
  - NKG_RF17vel used for reduction to epoch 1999.5
  - Tested different sets of fitting points with following criteria:
    - Best fit with priority to areas with the lowest uncertainties in SWEPOS services (project adapted areas)
    - Best agreement of orientation with EPN’s realisation of ETRS89

SWEREF 99 MINUS SWEREF 99, UPDATE 2021



RMS:
2.7 2.4 4.9 mm

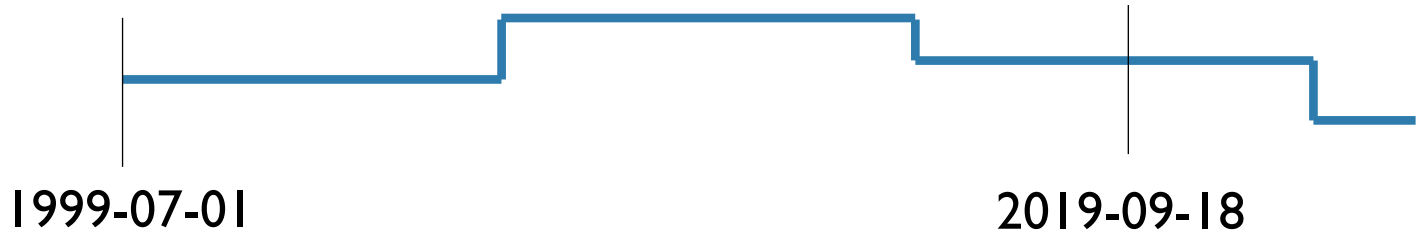
577 points

At the epoch
2019-09-18

RMS project adapted areas (14):
2.1 2.1 3.1 mm

IMPLEMENTATION IN SWEPOS SERVICES

The new updated coordinates were implemented in SWEPOS 2021-02-07, after:



- Coordinates for time intervals after 2019-09-18 – all stations
- Coordinates for earlier intervals - fundamenat stations and for projected adapted stations (where our partners wished so)
- The NKG Repro1 + operational is used for checking the offsets

SUMMARY

- The review shows that we had a **general uncertainty level on 2/2/5 mm** in N/E/U
- The remaining errors of the 20 years land uplift, after modelling with NKG_RF17vel, is 1-2 mm in NE and 4 mm in U, which correspond to **2-3% of the total deformation**.
- Larger differences for GPS - GPS/GLO than GPS/GLO - GPS/GLO/GAL
- Better agreement for 3° than 10°
- A **new set of SWEREF 99 coordinates** have been implemented in Swepos
  - ✓ We consider it as an update and not a new frame
  - ✓ Consistent with observations and models of today
  - ✓ Better geographical coverage and the orientation agrees better with EPN ETRS89
  - ✓ Agree with earlier used coordinates within the uncertainty limits of the SWEPOS services

THANKS FOR YOUR ATTENTION!

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