The maintenance of SWEREF 99, including the use of a deformation model

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LANTMÄTERIET

SWEREF 99 , 15 years

- Relative deformations within Sweden up to 15 cm in vertical and 4 cm in horizontal
- Processing strategy for accurate coordinate determination has changed (antenna models, elevation cut-off, ..)
- Some countries have alreday replaced their earlier ETRS 89 realizations
- WE WILL NOT REPLACE SWEREF 99!
  - Why?
  - How to manage with the deformations and other alterations?

SWEREF 99, ETRS 89 epoch 1999.5, Definition

49 permanent stations

21 class A in Sweden
12 in Finland
9 in Norway
3 in Denmark

6 weeks of data, middle epoch 1999.5

Accepted as EUREF class B standard in Tromsö 2000

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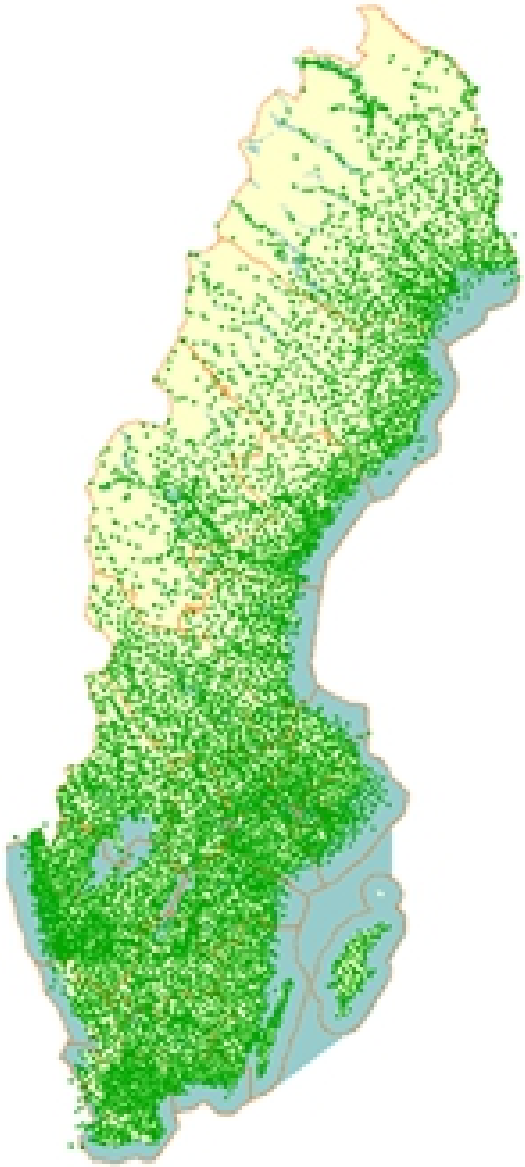
The use of SWEREF 99

- Replaced the old national geodetic reference frame 1st of January 2007 and has been used for SWEPOS GNSS services since 2001
- 93 % of the 290 Swedish municipalities have started the process to replace their old refe-rence frames with SWEREF 99 (83% have changed)
- 9029 national control points have been determined in the project RIX 95 (with the primary aim to connect local reference frames)



Definition by a passive or an active network? (RIX 95 – SWEPOS)

Passive network

- Type of coordinate system (X,Y,Z e.t.c)
- Points in the reference network
- The coordinates of the points in the reference network

Additional for active network:

- Reference epoch. Best possible correction model for reduction to the reference epoch should be used.

Definition of SWEREF 99

- We have chosen to define SWEREF99 using the active reference network (SWEPOS)

Carrier:

- 21 class A SWEPOS stations in Sweden
- ”Stable” permanent GNSS stations in Finland, Denmark and Norway

The basic idea is to get the same coordinates as if they were measured in 1999.5, except for local motions. (No corrections for geodynamic motions with a resolution smaller than 100 km).

Arguments for definition by an active network

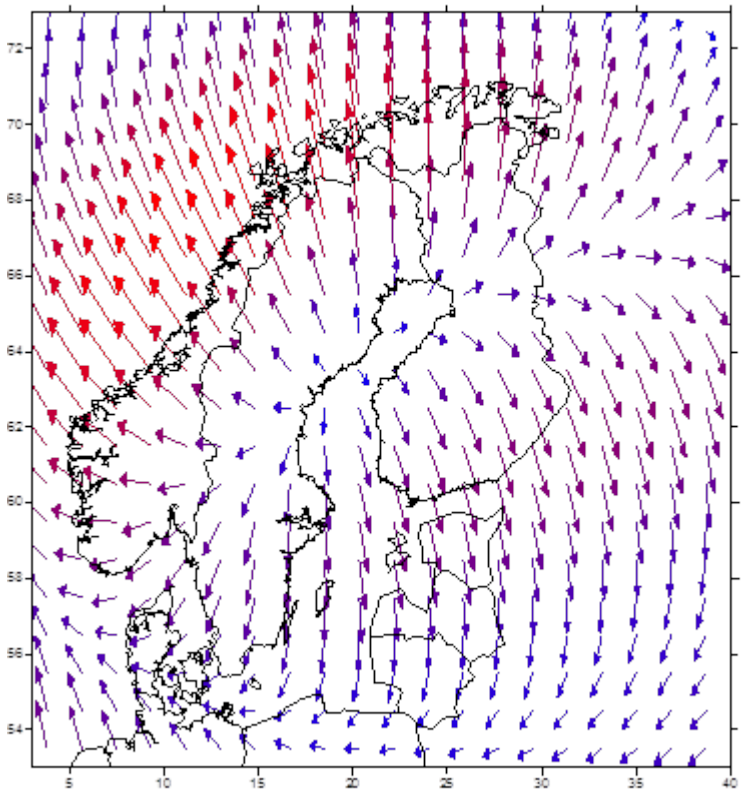
+ No maintenance of the passive network
+ Efficient GNSS measurements
+ No risk of problems with lower quality densification in comparison to the future accuracy of GNSS
+ The stations control each other continuously

- Jump when velocity model is changed or other uncorrected changes are introduced in the active system
- In some areas discrepancies between SWEPOS and RIX95
- Geodynamic motions with a resolution <100 km

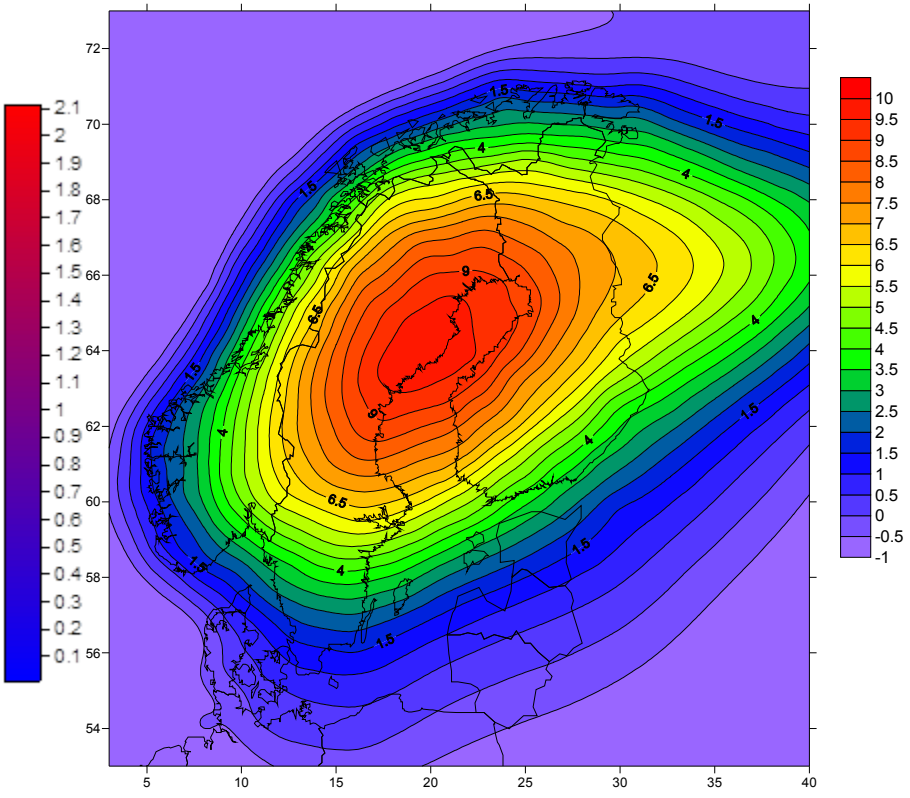
Deformation model

- Reduction to epoch 1999.5
- Best possible correction model , today we are using NKG_RF03vel
- Will be replaced in the future with better models
- Local movements not taken into account

The deformation model NKG_RF03vel (velocities within the European plate)



Horizontal (0 to 2 mm/yr):
Milne 2001, transformed to the GPS-velocities in Lidberg 2004.



Vertical (-1 to 10 mm/yr):
NKG2005LU(ABS)
Ågren&Svensson 2006. Based on: TG, repeated levelling, and GPS.

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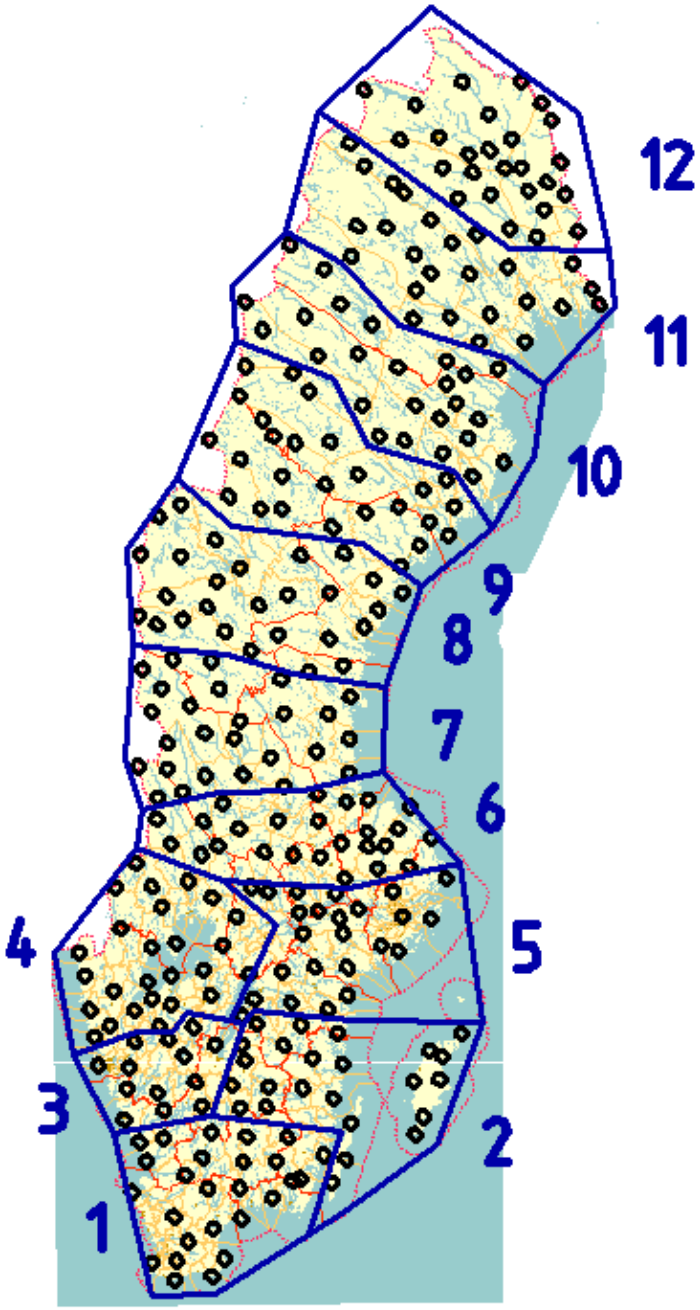


Consolidation points

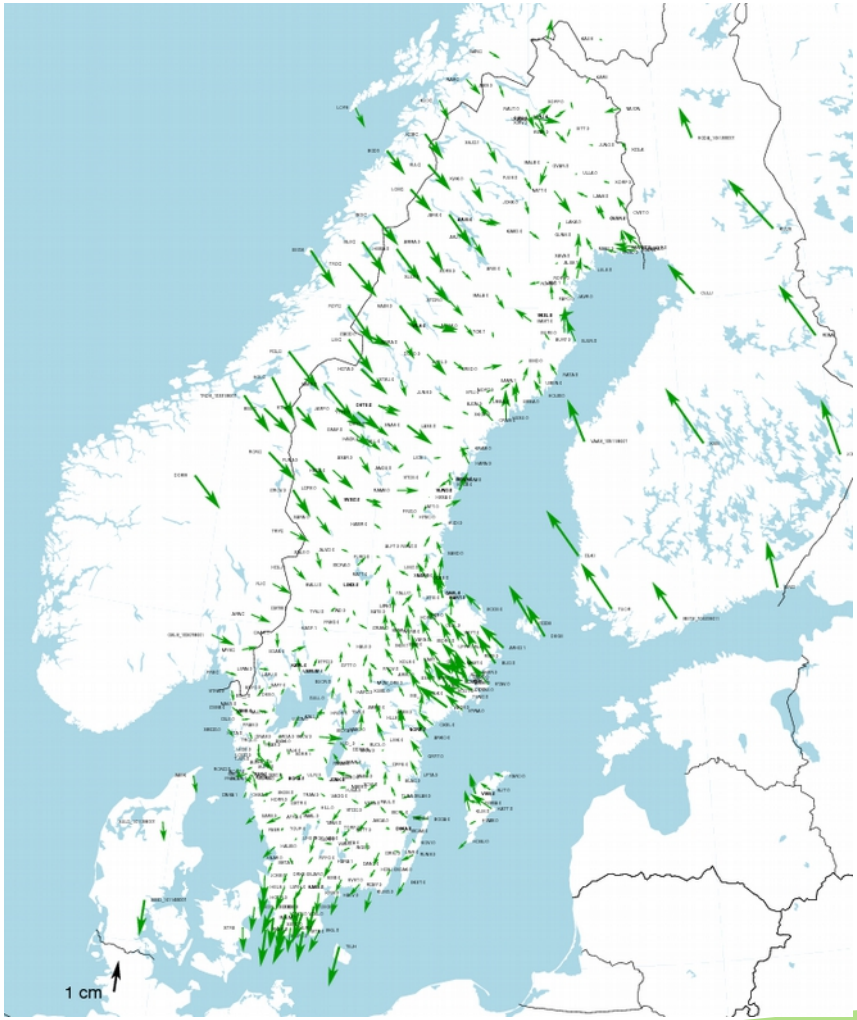
- By defining SWEREF 99 as an active reference frame we are exposed to rely on SWEPOS' positioning services
- All alterations of equip-ment and software as well as movements at the stations will in the end affect the coordinates
- To keep a check on all these alterations we have introduced consolidation points
- 300 points, 50 measured each year.

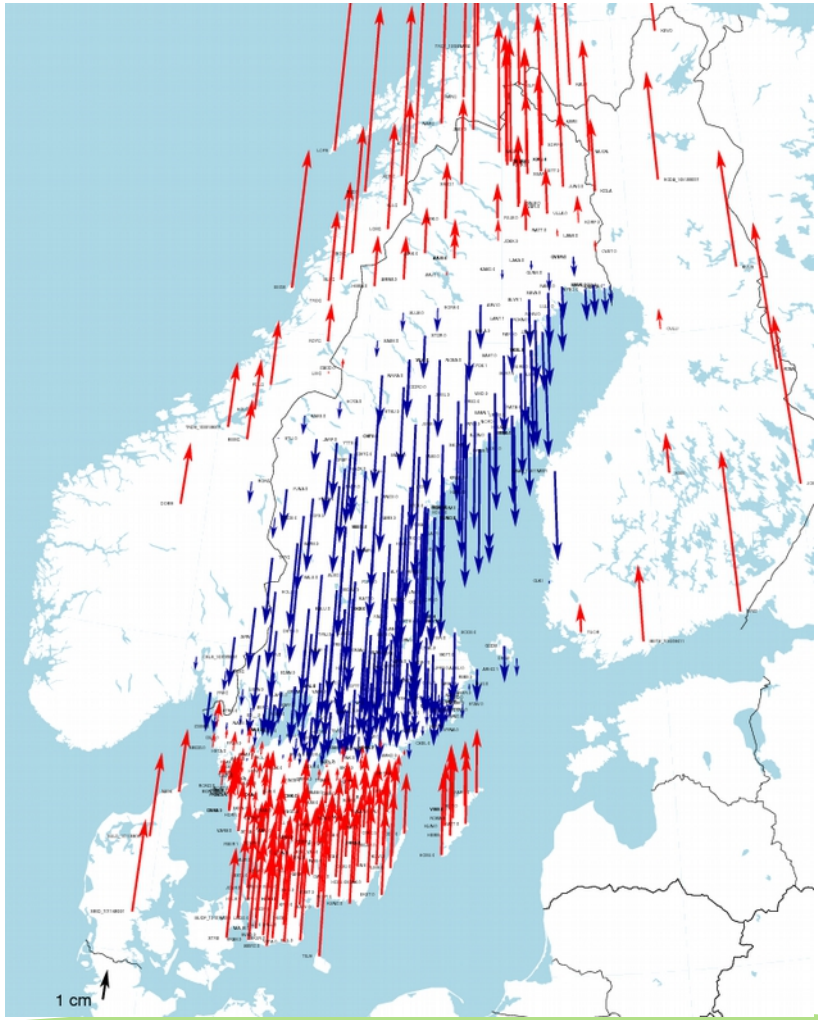
Coordinate determination of the SWEPOS-stations

Station coordinates are determined by local fits to 5-8 fundamental SWEPOS-stations after reduction to epoch 1999.5 using the NKG_RF03.VEL.

- Preliminary coordinates calculated for new stations and before and after an antenna repacement (5 days)
- ”Definitive” coordinates determined twice a year for new stations, stations with antenna replacements and for ”unstable” stations (3-5 weeks)
- Coordinates updated for the introduction of I08.ATX antenna models

SWEPOS week 1789 fitted to SWEREF 99 with 7-parameter Helmert





Rms: 5.4 3.9 26.0 mm

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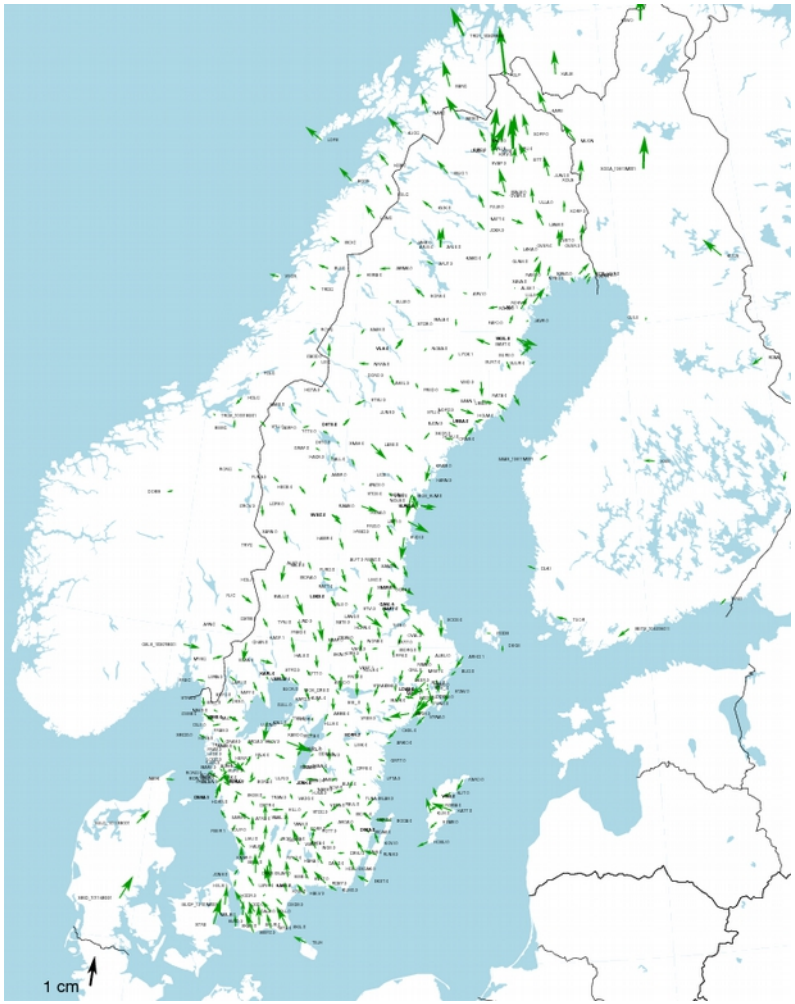
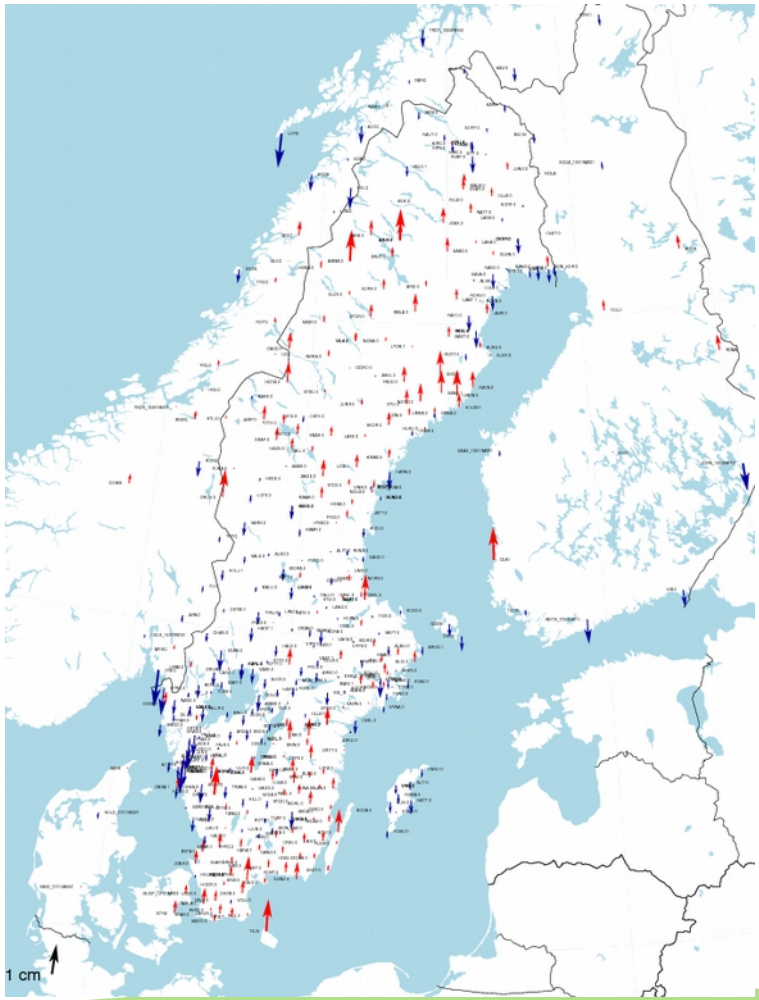
SWEPOS week 1789, reduced for NKG_RF03.VEL, fitted to SWEREF 99 with 7-par Helmert.





Rms: 3.5 2.4 3.6 mm

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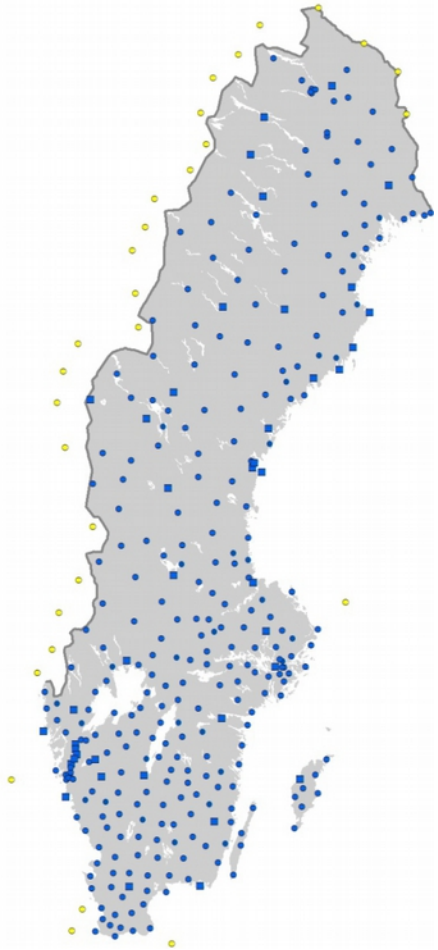
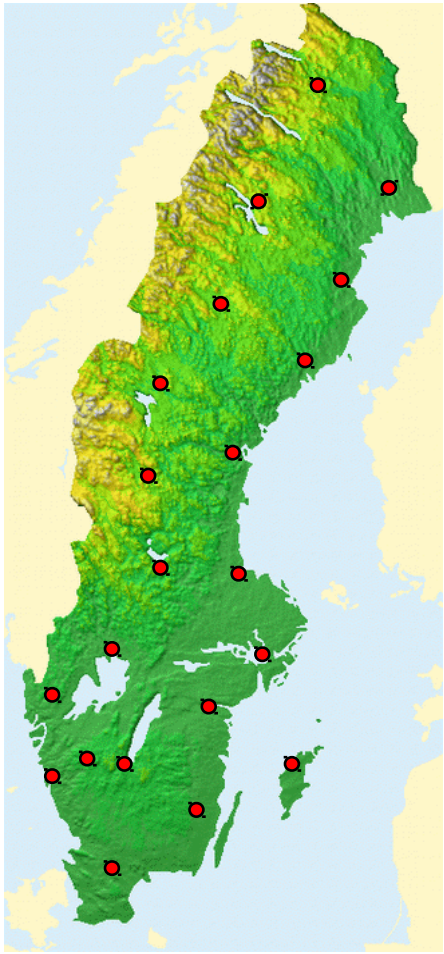
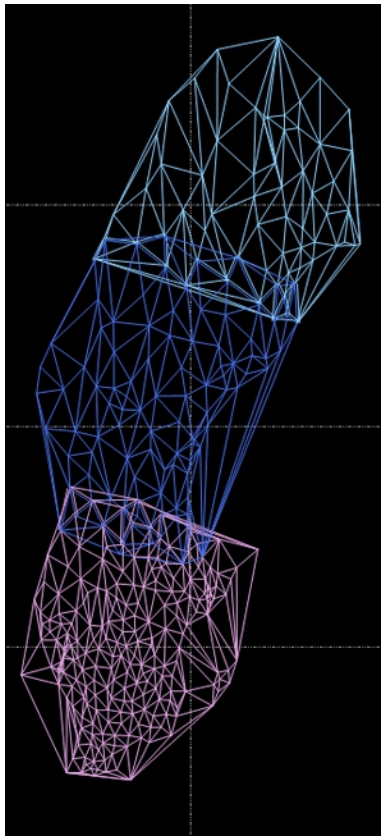
SWEPOS Network-RTK



SWEPOS Post Processing Service



SWEPOS Network-RTK



Landuplift differences 1999-2014
within each sub-network

North 8 cm

Middle 5 cm

South 10 cm

Setup in TPP (Trimble Pivot Platform)

Position References

Reference frame	ETRS89
Default tectonic plate	Eurasia
Reference time [System startup]	Year [01.01.yy 00:00:00]
Agency	Trimble Navigation Limited
Observer	

Station Information

Station ID	381
Station name	QABI
Station code	QABI
Last modification time [GPS Time]	2014-03-04 19:48:39

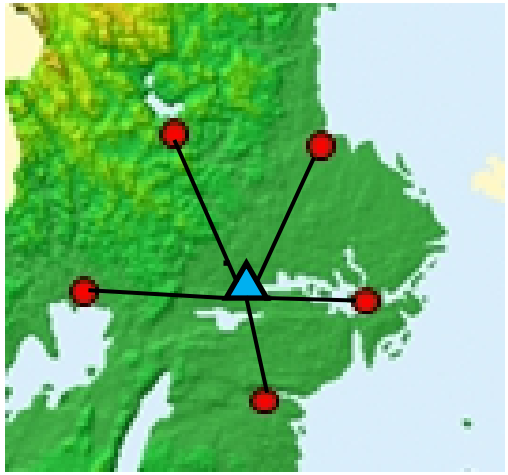
Position

Tectonic plate	Eurasia
X	2233558.0134
Y	761080.1007
Z	5906185.7509
Velocity X [m/year]	0.000580
Velocity Y [m/year]	-0.000590
Velocity Z [m/year]	0.005600
Reference time	1999-07-01 00:00

NKG_RF03.VEL

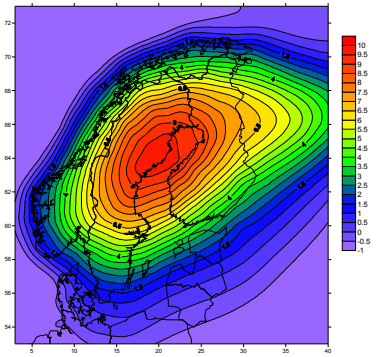
SWEPOS post processing service

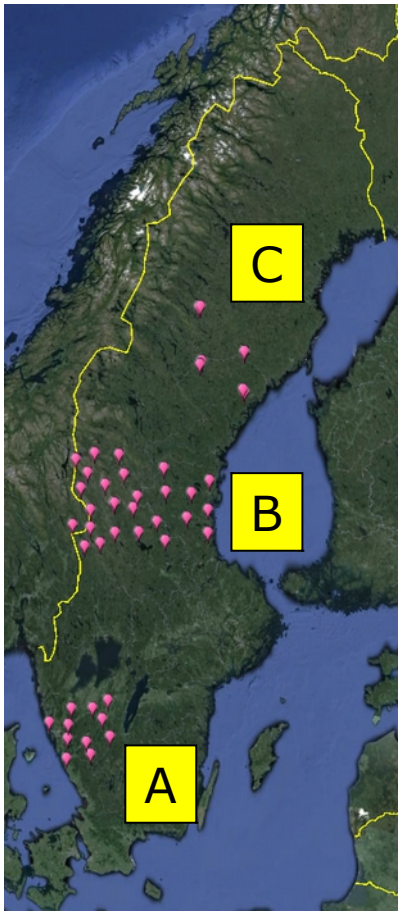
- Based on the Bernese GNSS Software, static measurements
- Single stations are connected to the 5 closest SWEPOS-stations
- Coordinates are initially calculated in ITRF2008 current epoch
- They are then reduced to epoch 1999.5 using NKG_RF03vel
- Finally a 6-parameter Helmert-fit is made on the SWEPOS-stations to achieve SWEREF 99 coordinates

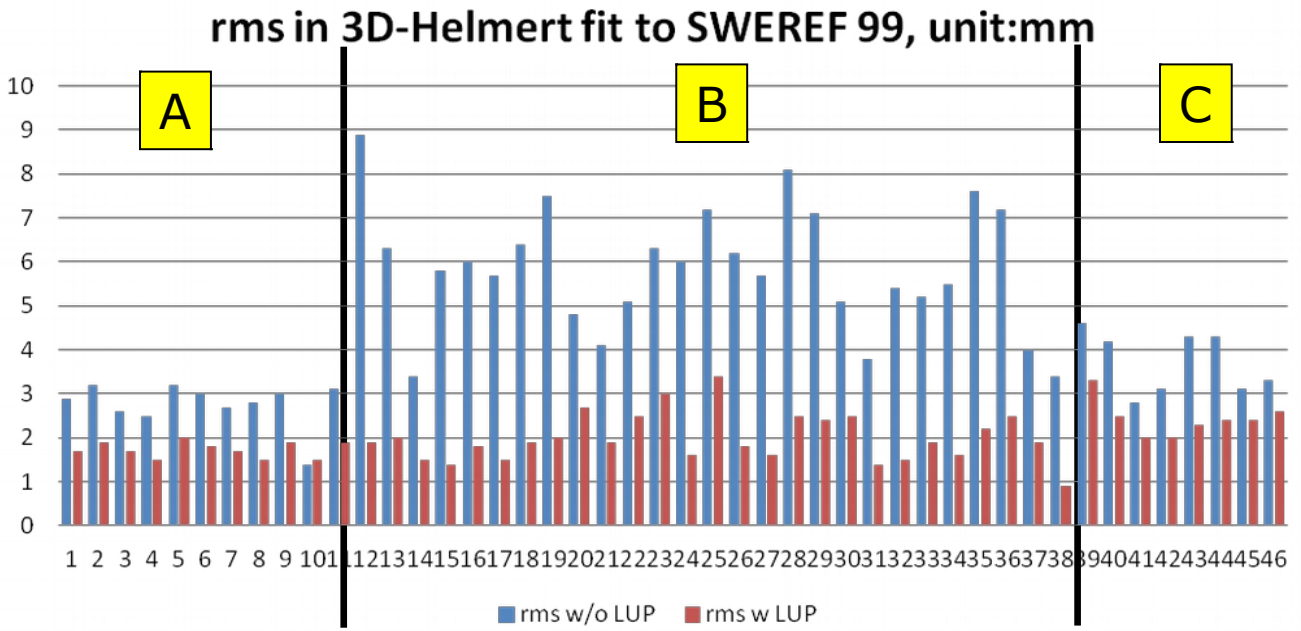


(Modified version for consolidation points – 6-8 SWEPOS and 6 or 7-parameter fit)

SWEPOS processing service - example (Consolidation points - year 2010)







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Summary

- SWEREF 99 is used as THE national reference frame since 2007 and 83% of the municipalities have already replaced their old systems with SWEREF 99 (another 10% are in the process of implementing SWEREF 99)
- SWEREF 99 is defined by an active network (SWEPOS) which implies the use of a deformation model (NKG_RF03.VEL)
- NKG_RF03.VEL is implemented both in SWEPOS network-RTK-service and in SWEPOS Post processing service
- NKG_RF03.VEL improves the fit of current solutions to SWEREF99, but we do see some problems close to the land-up-lift maximum