

New velocity solutions from 13 years of BIFROST activities

Martin Lidberg^{1,2}, Jan M. Johansson^{2,3}

¹Lantmäteriet (National Land Survey of Sweden)

²Onsala Space Observatory, Chalmers, Sweden

³Swedish National Testing and Research Institute

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Outline

- The extended BIFROST network
- GPS analysis
- Reference frame realization
- Time series analysis
- Evaluation of the velocity field
- Conclusions



The extended BIFROST network

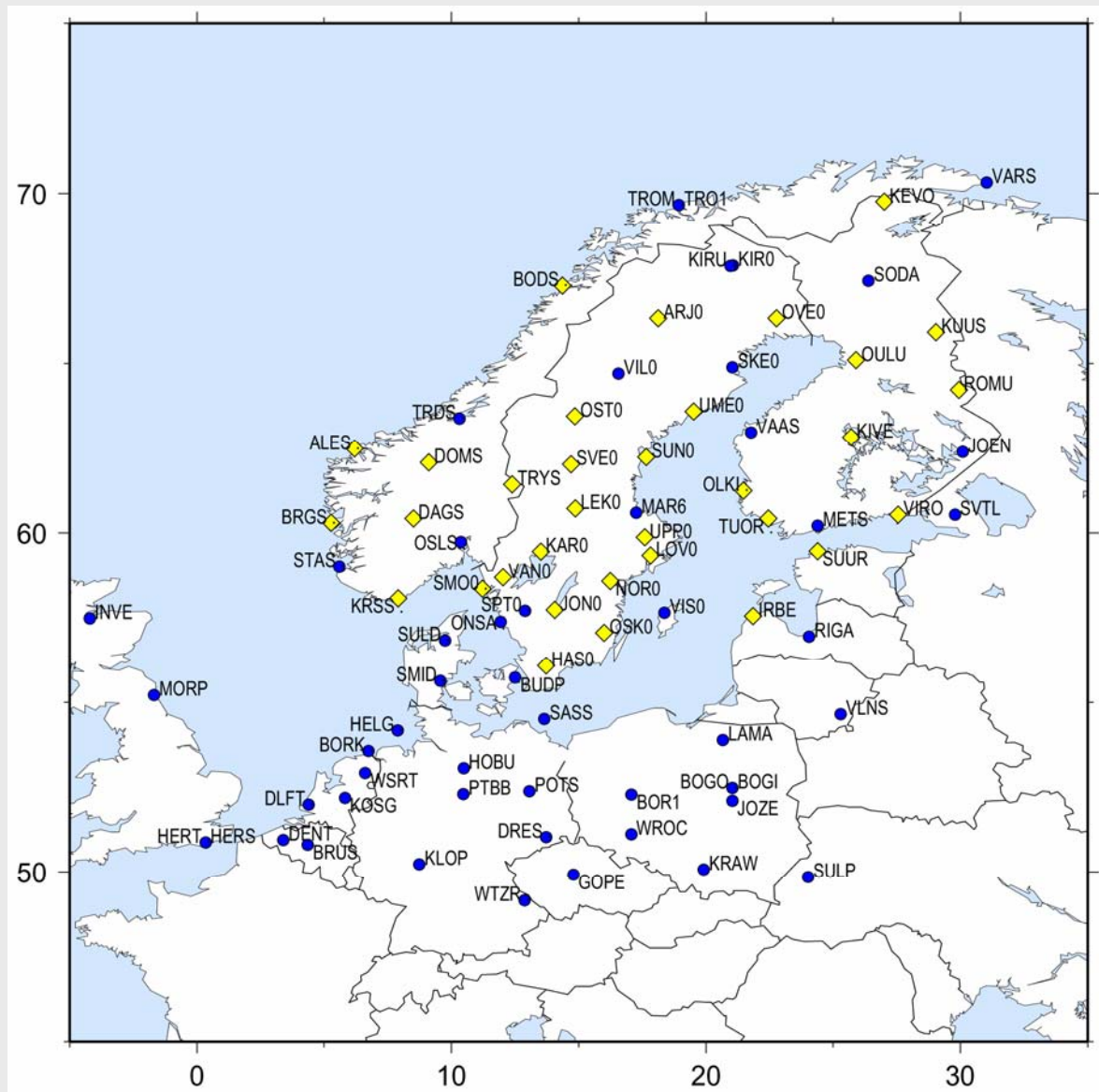
The analysis includes:

- Public sites from IGS and EPN (EUREF Permanent Network) (blue dots)
- Sites not in the public domain (yellow diamonds)

Totally: 83 sites

Period of analysis:

Aug. 1993 – Nov. 2006



GPS analysis strategy

GAMIT / GLOBK

GAMIT (GPS analysis)

- Traditional analysis strategy
- 10° elevation cut off angle
- Trop. zenith delay & gradients
- the Niell 1996 mapping functions
- Relative antenna PCV values (“absolute” PCV not used so far)
- a priori orbits from SCRIPPS

GLOBK (combination & ref. frame)

- combination of sub-networks
- reference frame realization.
- Combine the regional analysis with “complete IGS” from SCRIPPS.
- Satellite orbits are given loose constraints in the quasi-observations.

GIPSY

- Precise Point Positioning (PPP)
- And ambiguity fixing
- NOT TREATED FURTHER IN THIS PRESENTATION



Combination for "global solution" & reference frame realization

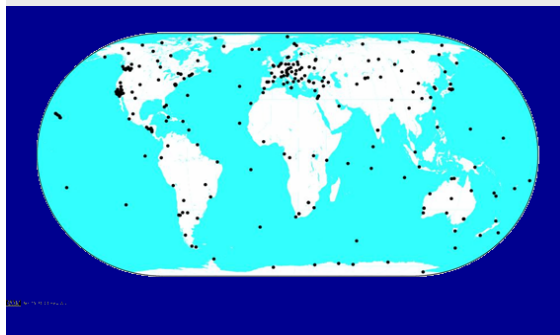
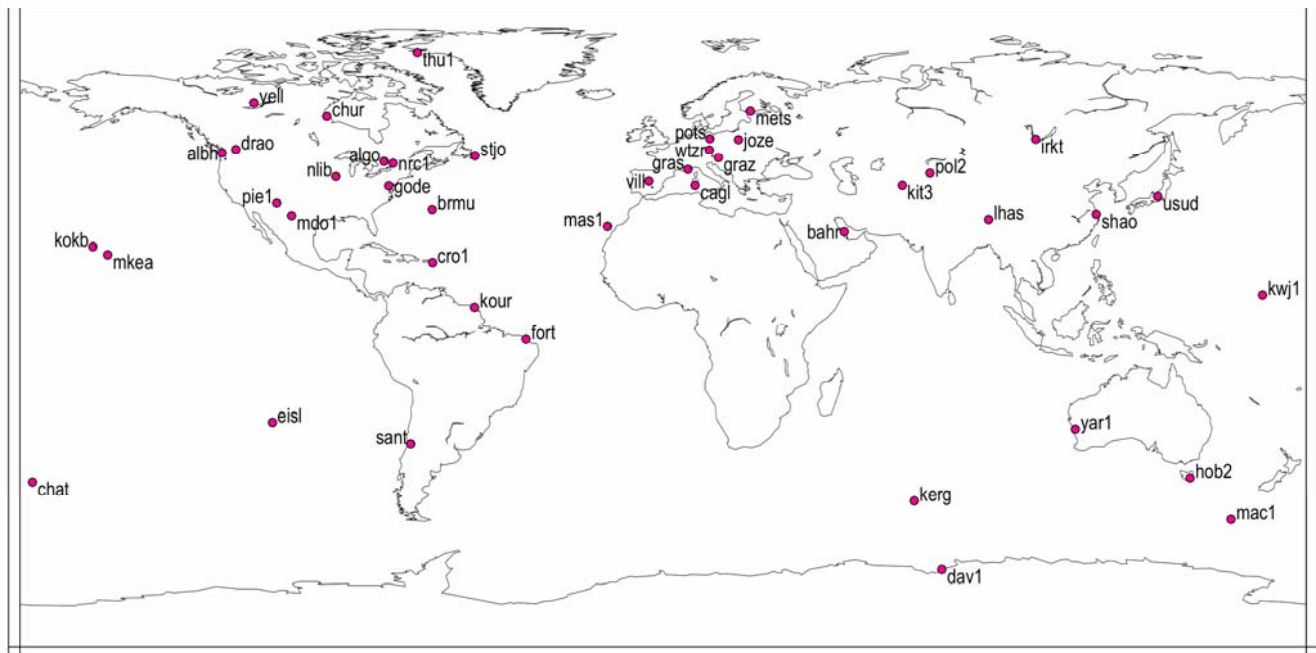
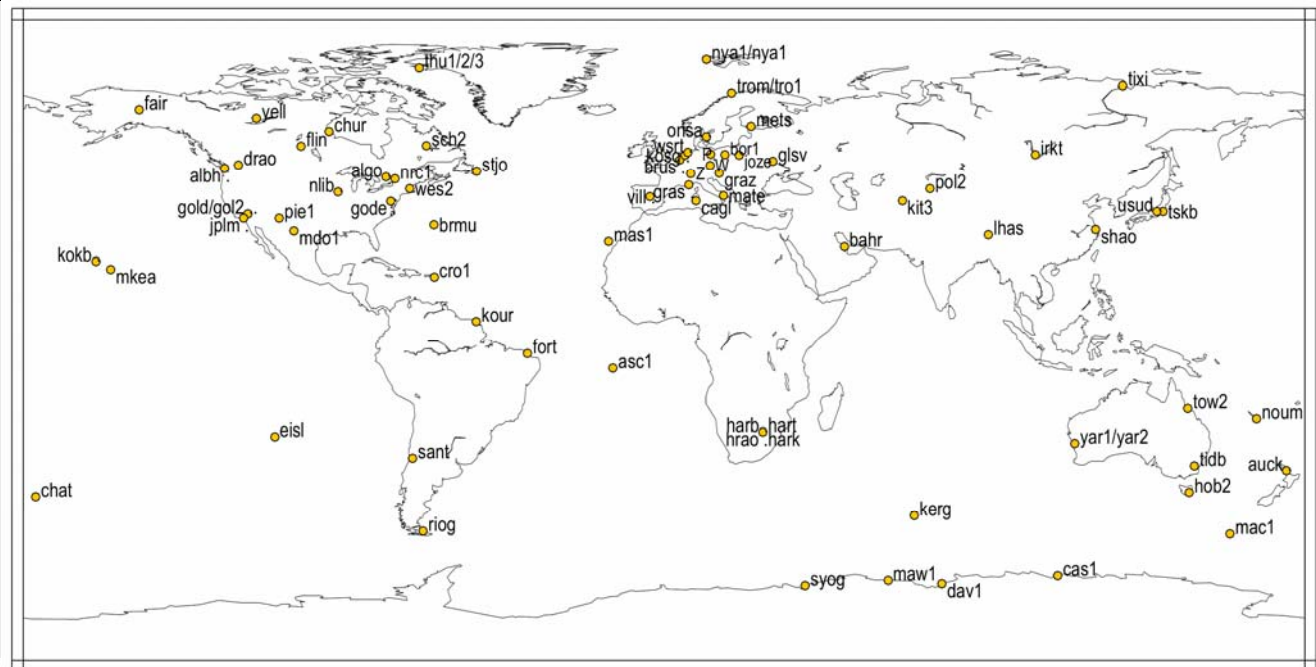
ITRF2000:

43 "good" sites as candidates for the daily stabilization. in GLOBK.

ITRF2005:

78 sites as candidates.

- Include breaks from ITRF2005 coordinate list



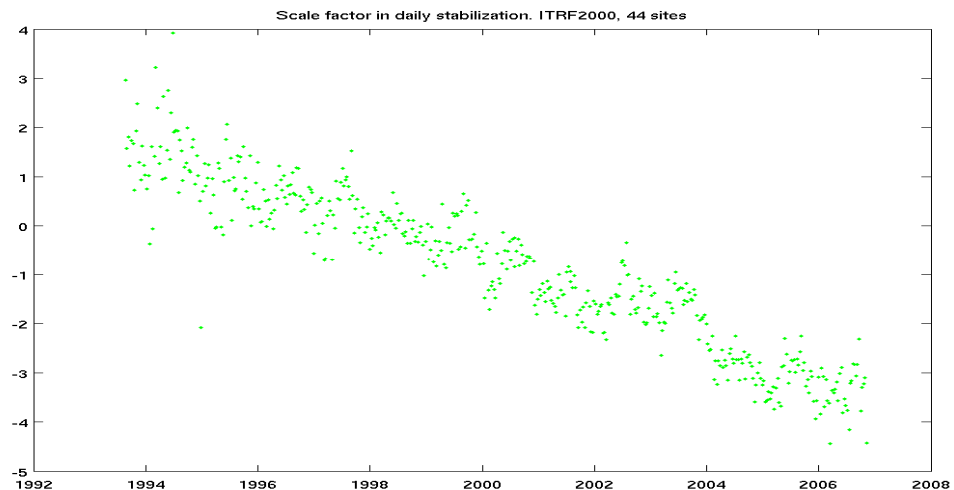
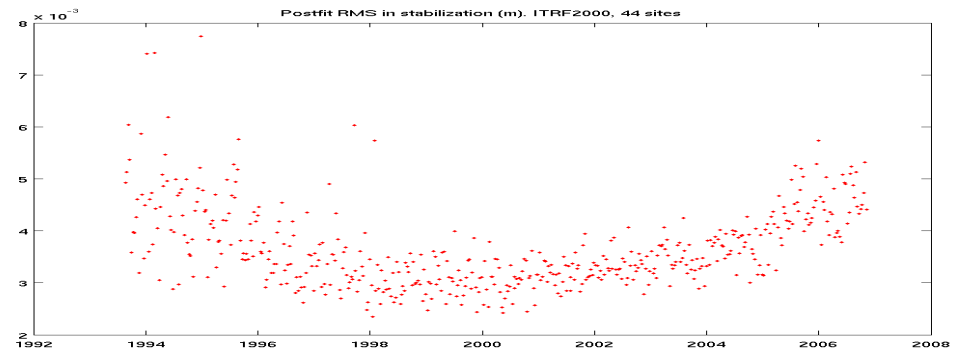
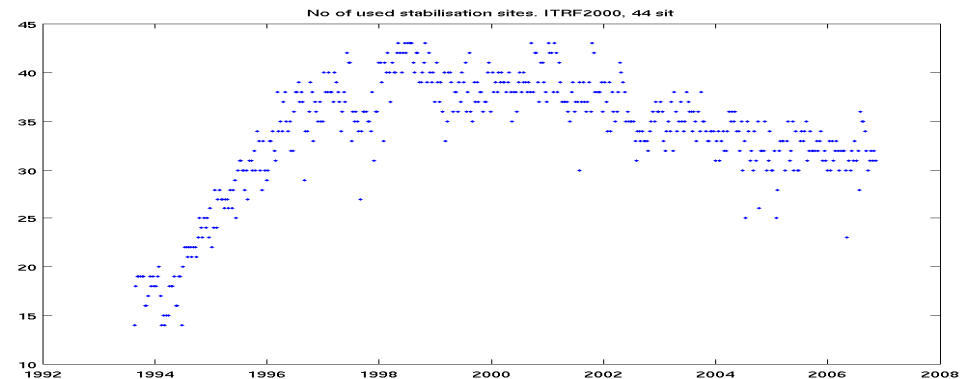
Results from stabilization (ITRF2000)

ITRF2000

No of used sites in
stabilization
15 to 43
(decreasing after 2002)

Postfit RMS in
stabilization (2-5 mm)
(increasing after 2002)

Scalefactor
2 to -4 ppb



Results from stabilization (ITRF2005)

ITRF2005

No of used sites in
stabilization

20 to 70

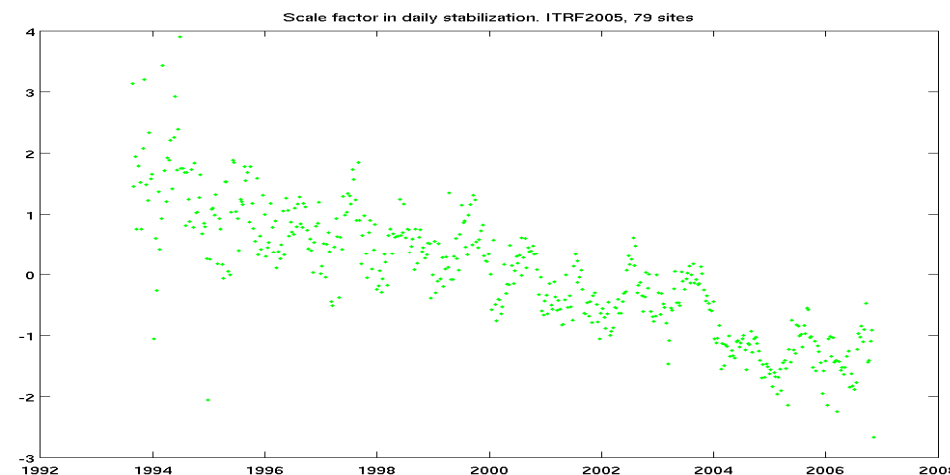
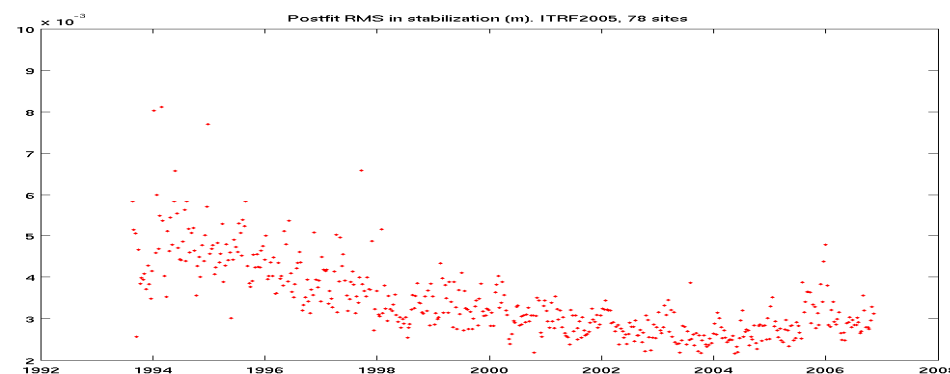
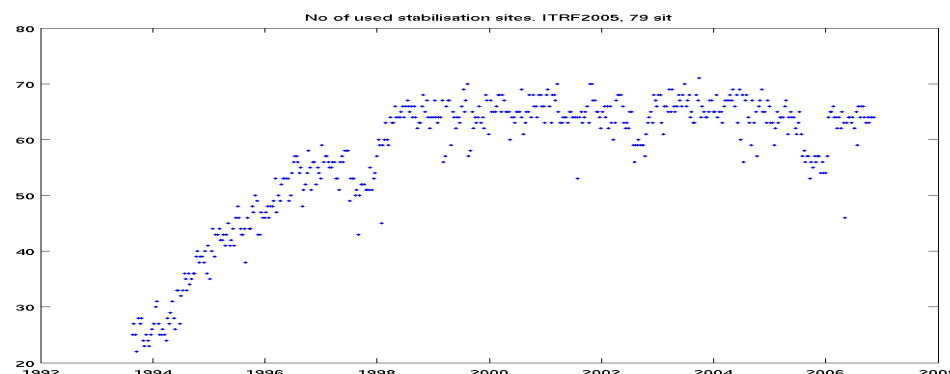
(“stable” after 1999)

Postfit RMS in
stabilization (2-5 mm)

(“stable” after 2000)

Scalefactor

2 to -2 ppb



Example of time series of GPS positions

De-trended position time series from Vilhelmina (VIL0)

1993-1996:

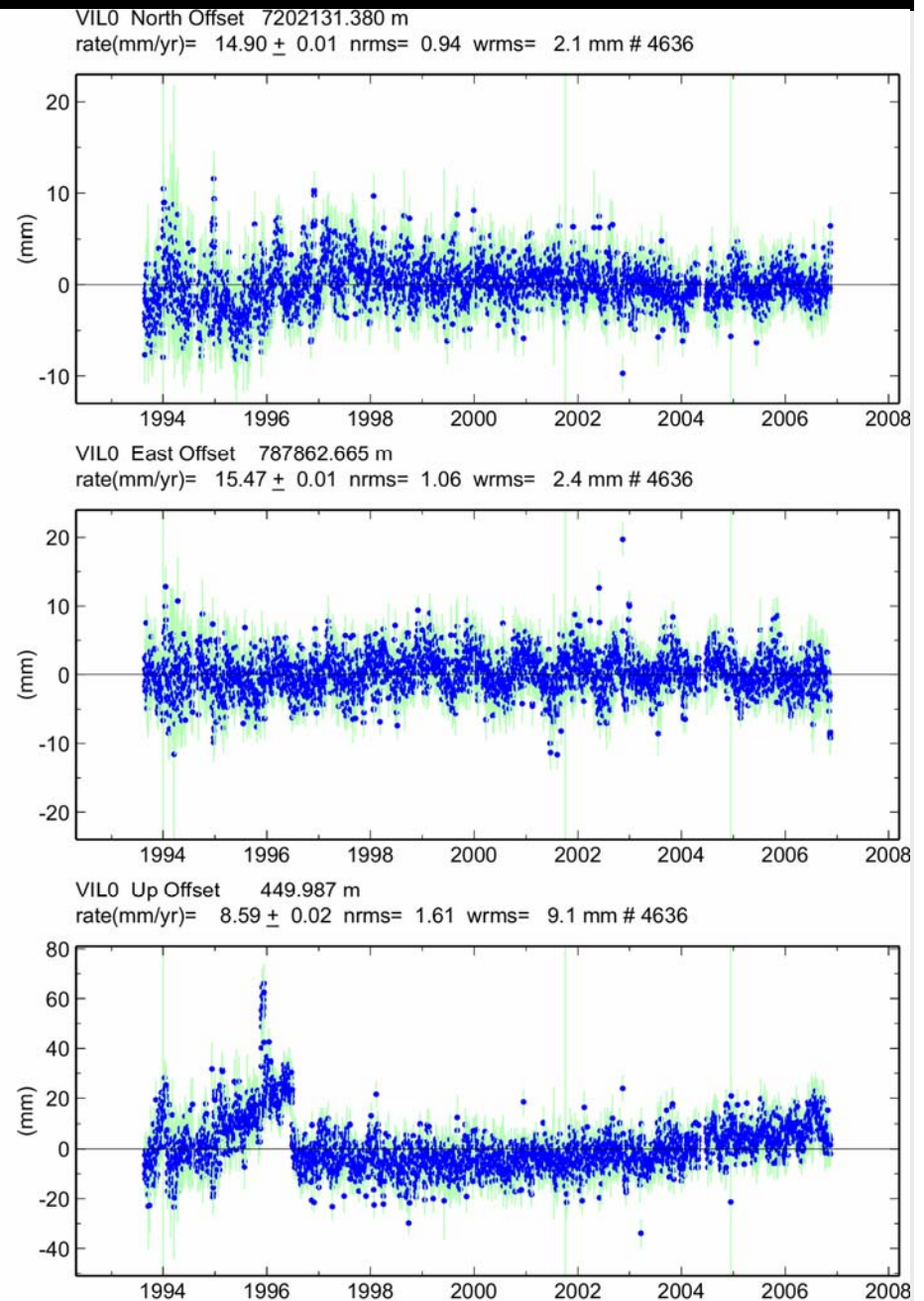
- some “bad” antenna radoms

No of used sites in

PROBLEMS !!!???

Non-linear time-series in the vertical:

- Bended “banana”-shape ???
- Or rate change by 2003 ???



New combination - with my own global analysis

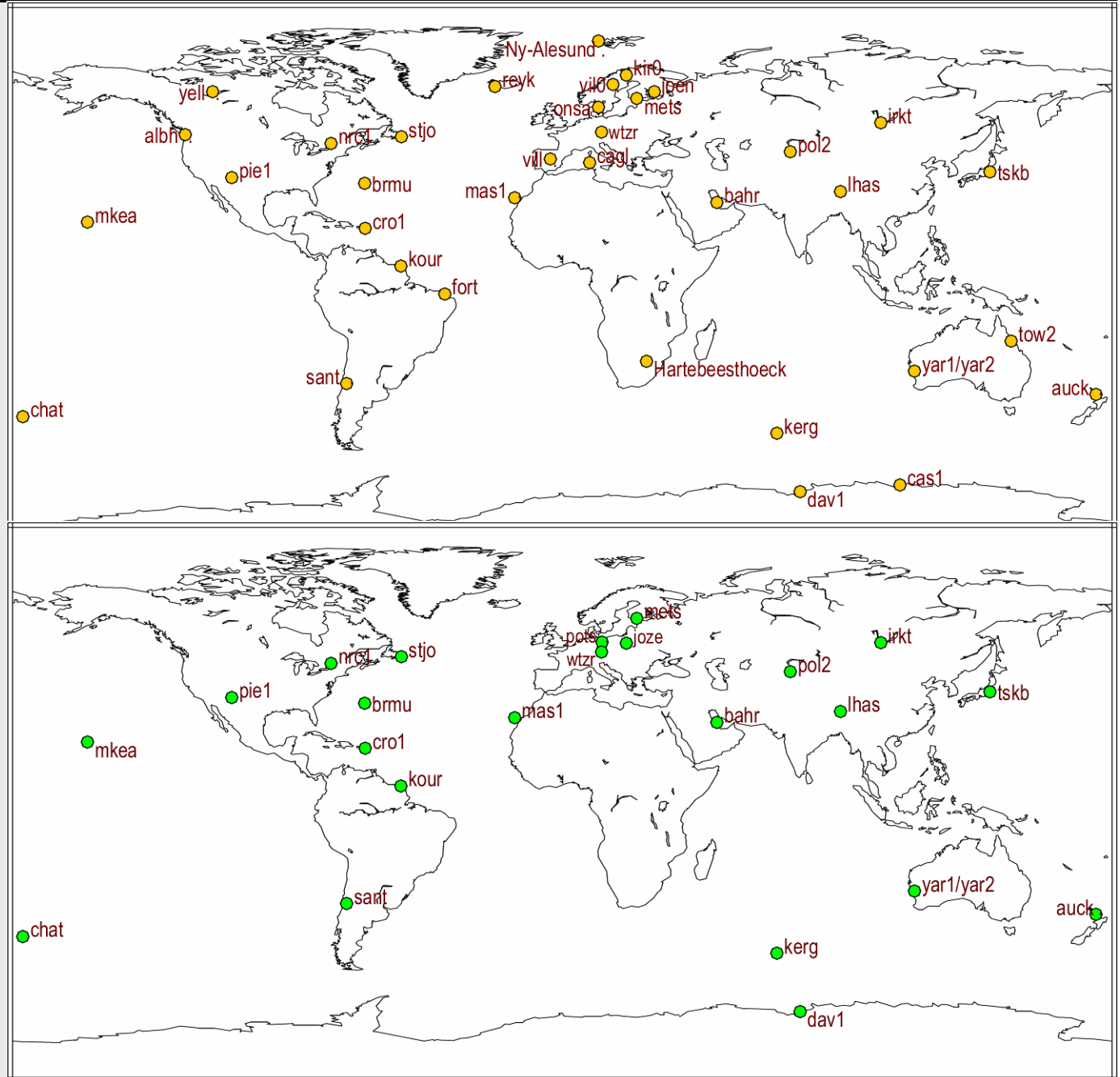
The global network:

35 selected sites.

- Cover the globe
- Connect regional & global analysis
- Include “good” sites for reference frame realization

Reference frame sites:

23 sites as candidates

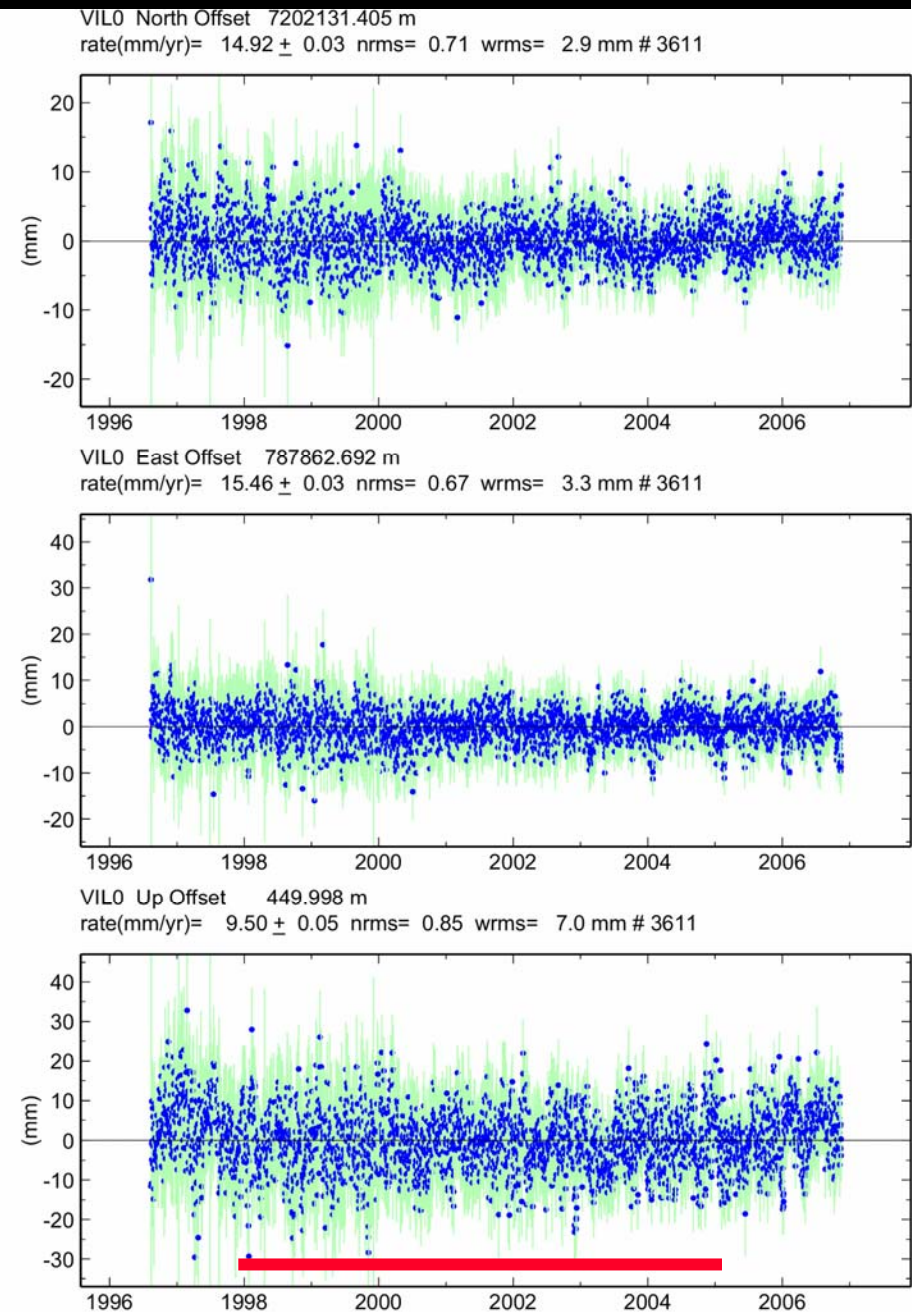


Combined Regional BIFROST + “35-site” global

- Vertical “banana-shape” heavily reduced!!! (maybe not eliminated..)
- In the analysis we have “stable” sites with +10 yr observations, and “new” sites (< 5 yr).

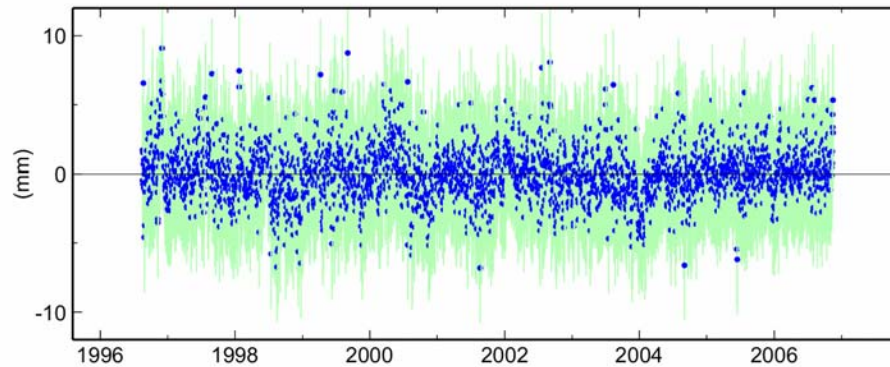
Two step reference frame approach

1. Determine pos+vel for 27 “good sites” (Swe+Fin+some EPN) from “stable” period 1998 to 2004 (7yr).
2. Apply 6-par transf. (no scale) of all daily solutions to the “regional” frame defined above.

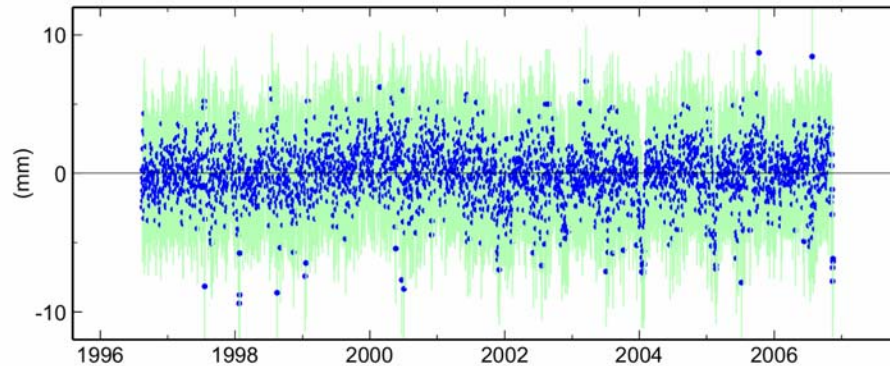


After common mode reduction using daily transformations

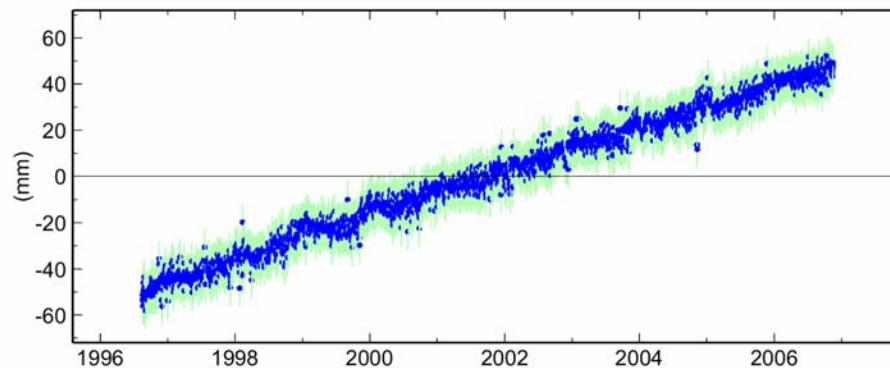
VIL0 North Offset 2620258.63837 m
rate(mm/yr)= 5483.84 ± 8.34 nrms= 0.46 wrms= 1.8 mm # 3545



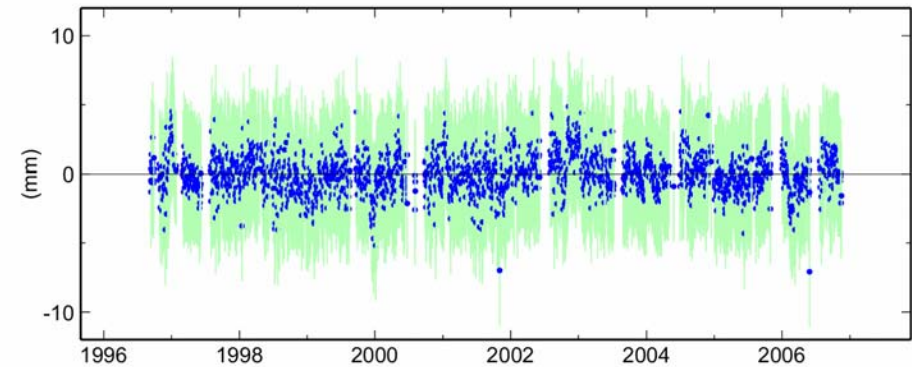
VIL0 East Offset 779138.11106 m
rate(mm/yr)= 5698.44 ± 8.34 nrms= 0.48 wrms= 1.9 mm # 3545



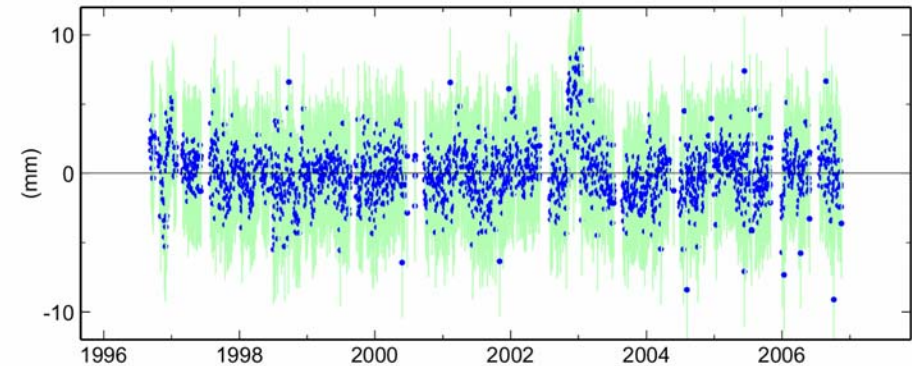
VIL0 Up Offset 5743799.44509 m
wmean(mm)= 0.00 ± 0.13 nrms= 3.48 wrms= 27.9 mm # 3545



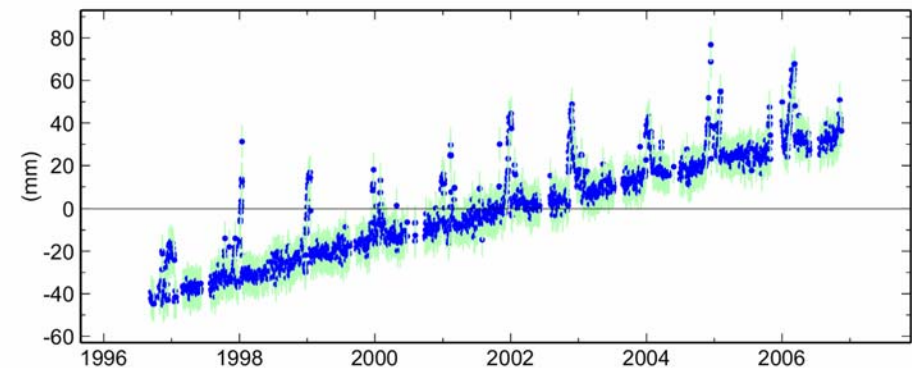
KIVE North Offset 2632277.22003 m
rate(mm/yr)= 4615.23 ± 9.77 nrms= 0.33 wrms= 1.3 mm # 2656



KIVE East Offset 1266957.40168 m
rate(mm/yr)= 7178.58 ± 9.77 nrms= 0.49 wrms= 1.9 mm # 2656



KIVE Up Offset 5651027.68616 m
wmean(mm)= 0.00 ± 0.16 nrms= 2.93 wrms= 23.5 mm # 2656



Derived velocity field relative to Eurasia

Red: ITRF2000 (eura)

Green: ITRF2005 (eura)

ITRF2000: removed the Eurasia plate tectonic motion using the ITRF2000 Euler pole for Europe

ITRF2005: transformed (rotated) to the ITRF2000_eura velocities

RMS of velocity at some 10 European sites: 0.5 mm/yr level

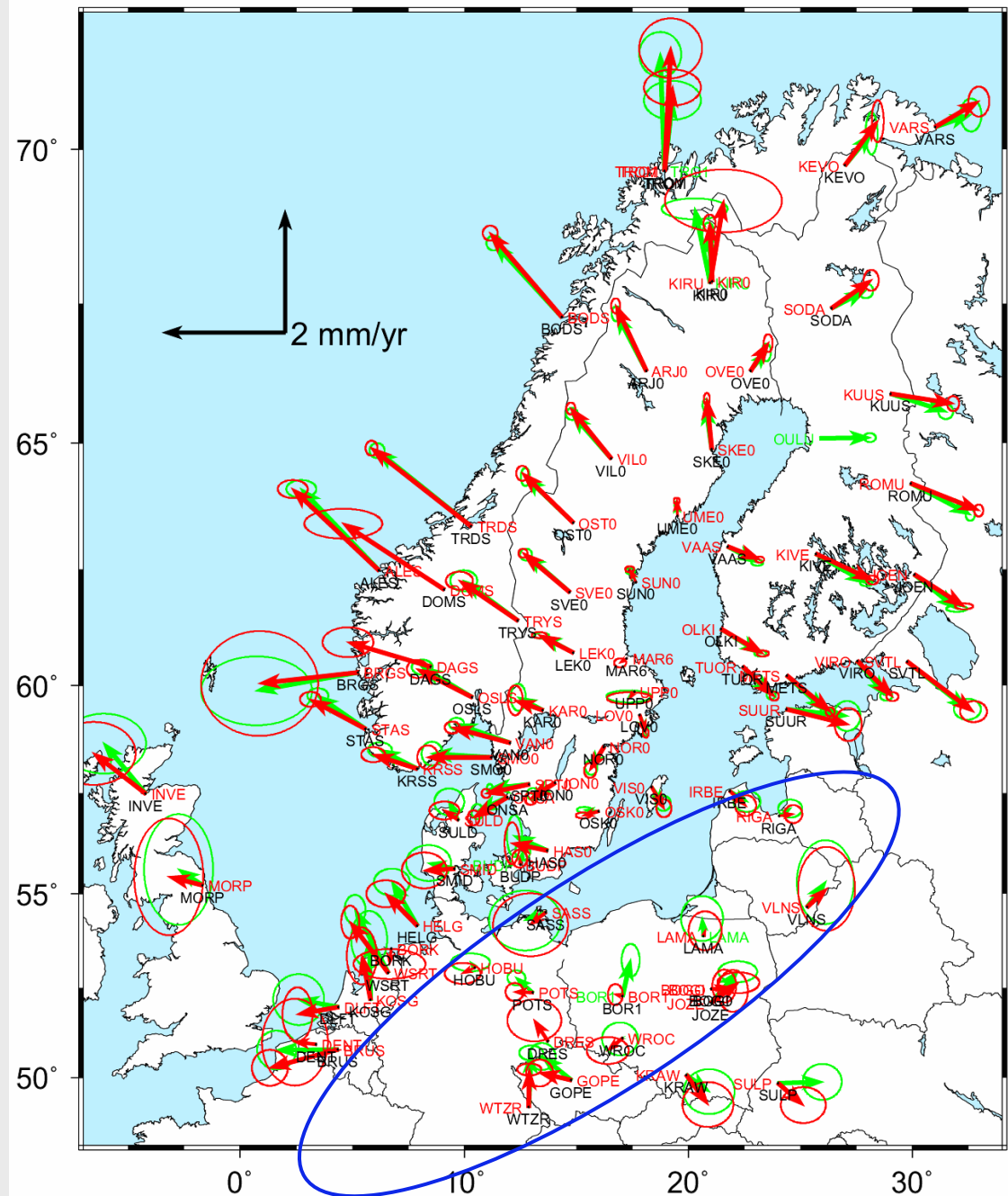
-> suggest a successful reference frame realization.

For POTS, METS, KIRU; “my” velocities and official ITRF2005 agree by:

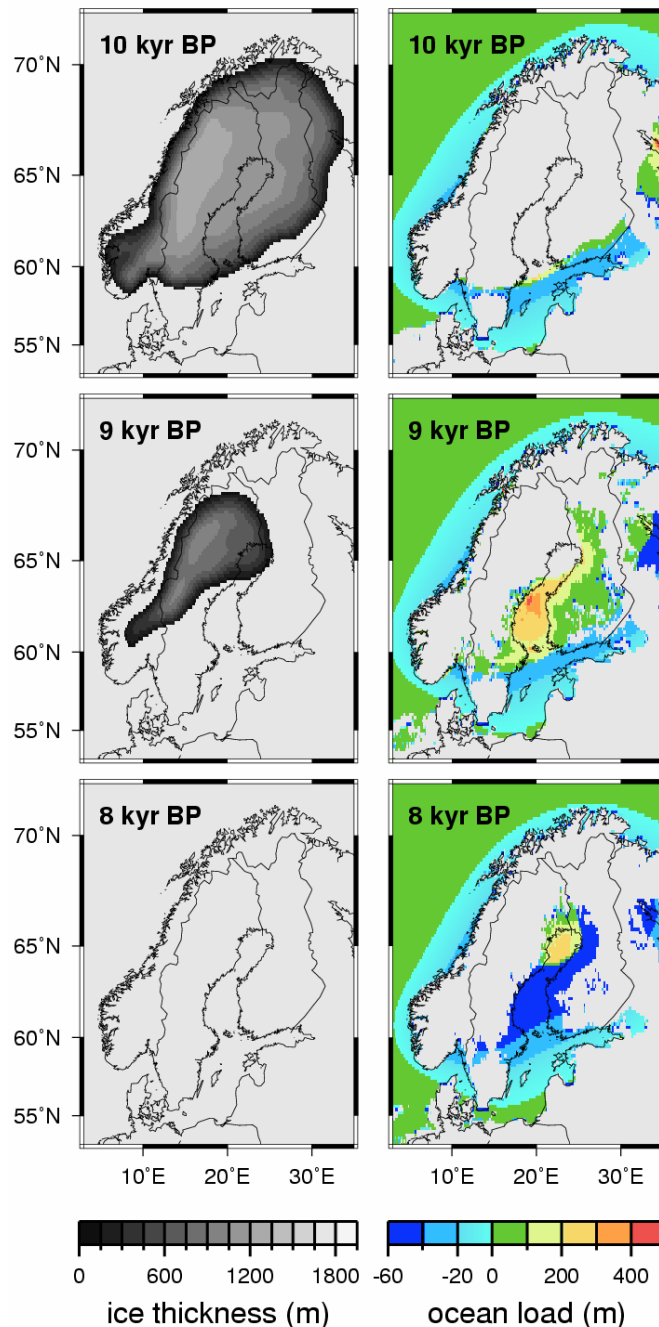
North: 0.1-0.2 mm/yr

East: 0.2-0.4 mm/yr

Up: 0.1-0.3 mm/yr



Glacial Isostatic Adjustment (GIA)

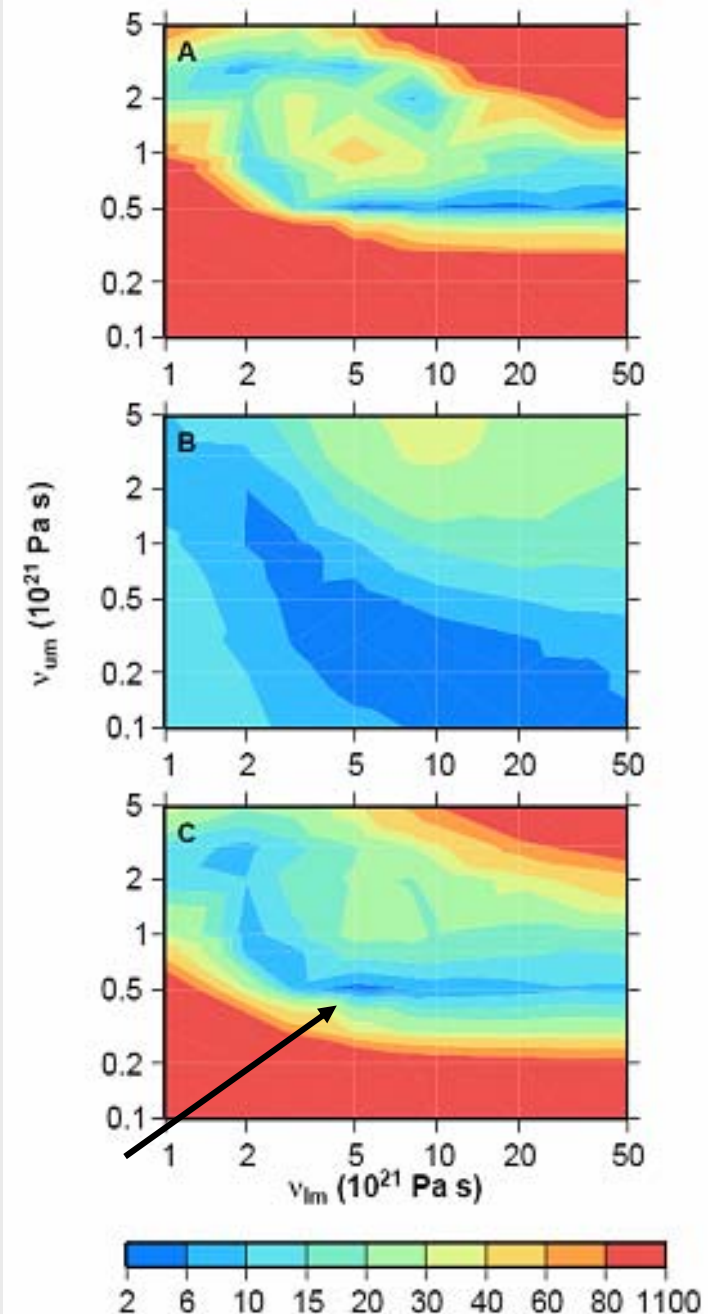


Glaciations cause depression of the earth due to load from ice and ocean. The load cause deformation of the earth shape and mass distribution.

Updated GIA model (Milne et al 2001)
Ice history model from Lambeck

120 km lithosphere,
upper mantle visc.
 5×10^{20} Pa s
lower mantle visc.
 5×10^{21} Pa s

Thanks Glenn Milne for the model work!!



Horizontal velocity evaluation

The updated GIA model

ITRF2000

ITRF2005

GIA-model to ITRF2000:

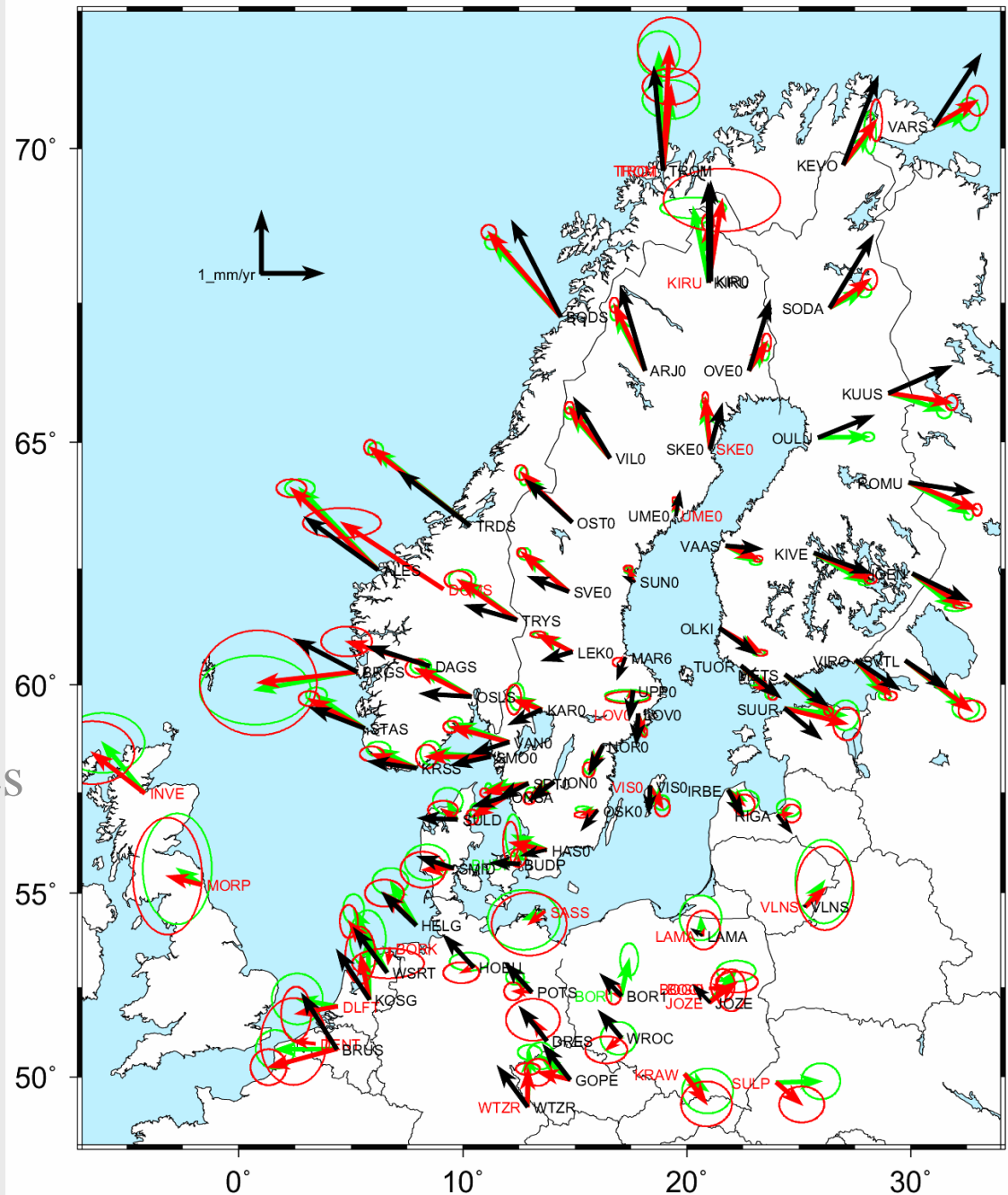
71 common points

RMS north: 0.36 mm/yr

RMS east : 0.24 mm/yr

“large” model velocities in continental Europe, possible caused by large discrepancies elsewhere?? (NW Finland, mid Norway???)

- due to transforming (rotating) the GIA model



Vertical velocity

ITRF2005

ITRF2000

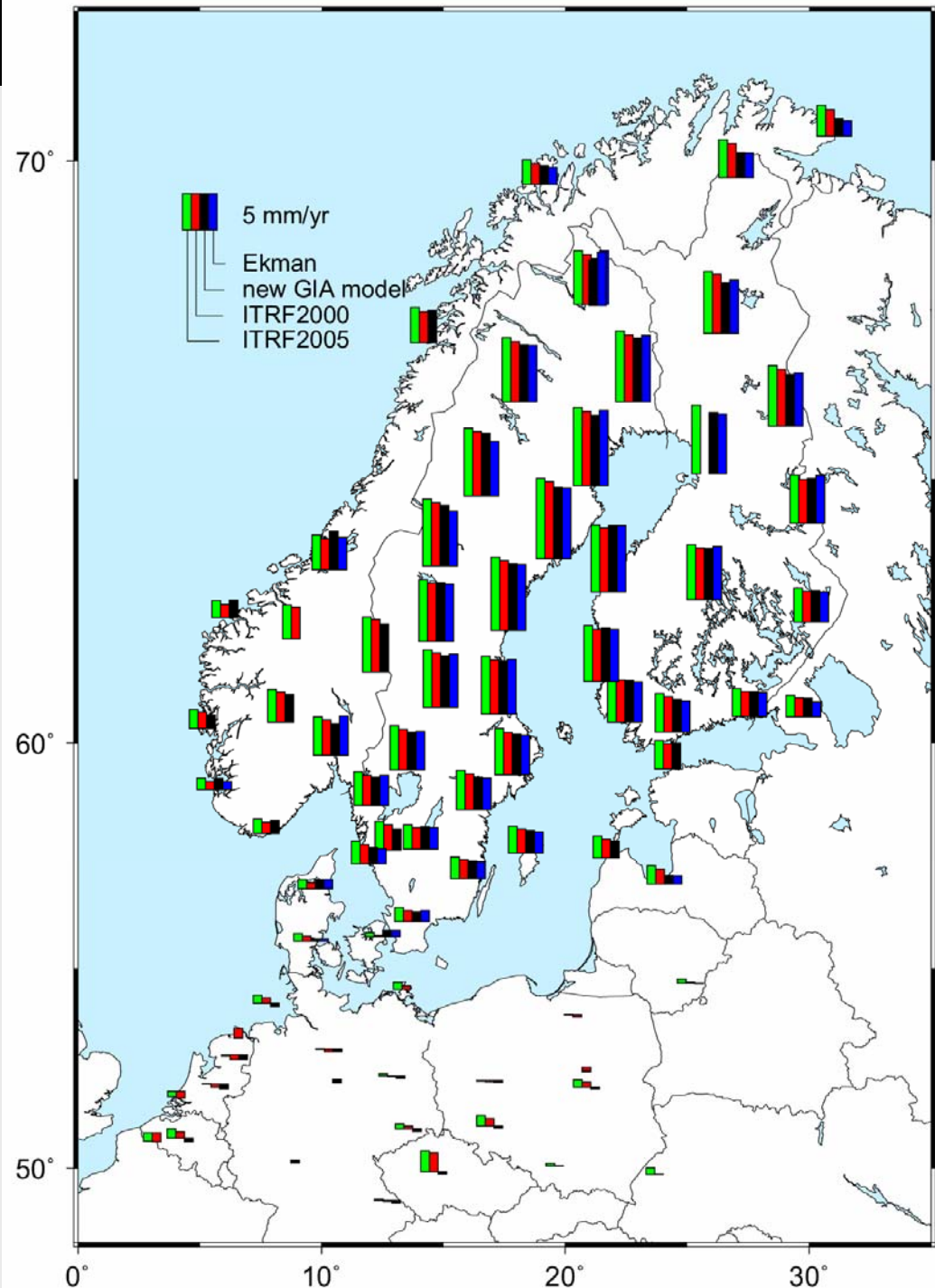
GIA model

Ekman (1998) based on:

- mareographs and levellings,
- 1.2 mm/yr eustatic sea level rise
- change of the geoid based on Ekman & Mäkinen (1998)

Compared to the ITRF2000 values:

	mean	RMS mm/yr
ITRF2005	0.4	0.4
GIA	-0.3	0.6
Ekman	-0.2	0.6

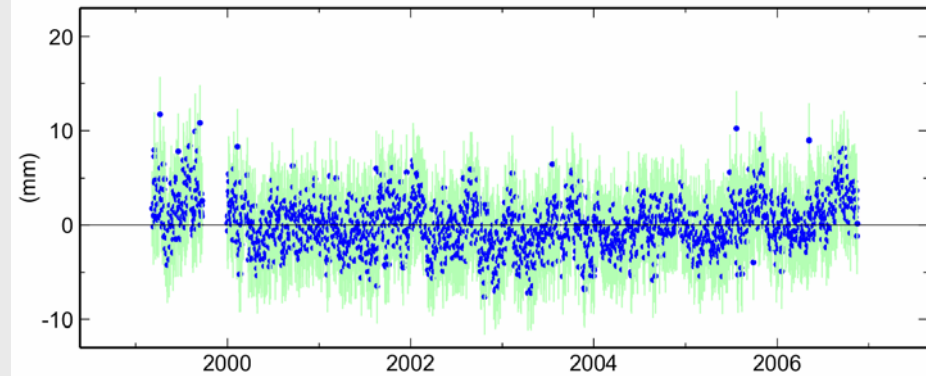


Example of site with non-linear
time series.

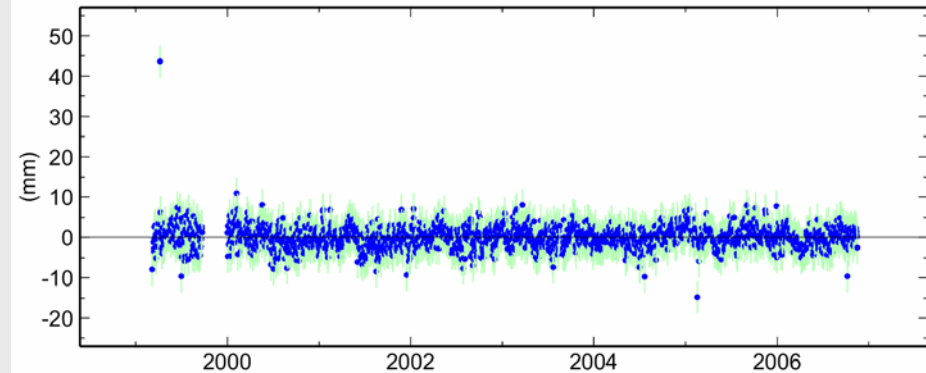
Estimated velocity becomes
uncertain.



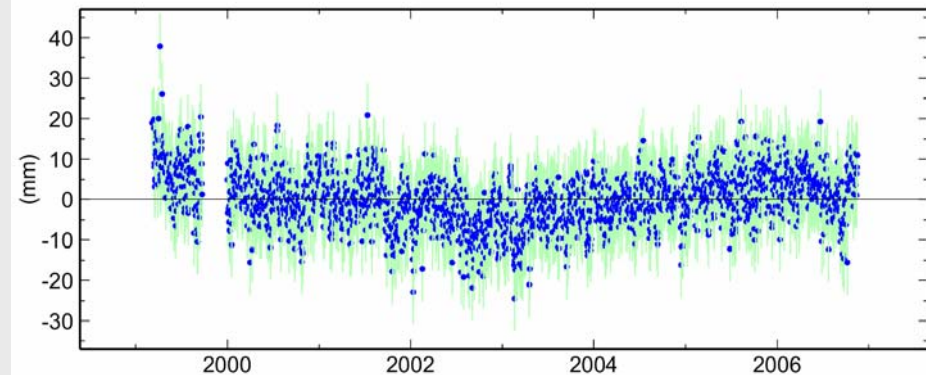
VARs North Offset 1844607.32038 m
rate(mm/yr)= 11.86 ± 0.04 nrms= 0.64 wrms= 2.5 mm # 2500



VARs East Offset 1109719.19819 m
rate(mm/yr)= 18.22 ± 0.04 nrms= 0.65 wrms= 2.6 mm # 2500



VARs Up Offset 5983936.13589 m
rate(mm/yr)= 2.96 ± 0.07 nrms= 0.82 wrms= 6.5 mm # 2500



Conclusion and outlook

The velocity solutions presented here are preliminary.

However, GPS-velocities and GIA-model agree at

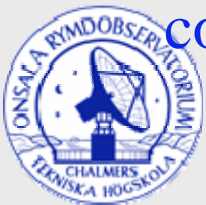
- 0.4 mm/yr level (1σ) horizontal
- 0.6 mm/yr level (1σ) vertically

EUREF implications:

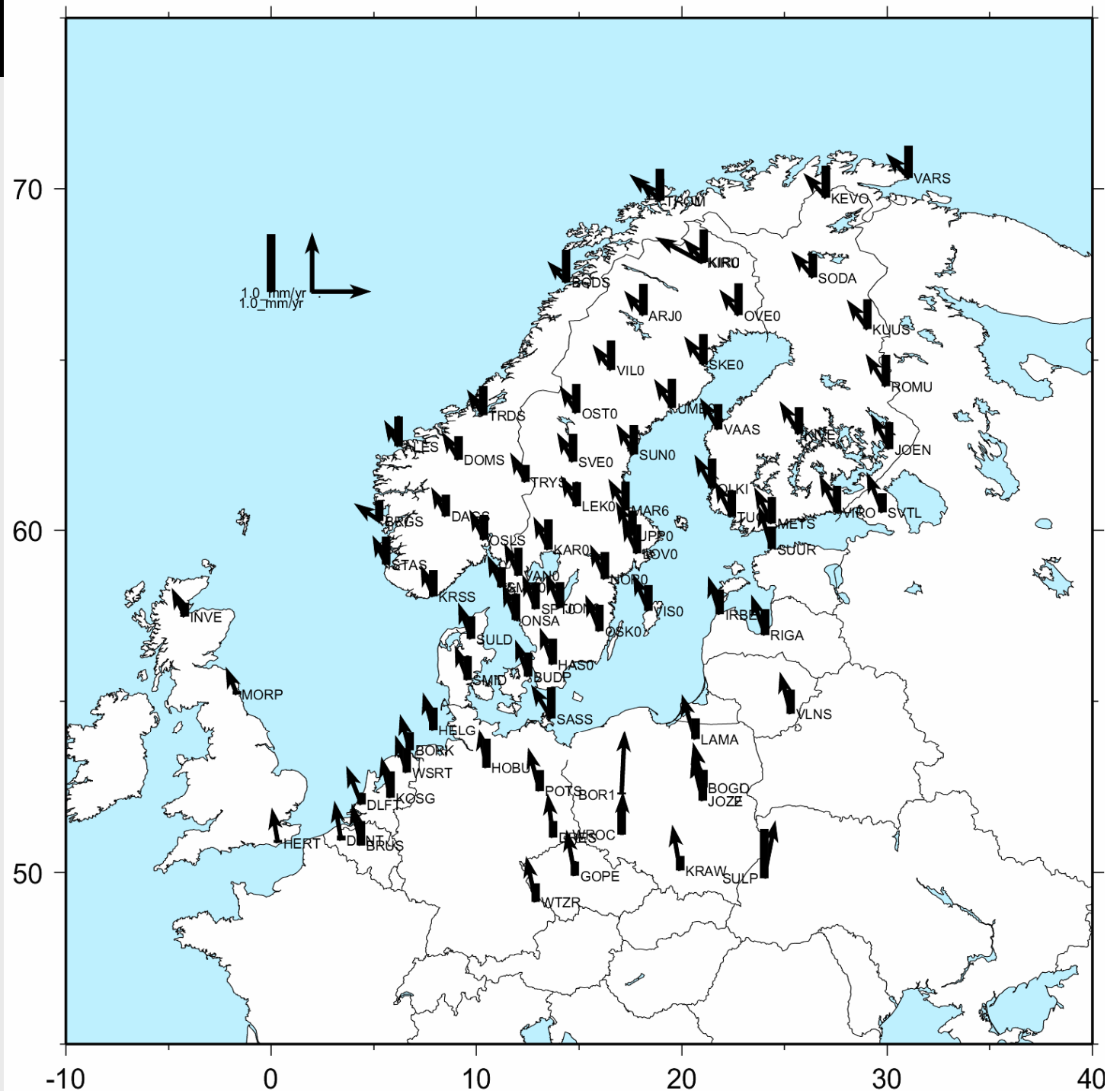
For the future, intraplate deformations will be important for maintenance of the ETRS89.

-We are on the right direction to get the tools to take care of these deformations!

For coordinate transformation and “geo-referencing” purposes the results seems to be OK, but for sea level work (exploring GPS and Tide gauge observations) we must be careful, and continue the work regarding the reference frame!



Up: 0.4



2 GAMIT + 2 GIPSY solutions

