New velocity solutions from 13 years of BIFROST activities

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Outline

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

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
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 ???
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
- 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

VILU North Offset 2620258.63837 m
rate (mm/yr) = 5483.84 ± 8.34 rms = 0.46 wrms = 1.6 mm # 3545

VILU East Offset 779135.11106 m
rate (mm/yr) = 5698.44 ± 8.34 rms = 0.46 wrms = 1.9 mm # 3545

VILU Up Offset 574379.44509 m
wmean (mm) = 0.00 ± 0.13 rms = 3.48 wrms = 27.9 mm # 3545

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

KIVE East Offset 1266957.40186 m
rate (mm/yr) = 7178.58 ± 9.77 rms = 0.49 wrms = 1.9 mm # 2656

KIVE Up Offset 5651027.68616 m
wmean (mm) = 0.00 ± 0.16 rms = 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. $5 \times 10^{20}$ Pas
lower mantle visc. $5 \times 10^{21}$ Pas

Thanks Glenn Milne for the model work!!
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
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:

<table>
<thead>
<tr>
<th></th>
<th>mean</th>
<th>RMS mm/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITRF2005</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>GIA</td>
<td>-0.3</td>
<td>0.6</td>
</tr>
<tr>
<td>Ekman</td>
<td>-0.2</td>
<td>0.6</td>
</tr>
</tbody>
</table>
Example of site with non-linear time series.

Estimated velocity becomes uncertain.
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!
Compare the ITRF2005 & ITRF2000 velocities
Before rotation to Eurasia:

Mean values: (mm/yr)
North: 0.5
East: -0.2
Up: 0.4
2 GAMIT + 2 GIPSY solutions