ETRS89 in Fennoscandia - with special emphasis on Sweden

EUREF2016 Tutorial on ETRS89, San Sebastian, Spain

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Outline

The specific situation in Fennoscandia

Realizations of ETRS89 in Fennoscandia

Expectations from the user community

Common Nordic/Baltic efforts of models of crustal deformations

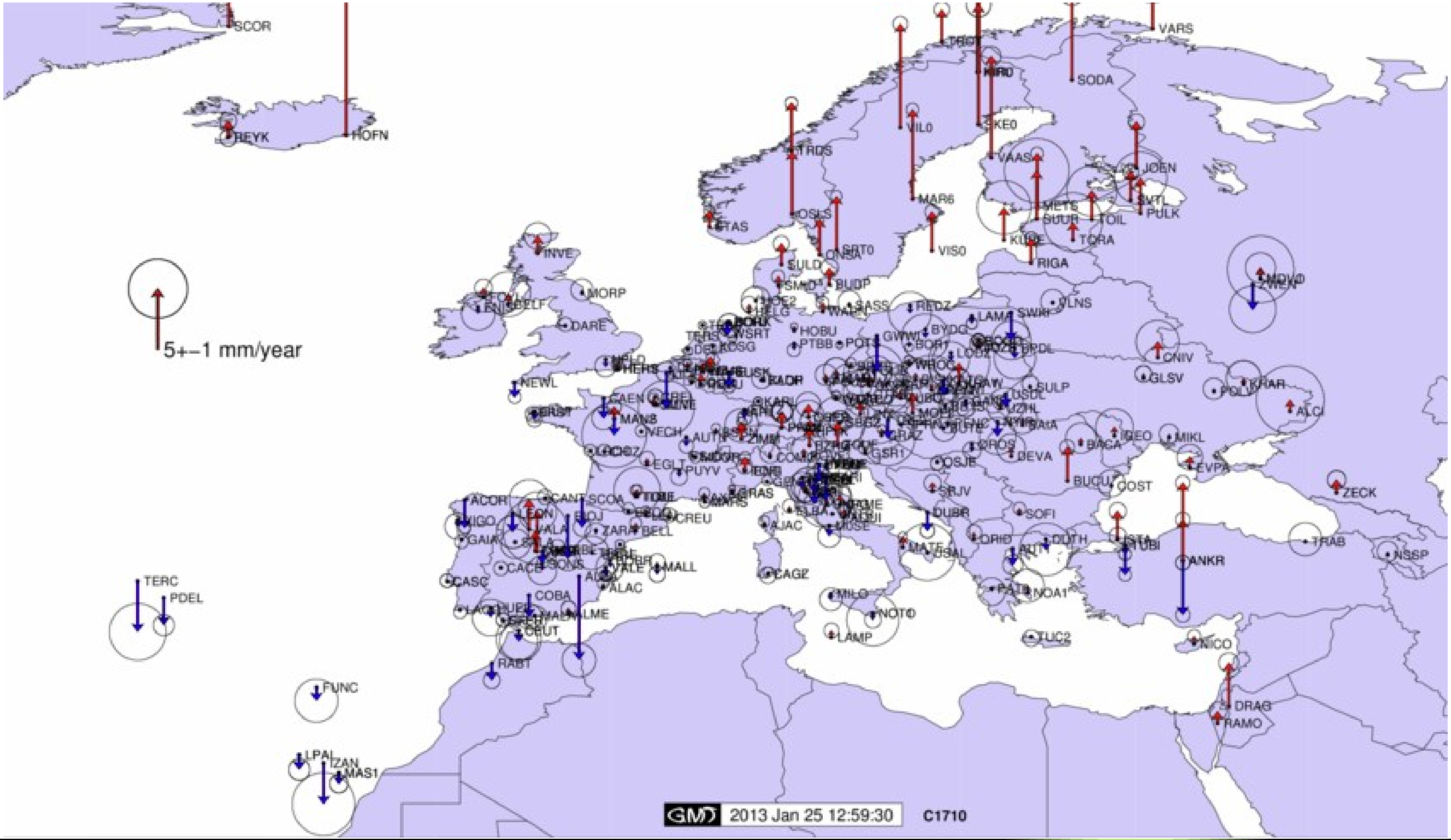
Transformation scheme from ITRFs to realization of ETRS89

Example from Sweden:

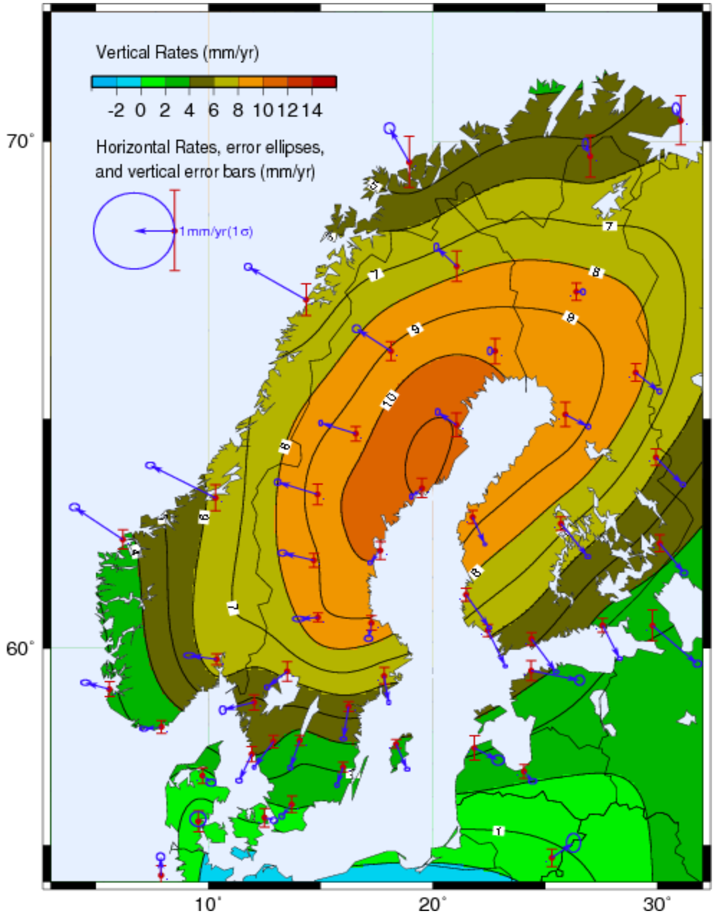
- Implementation in post-processing service
- About the network RTK service

Discussion!

Vertical velocities in ETRS89



The Specific situation in Fennoscandia



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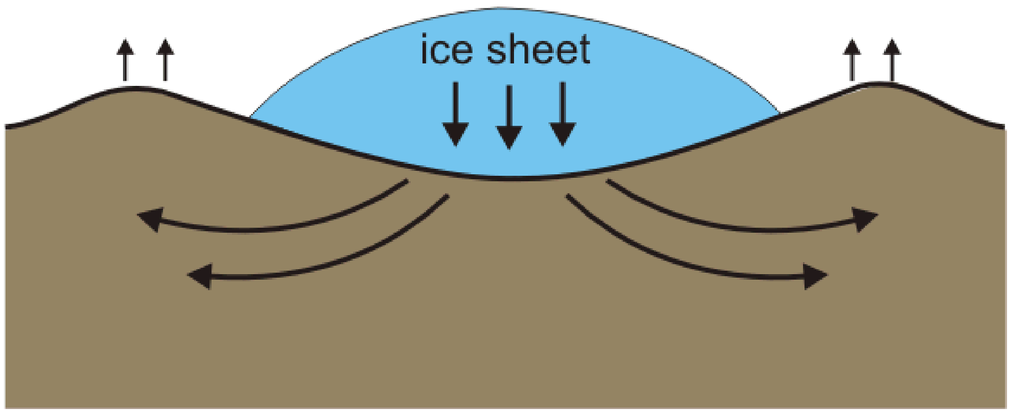
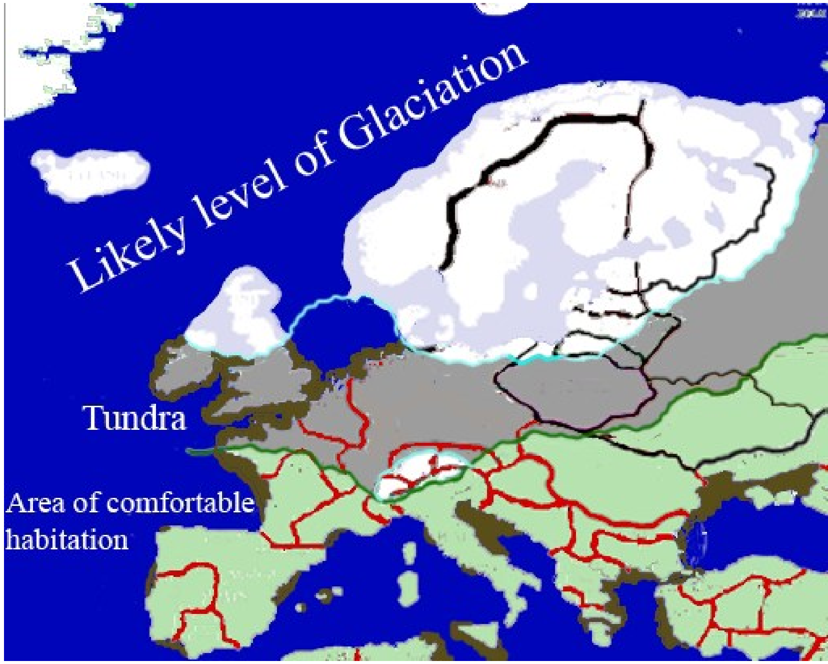
The Glacial Isostatic Adjustment (GIA) phenomenon





To note:

In presence of crustal deformations, the epoch is crucial.

Therefore:

Time tag everything!

Realizations of ETRS89 in Fennoscandia
(the Nordic /Baltic countries)

Country	Country ID	Name of realization	Based on ITRFxx	Realization epoch
Denmark	DK	EUREF-DK94	ITRF92	1994.704
Estonia	EE	EUREF-EST97	ITRF96	1997.56
Faroe Islands	FO		ITRF2005 (ETRF2000)	2008.75
Finland	FI	EUREF-FIN	ITRF96	1997.0
Latvia	LV	LKS-92	ITRF89(?)	1992.75
Lithuania	LT	EUREF-NKG-2003	ITRF2000	2003.75
Norway	NO	EUREF89	ITRF93	1995.0
Sweden	SE	SWEREF 99	ITRF97	1999.5

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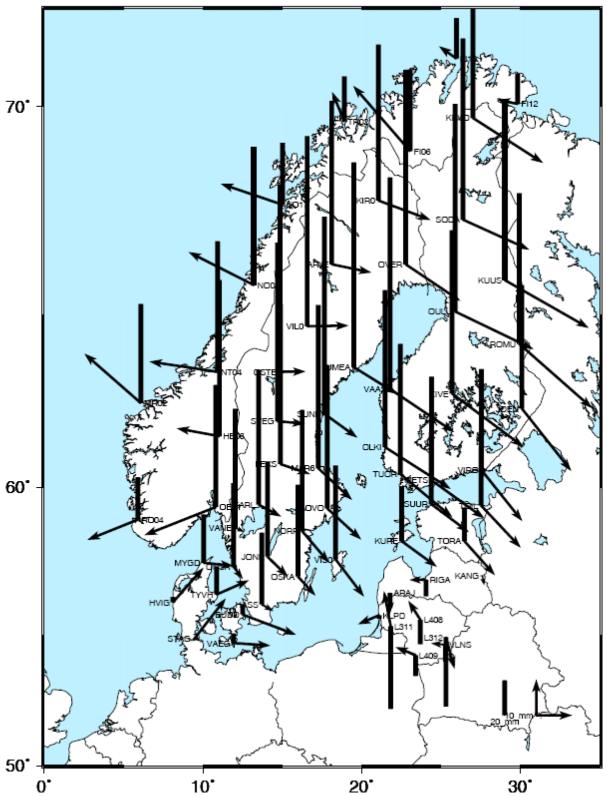
Comparing the national realizations of ETRS89 in Fennoscandia

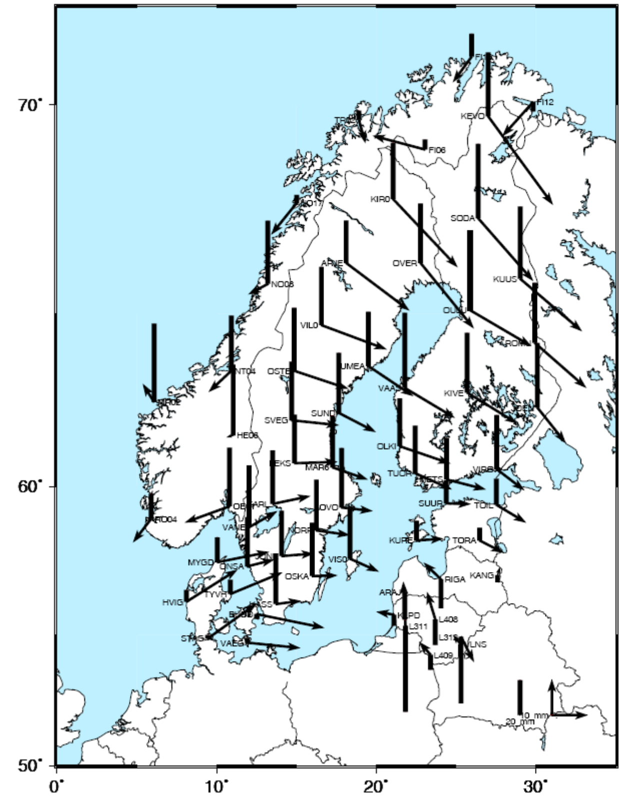


Statistics:	(n,e,u) in mm		
RMS	9	12	69
Mean	-4	5	53

The NKG2008 campaign in ETRS2000 compared to national realizations.

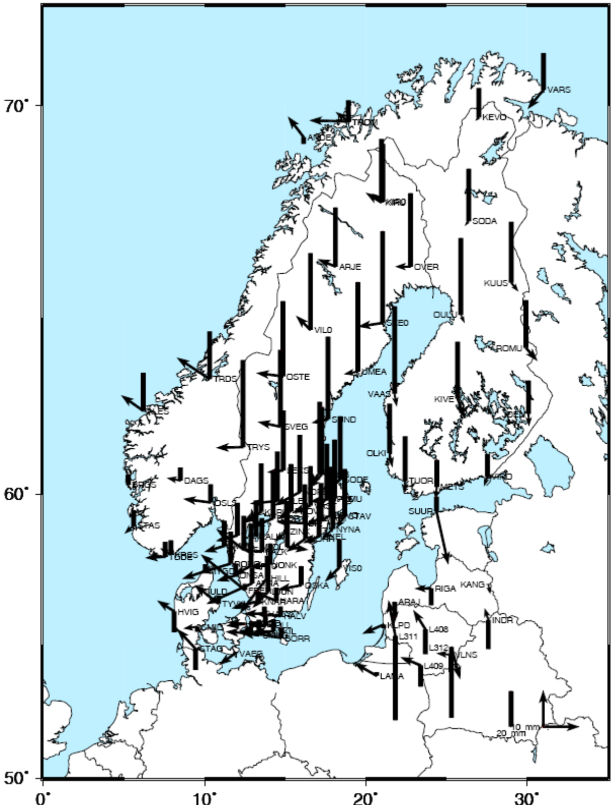
Left, @ epoch 2008.75.

Right, @ epoch 2000.0, using a model for intraplate velocities (NKG_RF03vel)



Statistics:	(n,e,u) in mm		
RMS	8	11	28
Mean	-3	7	19

Comparing the NKG2008, and the NKG2003 common campaigns. (in ETRF2000)



Statistics:	(n,e,u) in mm		
RMS	4	5	24
Mean	-5	-4	16

NKG2003 based on ITRF2000,

NKG2008 based on ITRF2005.

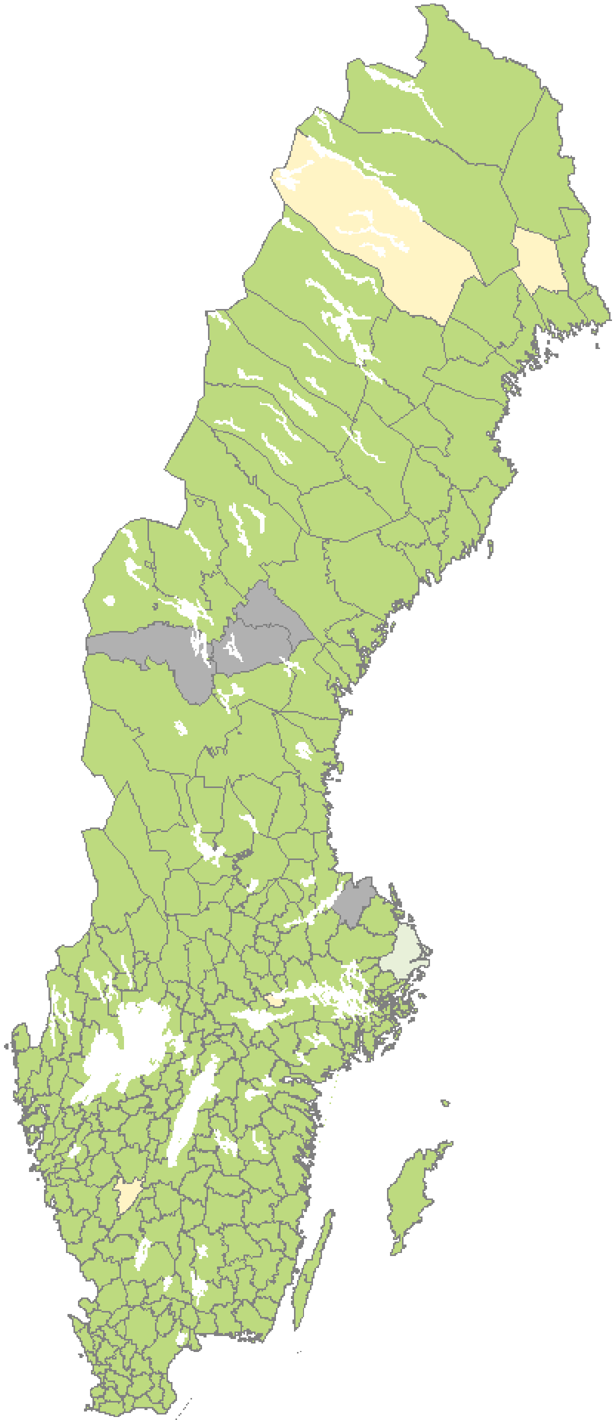
Left, NKG2008 @2008.75; NKG2003 @ 2003.75

Right, booth @ epoch 2003.75, using the model NKG_RF03vel

(No fit – just coordinate differences!)

Accidentally good luck in reference frame realization??

Statistics:	(n,e,u) in mm		
RMS	4	4	8
Mean	0	-3	-3



Adoption of ETRS89 (SWEREF 99) in Sweden at the local authority level (2016-04-22)

In total 290 local authorities

- Adopted (281)
- Relation delivered (1)
- Work in progress (4)
- Progress unclear (4)

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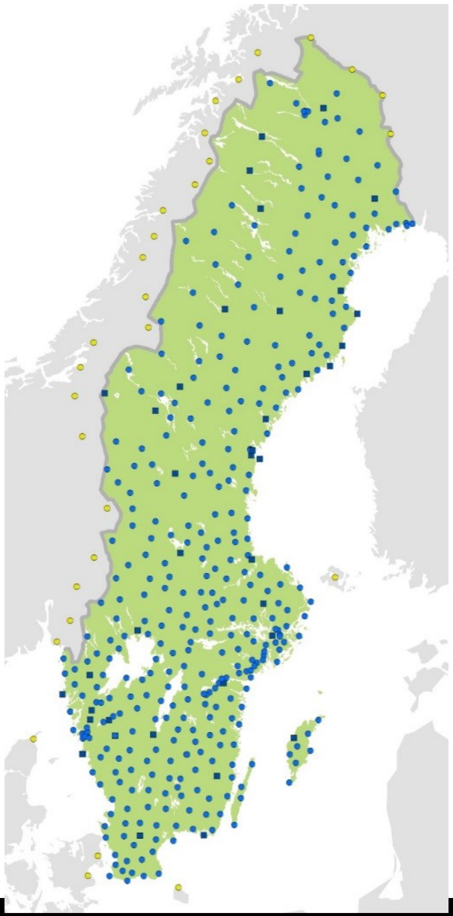
Expectations from users – users asking for improved performance, and "stable" coordinates in time.



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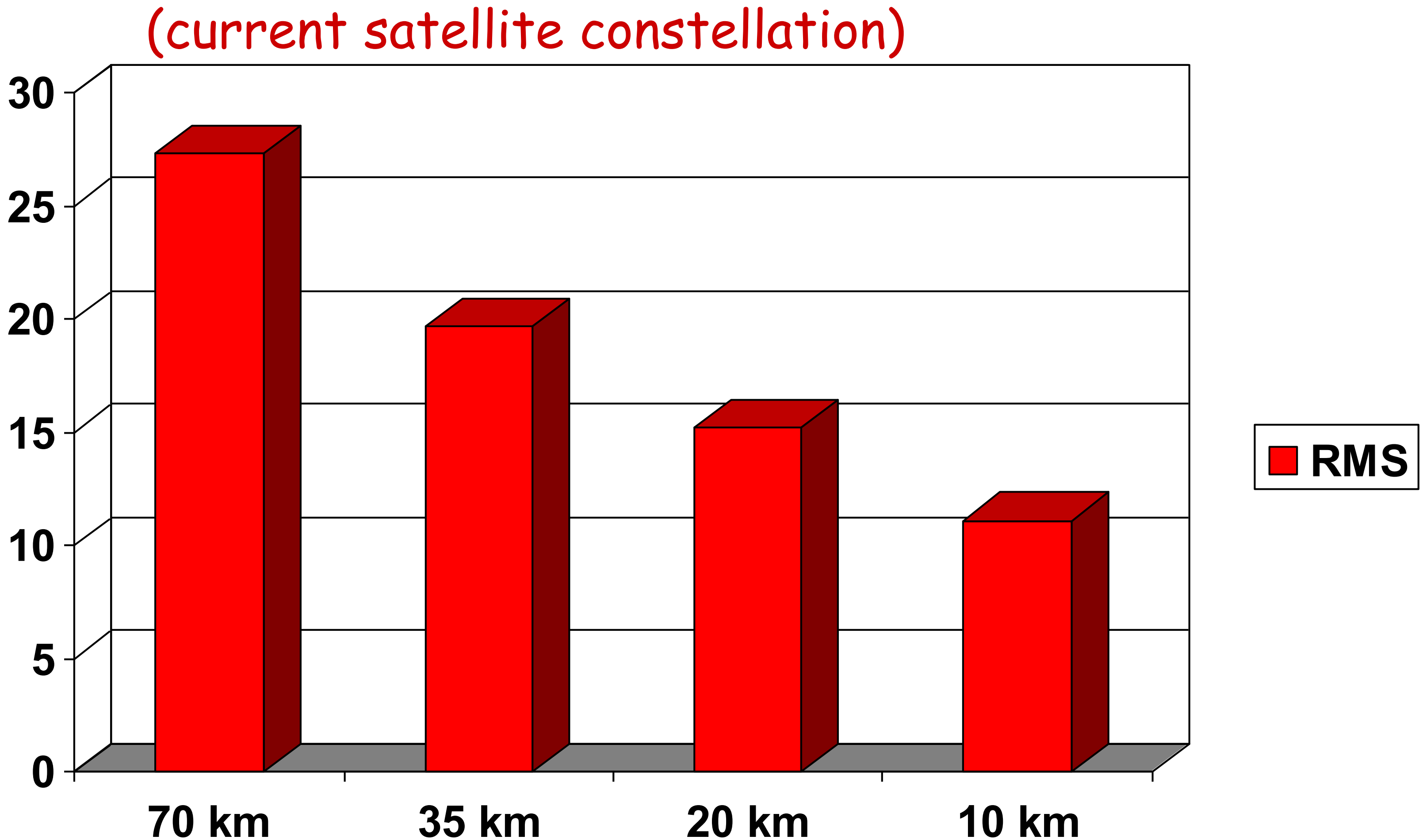
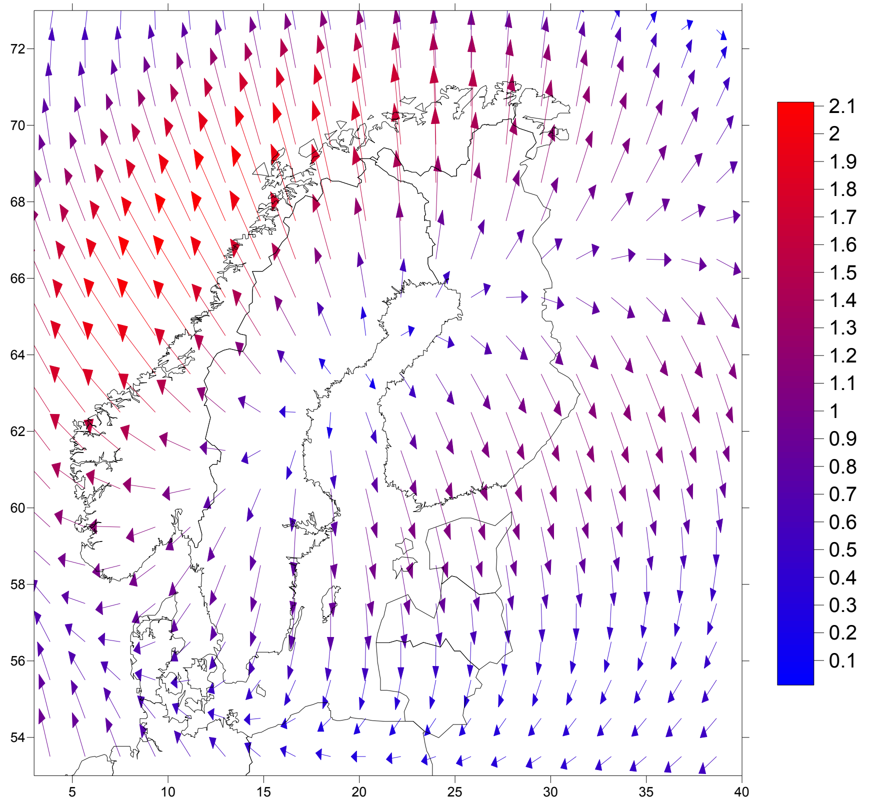
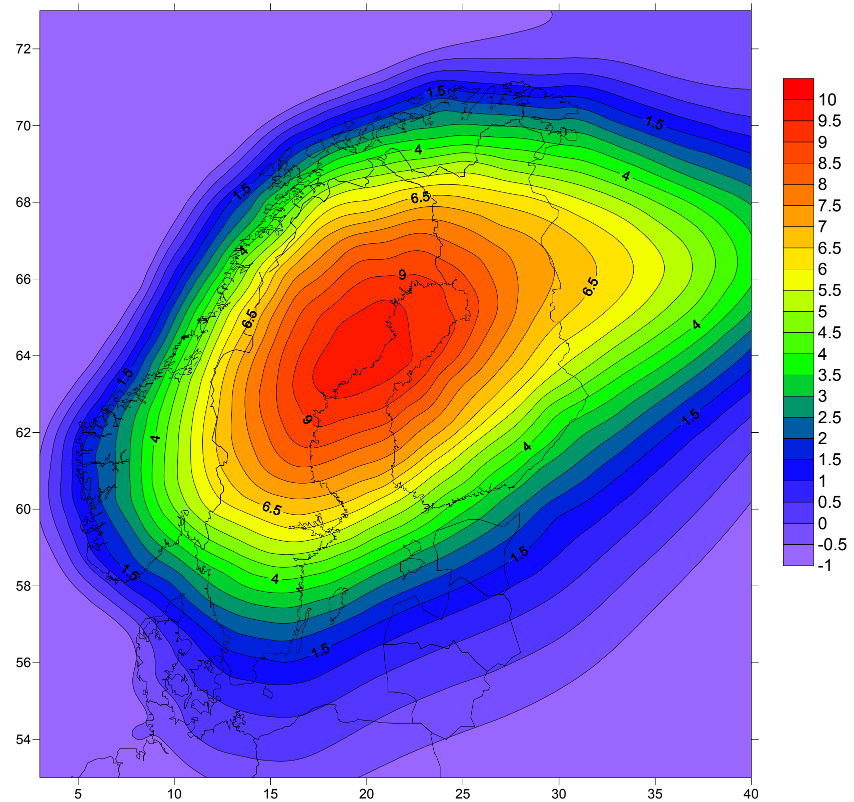
Realistic expectations?
Vertical performance from Network-RTK.
(The CLOSE-RTK study. The EUREF meeting in Florence)



The NKG_RF2003_vel velocity model





Horizontal (0 to 2 mm/yr):
The GIA model in Milne 2001 transformed to the GPS-velocities (in Lidberg 2007).

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

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Some formulas for the use of the model of crustal (intraplate) deformation

From velocities to coordinate differences

$$\begin{pmatrix} dX \\ dY \\ dZ \end{pmatrix} = \left(t_{target\_epoch} - t_{observation\_epoch}\right) \begin{pmatrix} V_{X_{intra}} \\ V_{Y_{intra}} \\ V_{Z_{intra}} \end{pmatrix}_{NKG\_RF03vel}$$

From velocities in (n,e,u) to (X,Y,Z) frame

$$\begin{cases} \dot{X} = \dfrac{-Z}{R}\dfrac{X}{P}\dot{n} + \dfrac{-Y}{P}\dot{e} + \dfrac{X}{R}\dot{u} \\ \dot{Y} = \dfrac{-Z}{R}\dfrac{Y}{P}\dot{n} + \dfrac{X}{P}\dot{e} + \dfrac{Y}{R}\dot{u} \\ \dot{Z} = \dfrac{P}{R}\dot{n} + \dfrac{Z}{R}\dot{u} \end{cases}$$

Where: $R = \sqrt{X^2 + Y^2 + Z^2}$

And: $P = \sqrt{X^2 + Y^2}$

(assuming a spherical earth)

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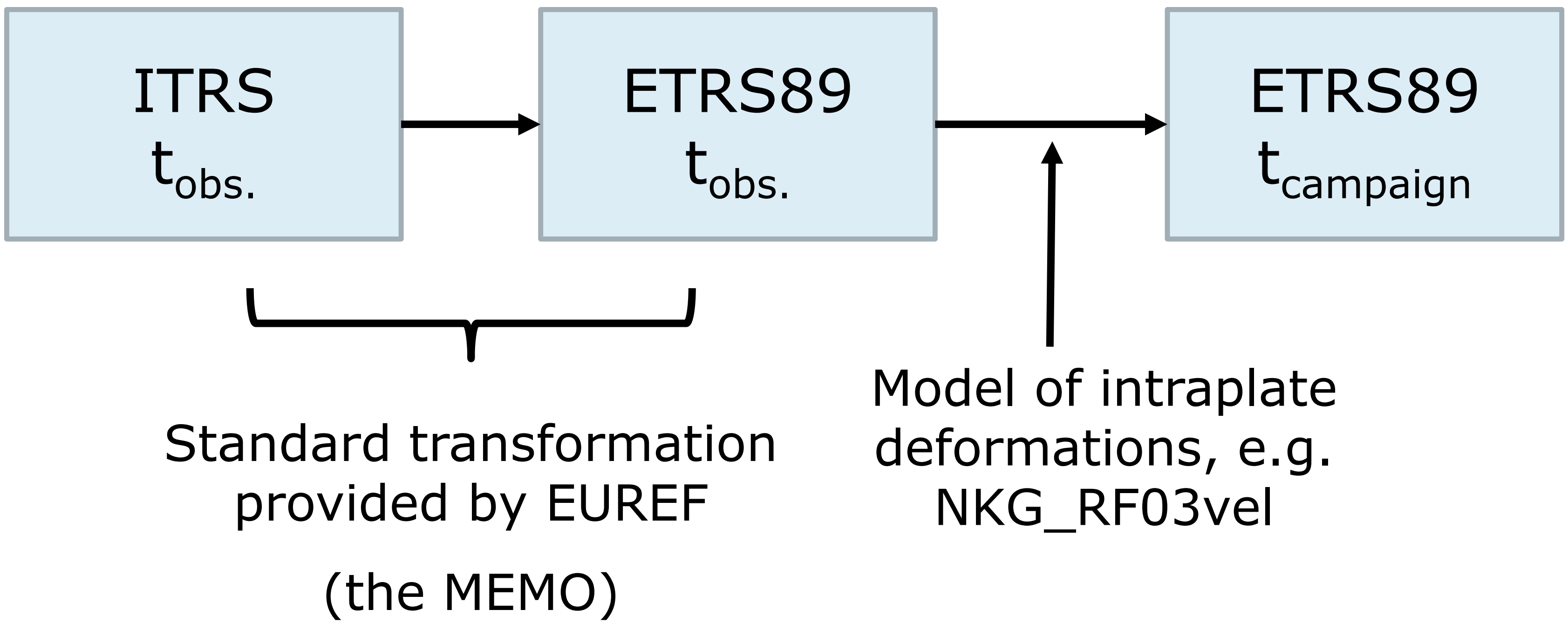
Transformation scheme from ITRFs to realization of ETRS89

Example from Sweden:

- Implementation in post-processing service
- About the network RTK service

Discussion!

Principle transformation scheme from ITRFs to national realization of ETRS89



Example of a Network-RTK service (VRS software)

And the reverse transformation

ETRS89 $t_{campaign}$

ETRS89 $t_{obs.}$

ITRS $t_{obs.}$

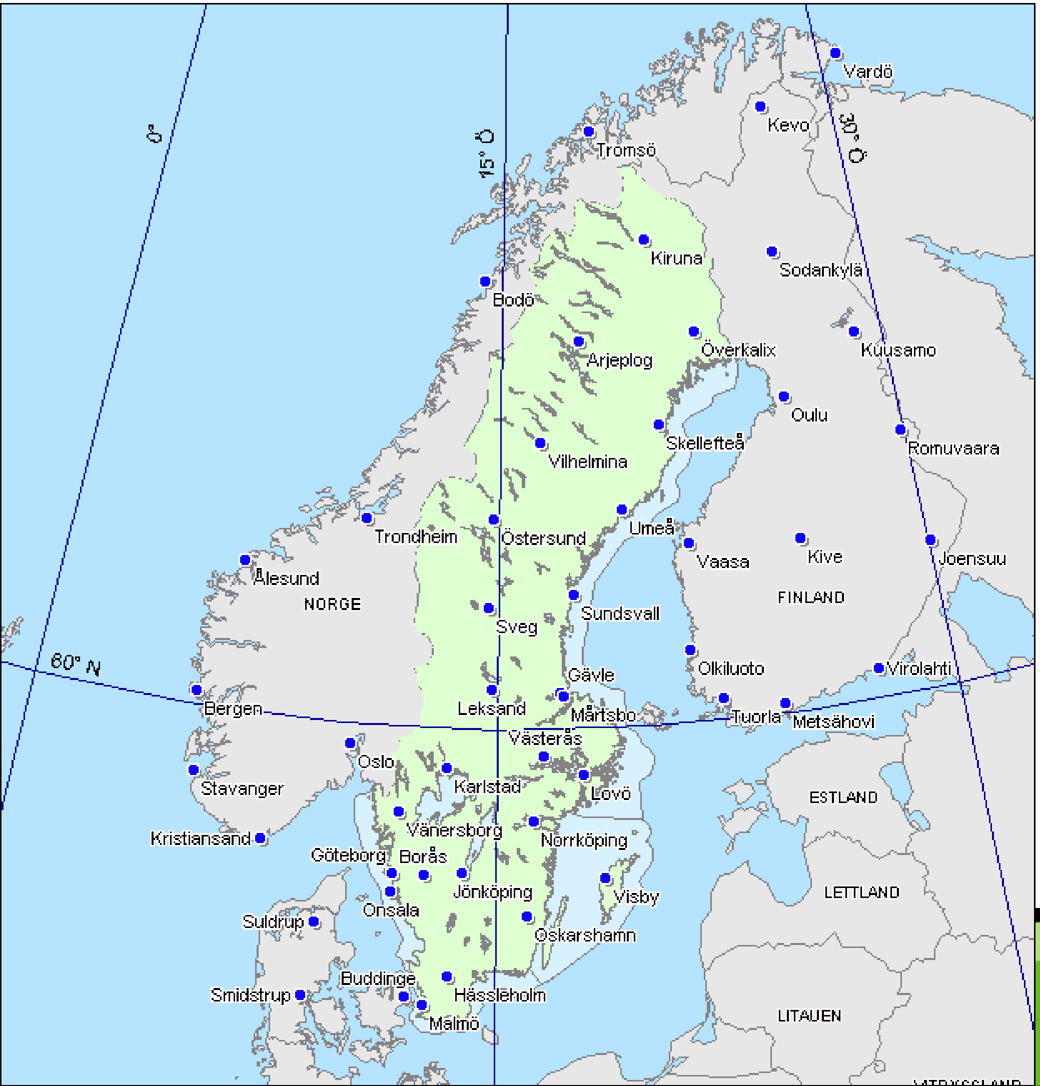
CRD of reference stations of validated densification

~~Neglected for stable part of Eurasia~~

Standard transformation provided by EUREF

(the MEMO)

Example from Sweden



SWEREF 99

Epoch 1999.5

Class B densification of ETRS89 validated by EUREF TWG

Used as the national geodetic reference frame in Sweden.

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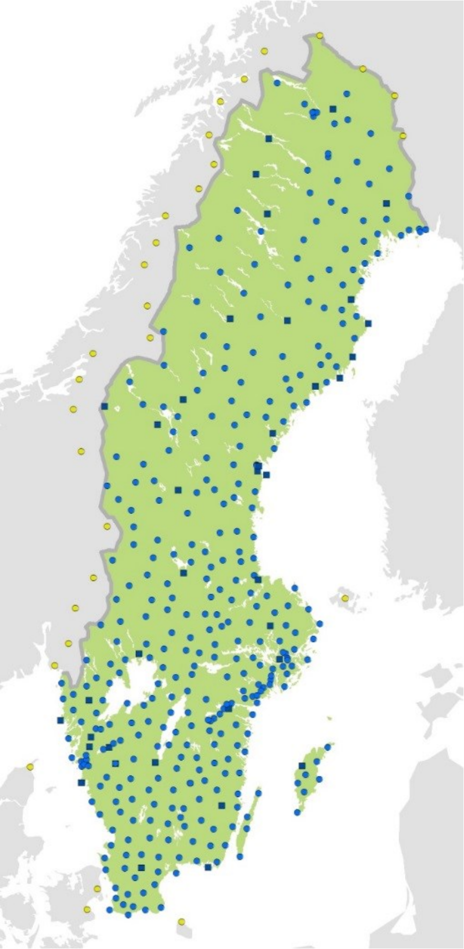
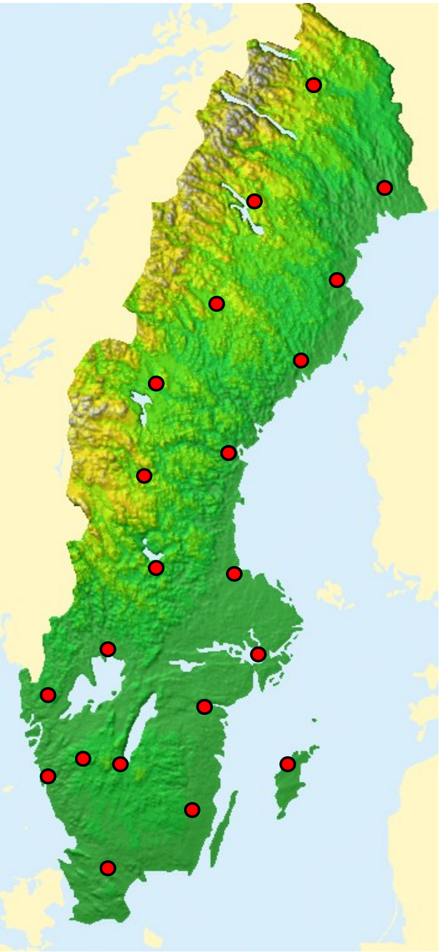
SWEPOS Network-RTK



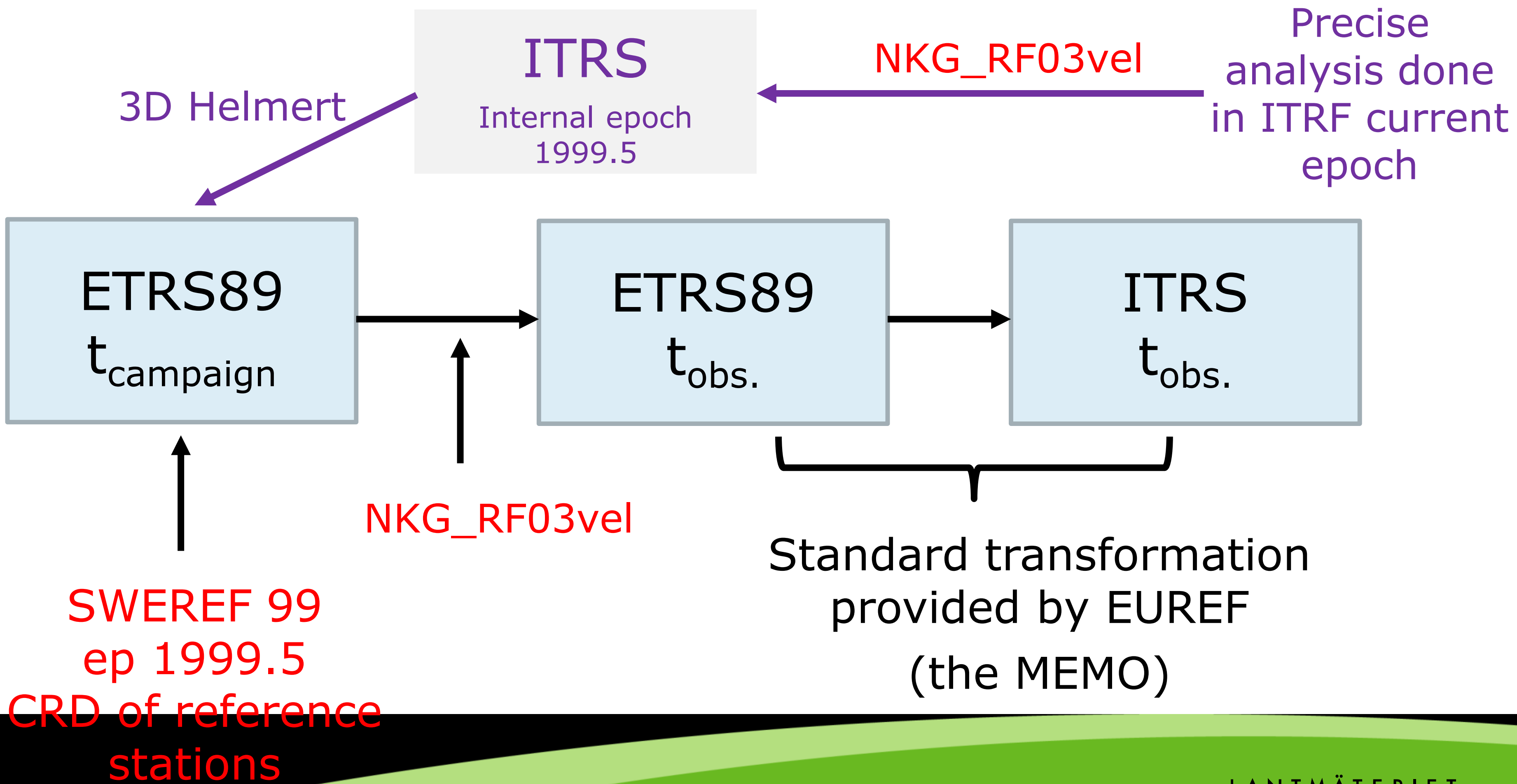
SWEPOS Post Processing Service



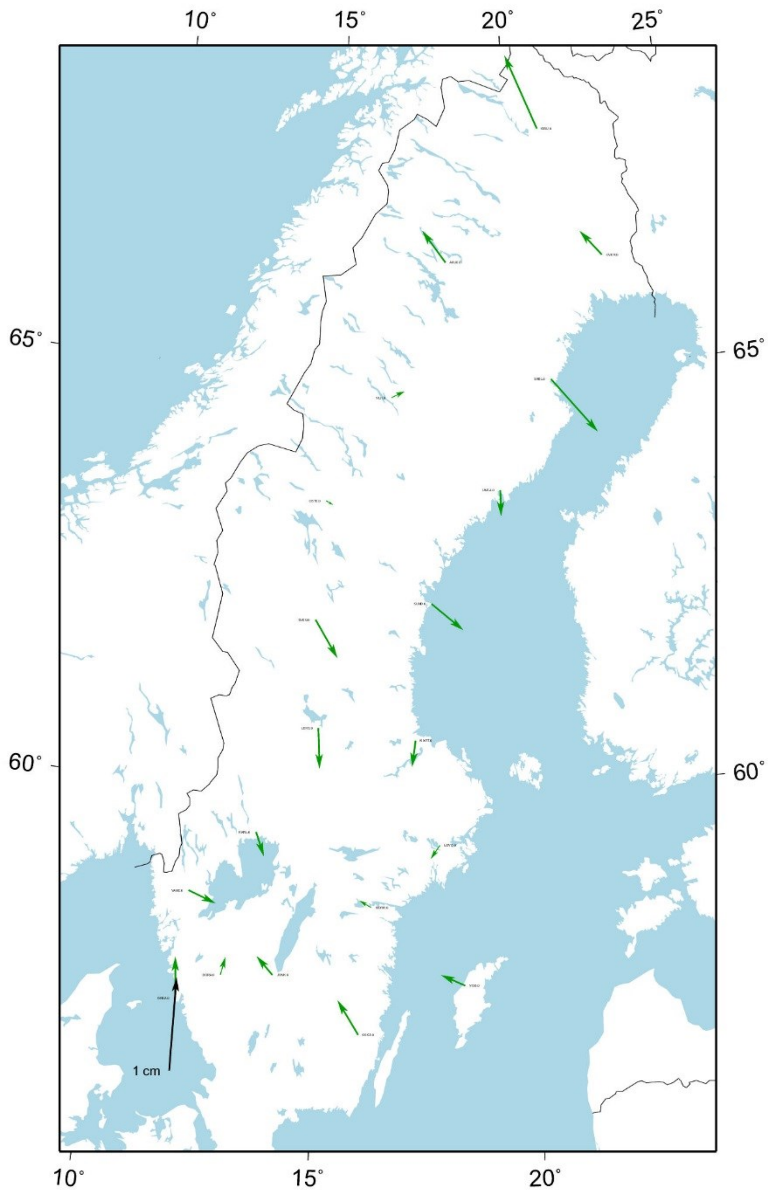
Also used for management of the geodetic infrastructure and the geodetic reference frame

Most (all?) precise applications in SWEREF 99 is done relative to the permanent GNSS stations!

Practical transformation scheme while connecting to known permanent GNSS stations – example SWEPOS



Agreement between a modern analysis using data from 2016, and SWEREF 99

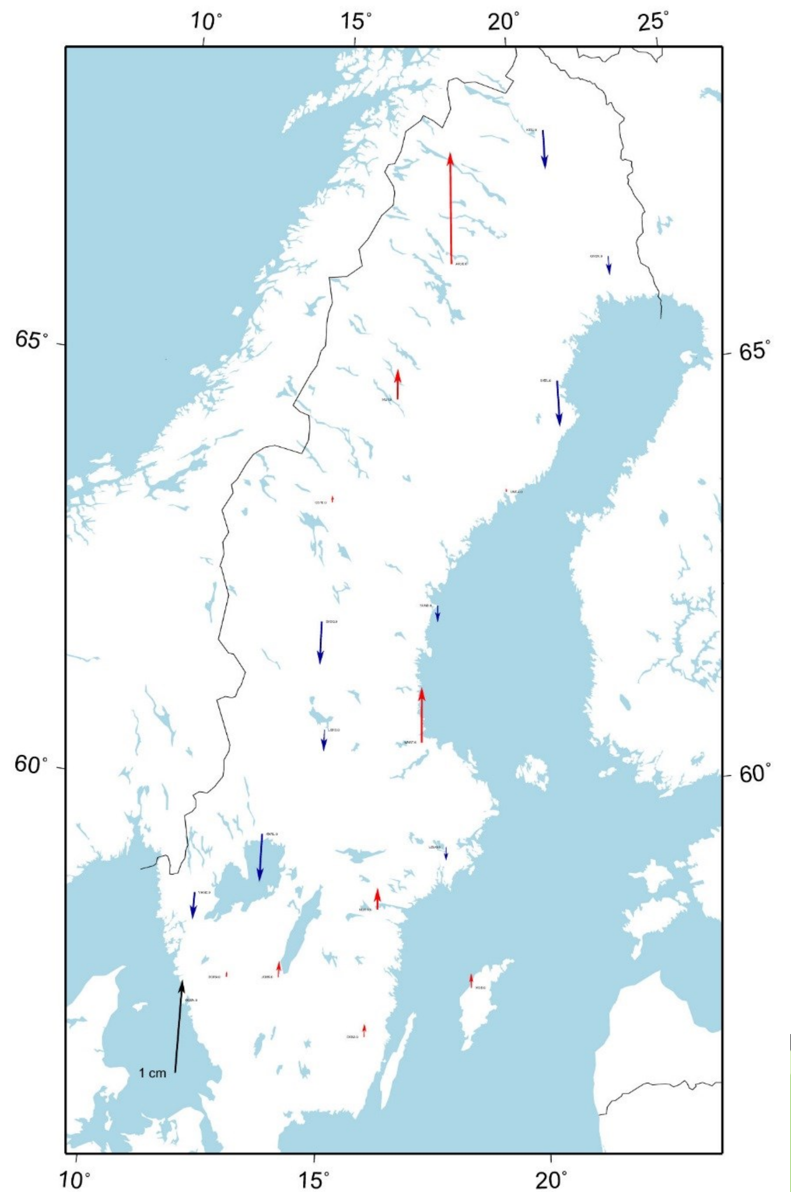


Statistics:

RMS (mm)
n : 3.5
e : 2.2
u : 4.1

Example from our internal weekly solution April 10-16, 2016

NKG_RF03vel model applied!



The SWEPOS RTK service:
- Setup in TPP (Trimble Pivot Platform)

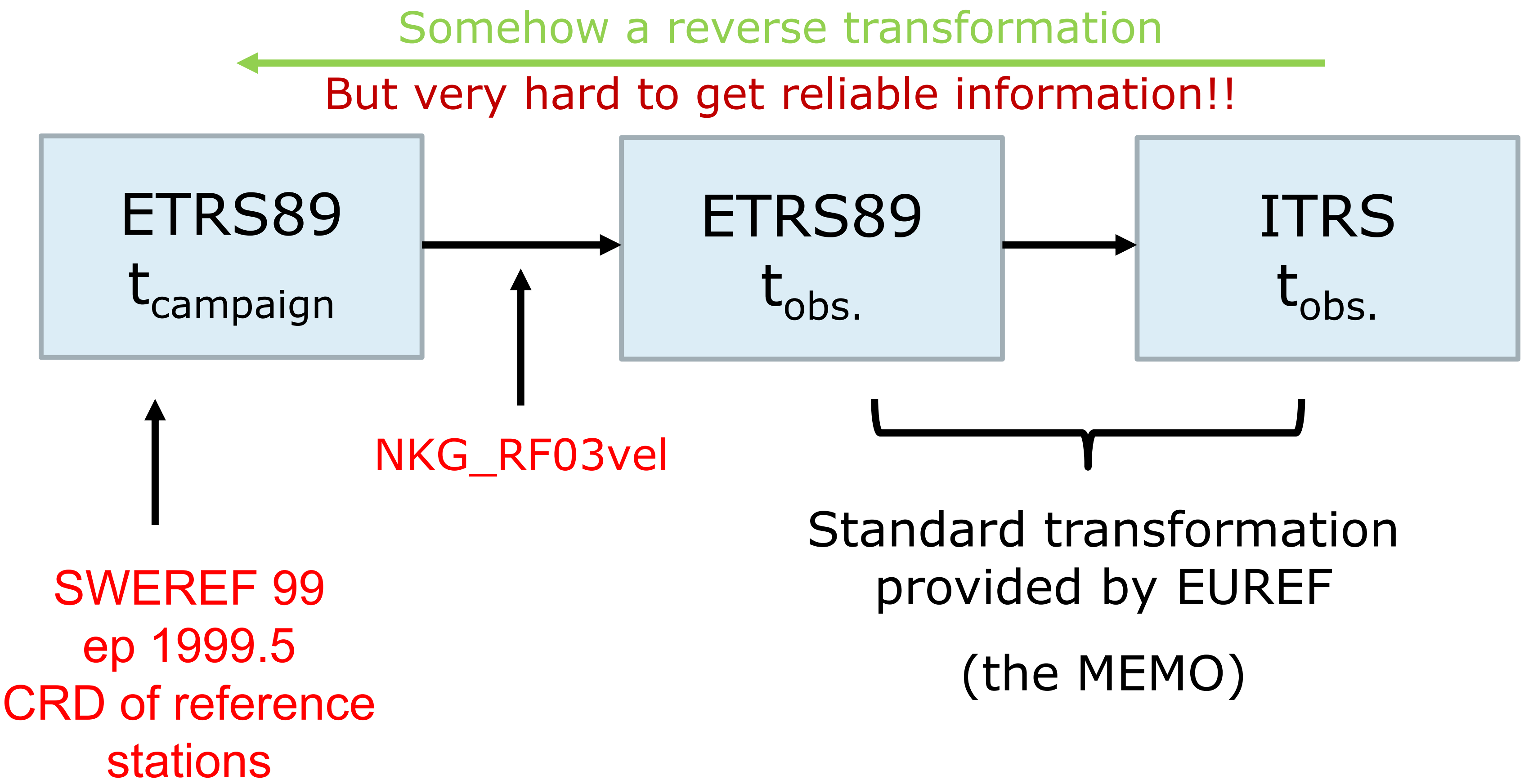
Position References

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	0ABI
Station code	0ABI
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

Example of a Network-RTK service (VRS software)



Thanks for your attention!

Discussions?

Presentation by Pasi Häkli tomorrow Wednesday at 11:45