Geodetic reference frames in the presence of crustal deformations

-with focus on Nordic conditions

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(Ack. NKG Working Group "Positioning and Reference Frames")

Background

- National realizations of ETRS89 have been developed and implemented in the Nordic countries during second part of 1990-ies
- Now in use for national and local GIS and construction work. These ETRS89 realizations will not be replaced!!
- Regulations on EU level demanding the use of ETRS89
- Common Nordic or European positioning services need a common reference frame
- Future: Proposed 1dm positioning service from Galileo without apparent ground control.
- So, how good are these national ETRS89 realizations and how do they agree?



The NKG 2003 GPS campaign

- 133 stations (Nordic and Baltic area - also Iceland, Greenland, and Svalbard)
- GPS week 1238, (w 40, 2003; 7days)
- Software: GIPSY, GAMIT, Berneese
- The result in ITRF2000, ep 2003.75
- Coordinated by the NKG w.g. Positioning and Reference Frames





Check ETRS89 realizations using NKG2003

Nation	epoch	based on ITRF
Denmark	1994.707	IIRF92
Finland	1997.0	ITRF96
Norway	1994.665	ITRF93
Sweden	1999.5	ITRF97

- Compare official ETRS89 using NKG2003.
- We have crustal deformation (about 1cm/yr vertical) not considered in the official ETRS89 realizations!
- Use a model to correct for intraplate deformations!







Model for horizontal displacements

In red - GPS solution presented at EUREF in Vienna 2005: GPS-data 1996 to 2004.5 GAMIT/GLOBK

GIA model from Milne et al (2001) Ice history model from Lambeck 120 km lithosphere, upper mantle visc. 8×10²⁰ Pas lower mantle visc. 1×10²² Pas

Agreement:

 $0.5 \text{ mm/yr} (1\sigma)$ using all 53 sites

Velocities relative stable Eurasia as defined by the ITRF2000 Euler pole for Eurasia.







Numerical velocity models in the *.gri grid format



Horizontal (0 to 2 mm/yr): The GIA model transformed to the GPS-velocities.





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

7-parameter fit. Each national ETRS89 vs. NKG 2003

Intraplate deformations reduced to:

Epoch of realization (1994.6 ... 1999.5)



RMS (mm)	north	east	up
Denmark (1994.7):	1.8	1.3	0.9
Finland (1997.0):	1.6	1.4	3.1
Norway (1994.6):	3.4	3.6	9.5
Sweden (1999.5):	1.7	1.3	3.1

Common epoch at 2000.0



north	east	up
2.5	2.0	1.8
1.3	1.4	3.7
2.7	3.9	7.5
1.5	1.3	2.5

NKG 2003 vs. official ETRS89 realizations

The NKG 2003 GPS campaign

- in ETRS89 (Boucher & Altamimi MEMO)
- compared to official ETRS89 realizations

	Mean	RMS (mm)
north	- 4	7
east	9	14
up	42	48





NKG 2003 vs. official ETRS89 (with internal deformations)

The NKG 2003 GPS campaign

- in ETRS89 (Boucher & Altamimi MEMO)
- internal deformations reduced to year 2000 using the velocity models
- compared to official ETRS89 realizations

	Mean	RMS (mm)
north	- 3	7
east	10	14
up	25	29





Discussion and preliminary conclusions so far

- Numerical models for intraplate deformations are now available
- The internal deformation at the 4 cm level are reduced to the 5 mm level (RMS) using the model
- Internal accuracy of the GPS campaigns fulfil ~1-2mm horizontal, and ~5mm vertical
- Different ETRS89 realizations fulfil ~1cm horizontal, and ~1-3cm vertical (when reduced for intraplate deformations)
- Models for intraplate deformations are now available (only for the Nordic/Baltic area). What is the proper target epoch regarding intraplate deformations for further ETRS89 realizations?

(1989 would not suit the adopted ETRS89 realizations!)



Epoch for adopted ETRS89 realizations

To note:

Most ETRS89 are performed during second part of 1990-ies or later





A modest (?) proposal

In order to facilitate for the common use of ETRS89 within Europe and EU it is necessary to maintain (the group of) ETRS89 realizations as an accurate pan-European high class geodetic reference frame.

The possibility to re-define the target epoch for intraplate deformations (so far ignored?!) in ETRS89, to better comply with the current adopted realizations, may therefore be considered and discussed.

(Considering the importance of agreement with EVRS, epoch 2000.0 may be a good choice!)

