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A new GNSS velocity field for Fennoscandia and comparison to GIA models

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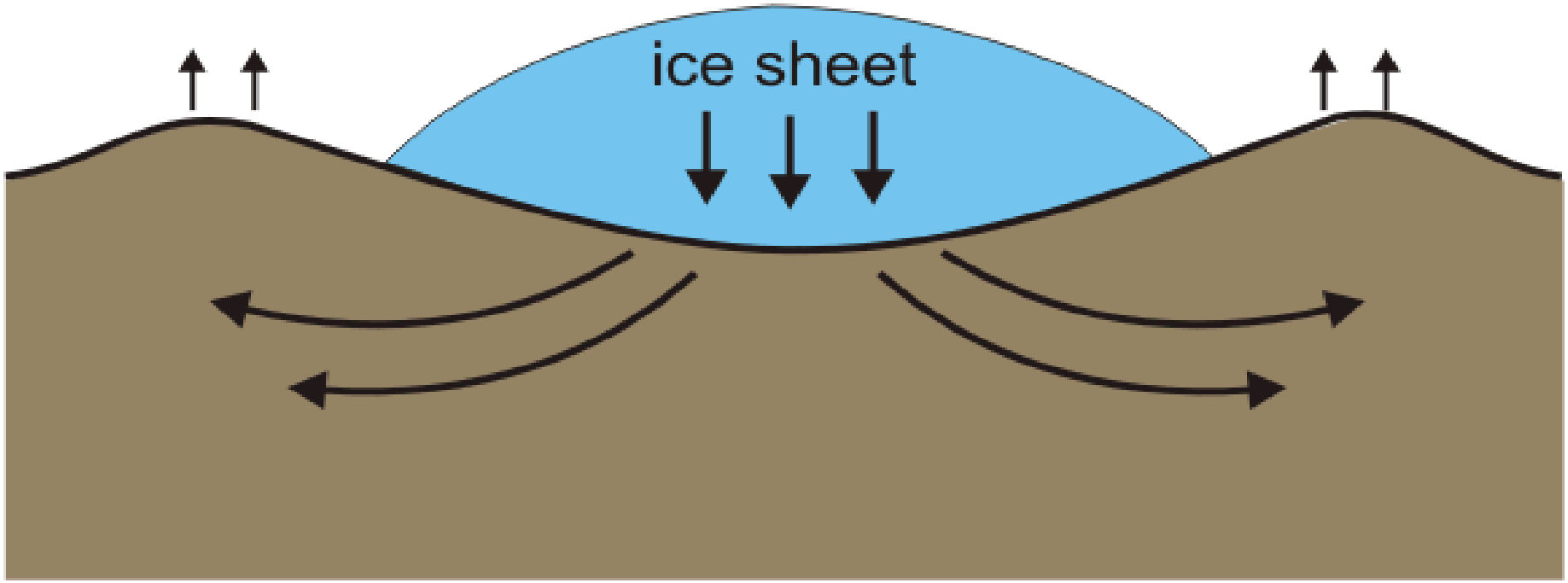
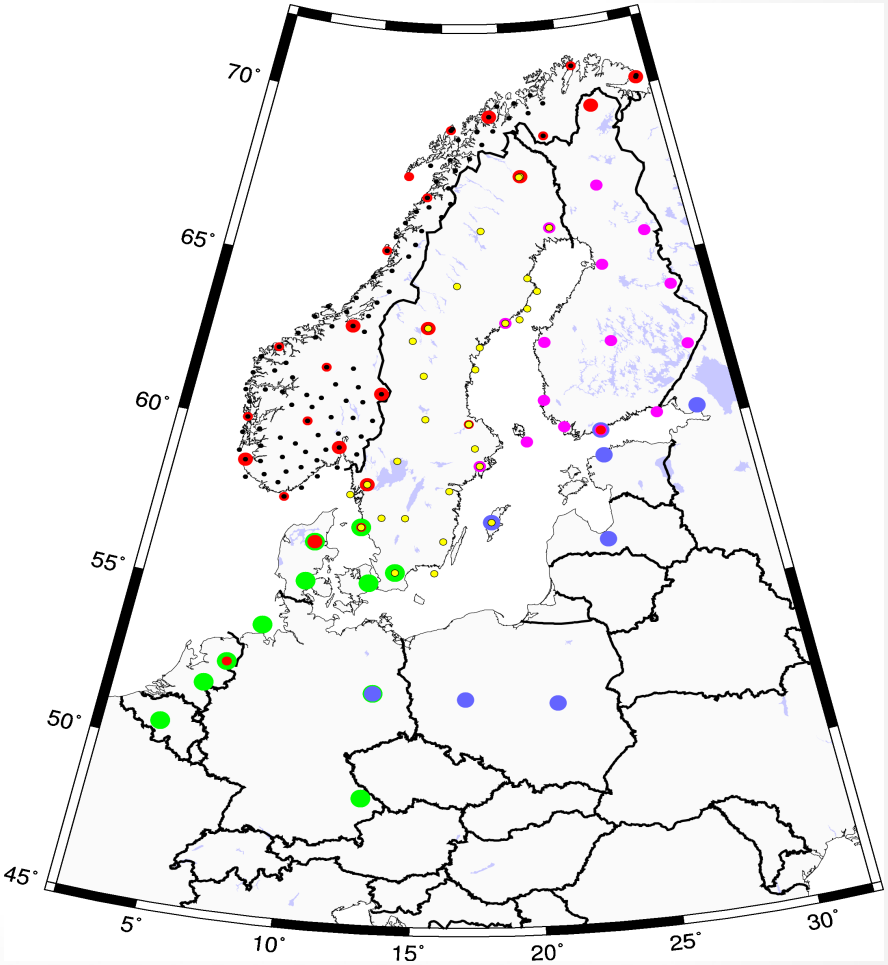


Based on: Kierulf, Steffen, Simpson, Lidberg, Wu and Wang, *GPS velocity field for Fennoscandia and a consistent comparison to glacial isostatic adjustment models,* J. of Geophys. Res.: Solid Earth 07/2014; DOI: 10.1002/2013JB010889

GNSS data are analyzed with the analysis software GAMIT

GNSS data from 2000 -->

Station with >3.5 years observation time



Analysis strategy:

-GAMIT analysis: (7 degree cut-off, VMF1, FES2004, Abs PVC-model)

-Sub-network solutions combined to loosely-constrained daily solutions (h-files)

-Combine daily solutions to a multi-year solution (using GLOBK)

Continuation of the BIFROST work, but with more stations and longer observation time

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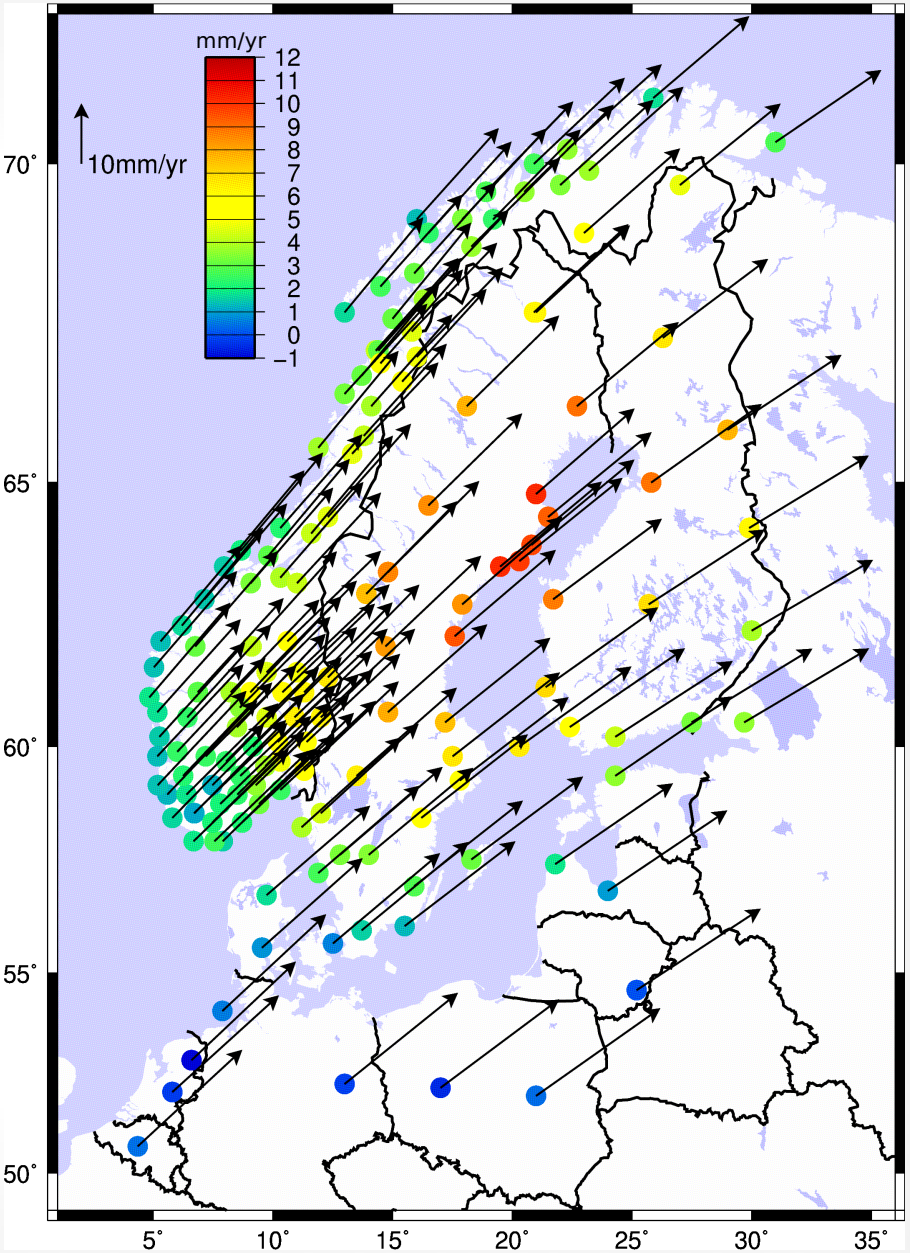
The GNSS results are combined to a new velocity field for Fennoscandia



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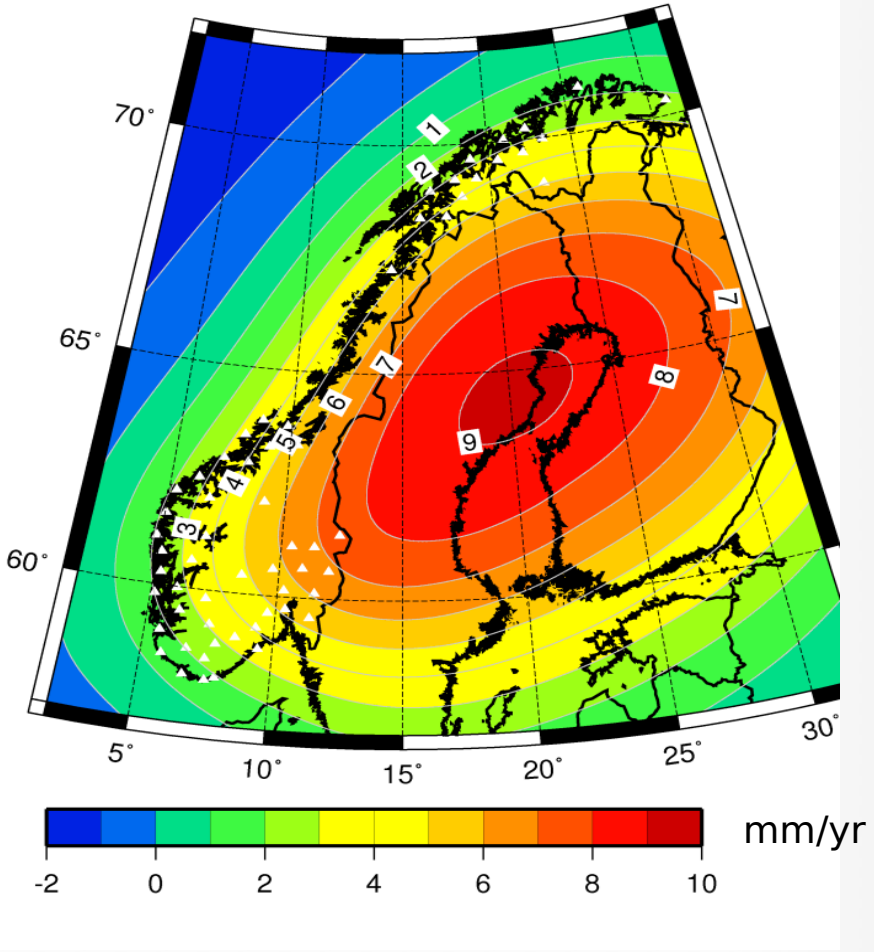
GIA models consists of both an Ice model and an Earth model

Ice models:
- KL 98 (Lambeck etal, 1998)
- + Ice3g (Tushingham+Peltier, 1991)

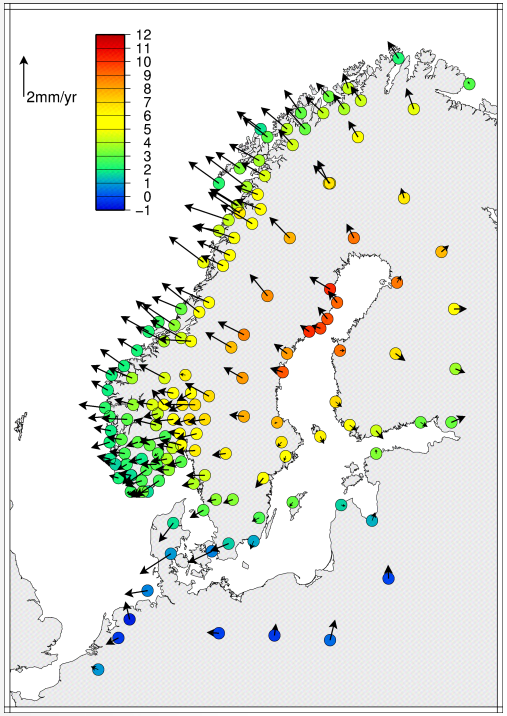
and
- Ice 5g (Peltier, 2004)

Earth models-1D;
- Lithospheric thickness
- Upper mantle viscosity
- Lower mantle viscosity

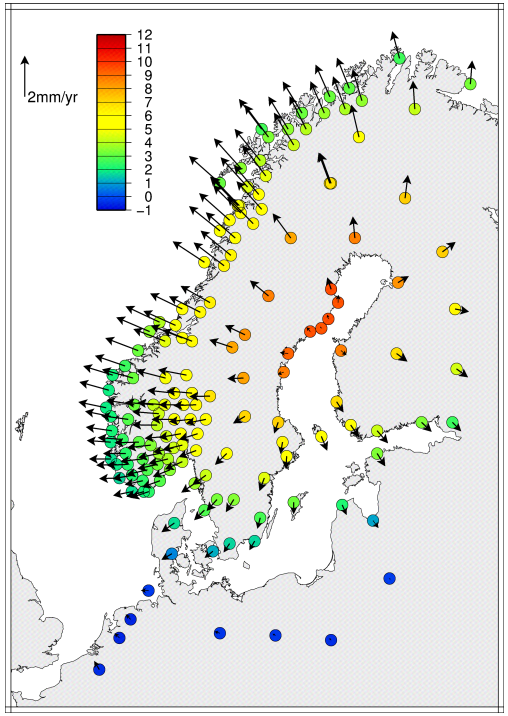
and
- 3D-models- Finite element method



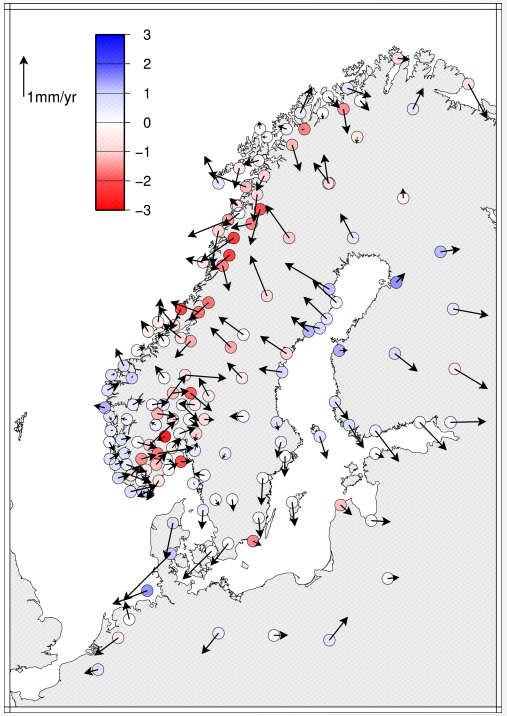
Weighted root mean square (WRMS) of the difference between models and observations is a measure of how well the GIA model fit the observations



Observations



Model



$$WRMS = \sqrt{\frac{\sum_{i=1}^{n}\left(\frac{r_i}{\sigma_i}\right)^2}{\sum_{i=1}^{n}\left(\frac{1}{\sigma_i}\right)^2}}.$$

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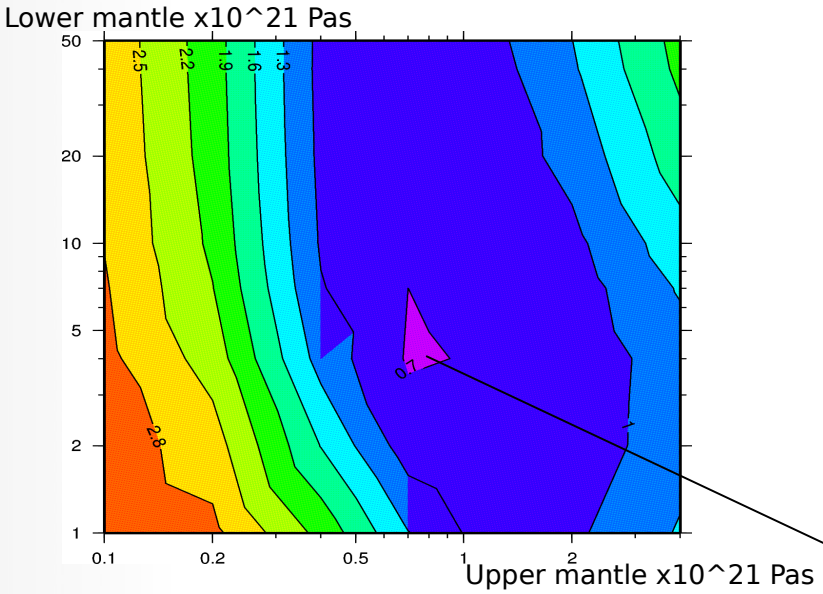
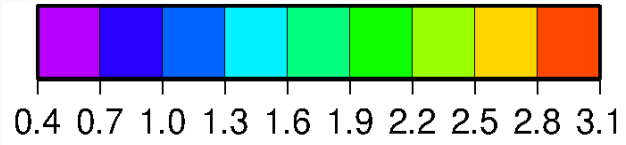
Best-fit GIA models can be found by comparing models with observations

Lithospher: 140 km



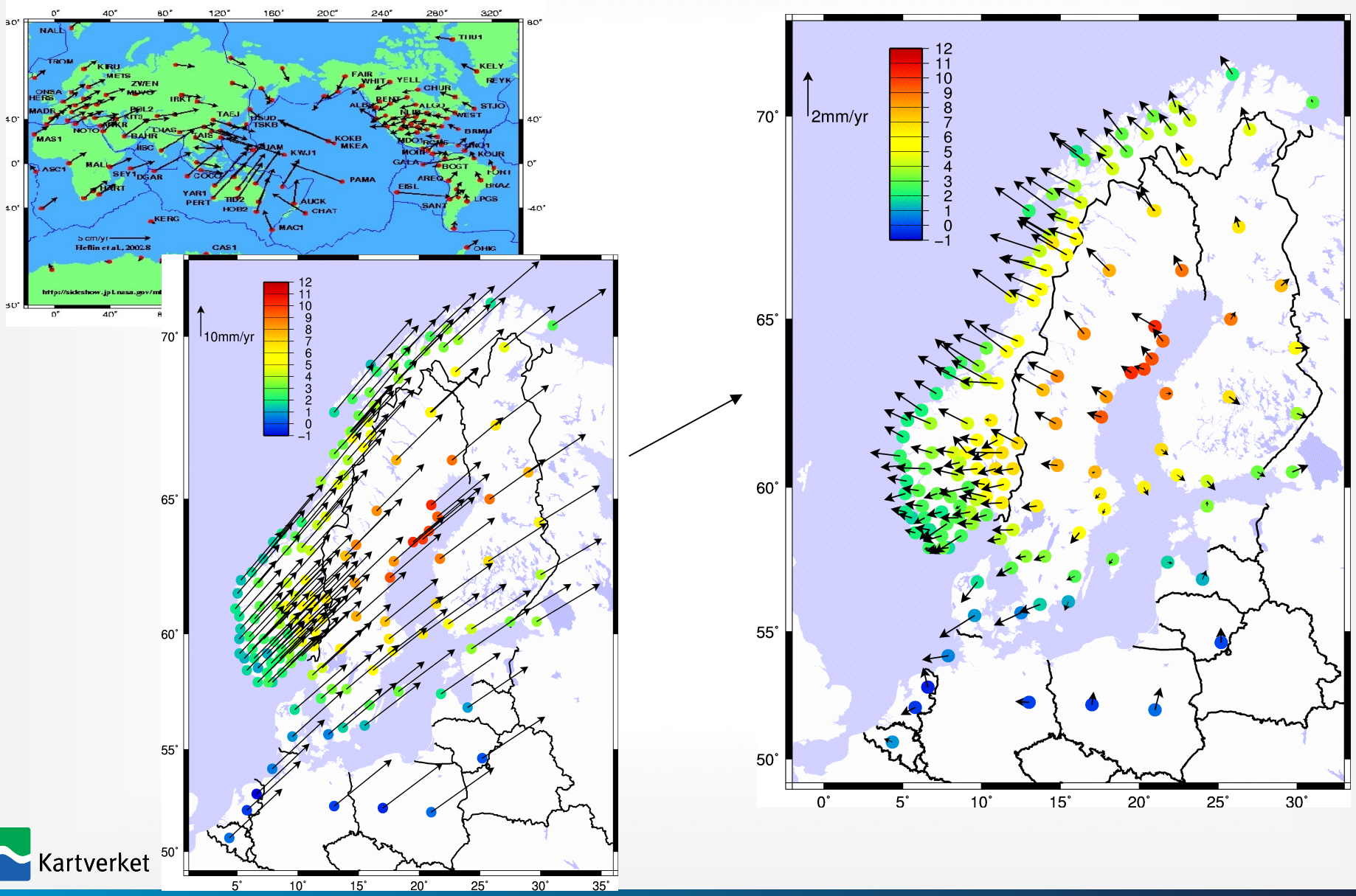


$$WRMS = \sqrt{\frac{\sum_{i=1}^{n}\left(\frac{r_i}{\sigma_i}\right)^2}{\sum_{i=1}^{n}\left(\frac{1}{\sigma_i}\right)^2}}.$$

Upper mantle: 0.7x10^21 Pa s
Lower mantle: 4.0x10^21 Pa s

However: Reference frame issues and plate tectonics might lead to wrong earth model (and ice model)

The plate tectonic signal has to be removed before comparing observations and models



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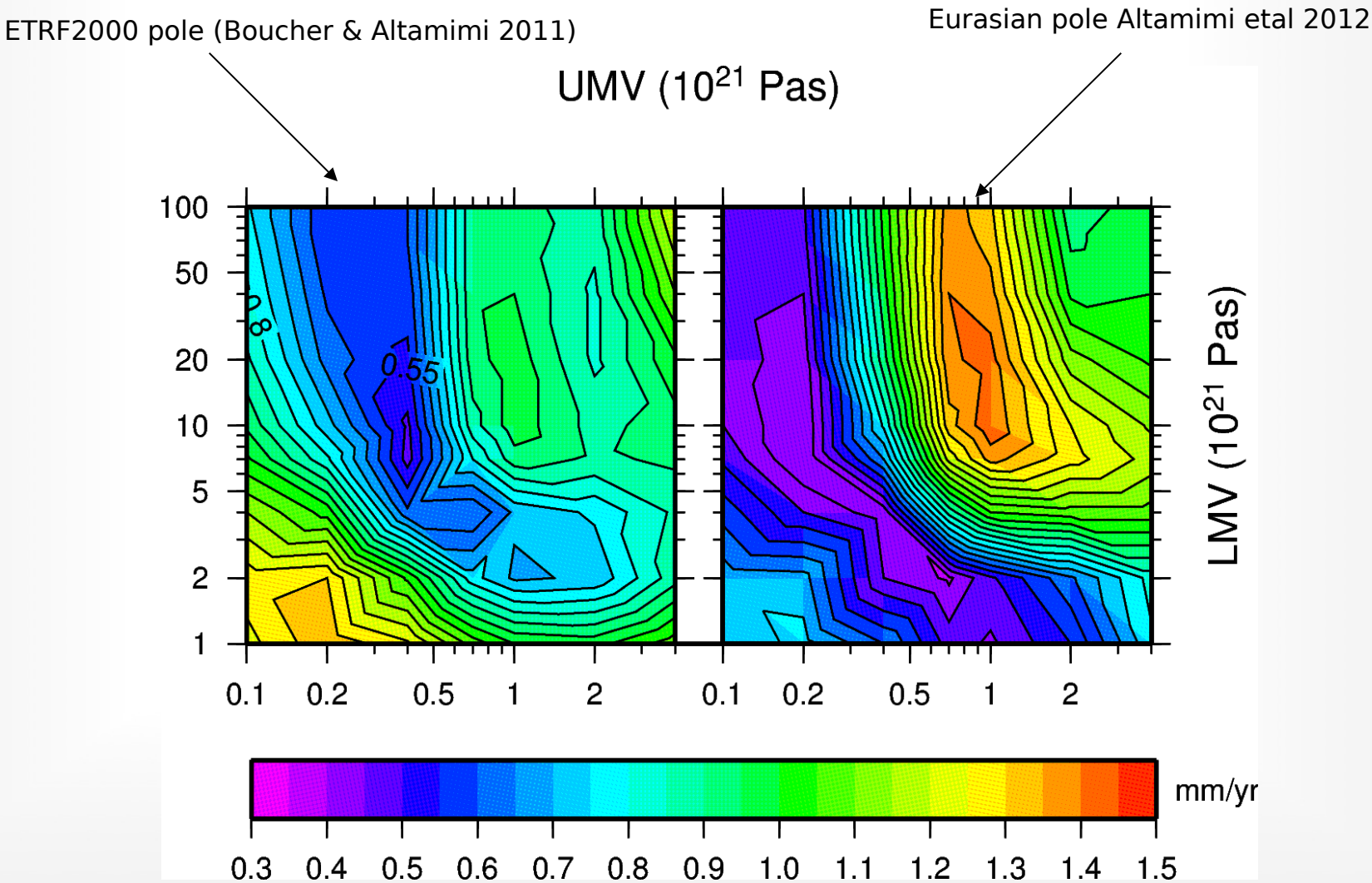
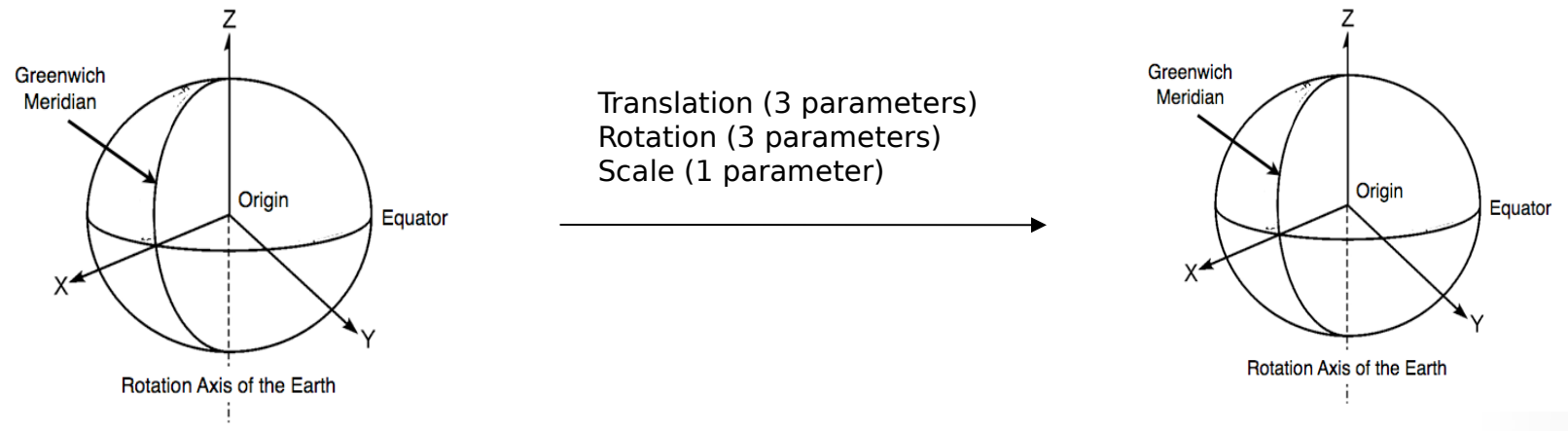
Different tectonic corrections give different best-fit Earth models



Different reference frames can be connected by 7-(14-) parameter transformation



ITRF2000 and ITRF2008 differ
in scale and translation (geocenter motion)

Difference in uplift of ~1.0mm/yr in Fennoscandia due to this reference frame differences

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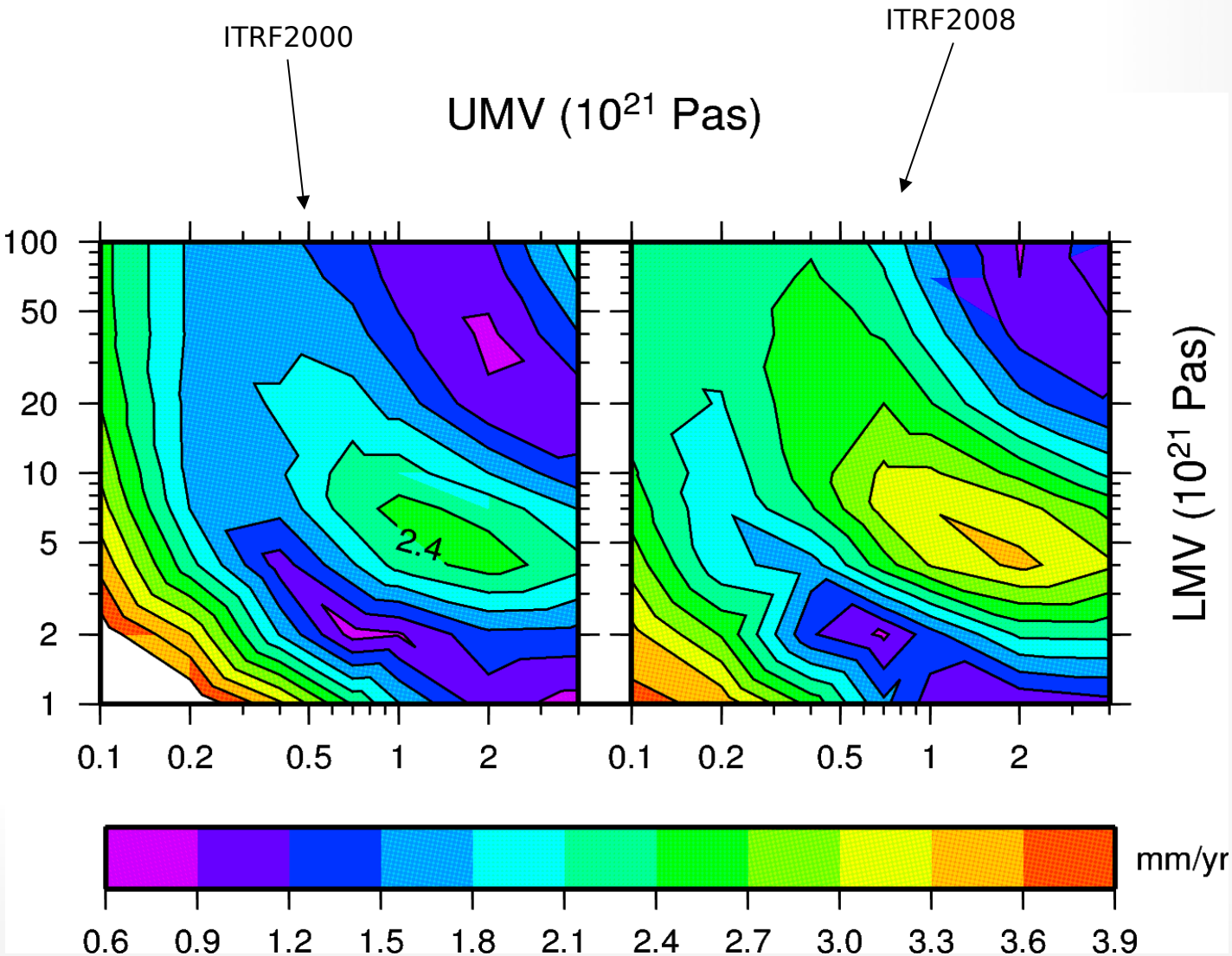
Different reference frame give different best fit Earth models



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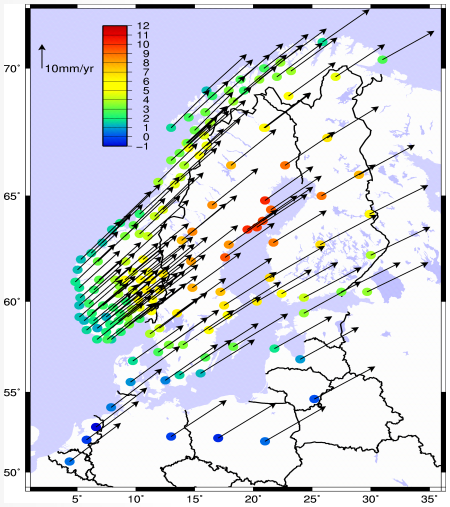
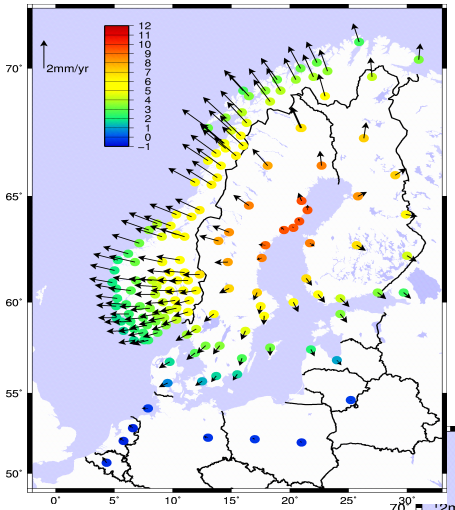
To avoid the problems with plate tectonics and reference frames we have used the *GIA-frame approach*

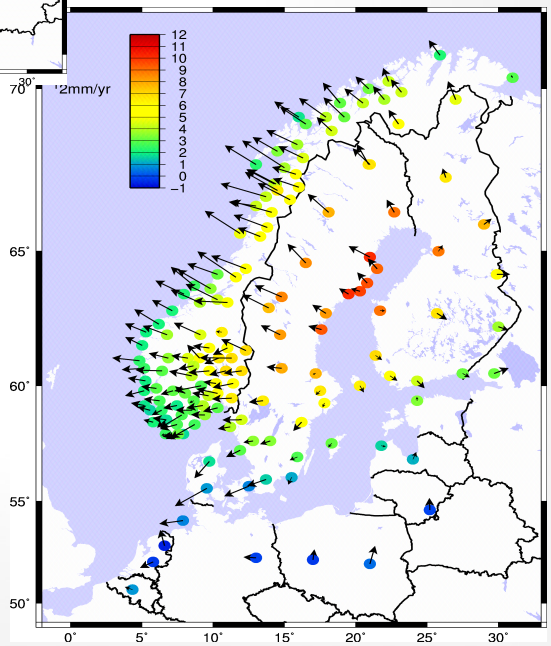
GNSS-Velocity field



4-parameter transformation

GIA-model





The result is:
A velocity field realized in the reference frame of the GIA-model

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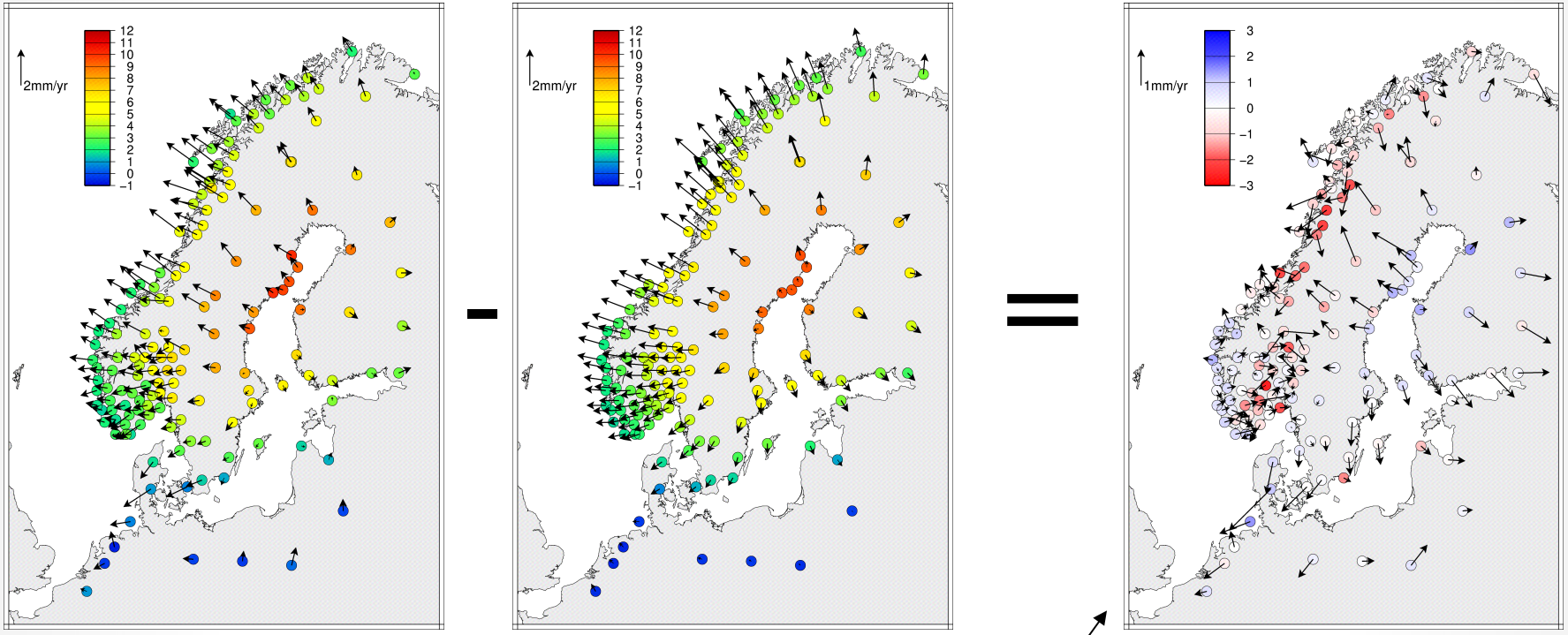
With this approach can we compare the observed velocity field and the GIA-models in consistent reference frames



Observations

Model

The velocity field is realized in the reference frame of the GIA-model

Residuals not contaminated by different reference frames or plate tectonics

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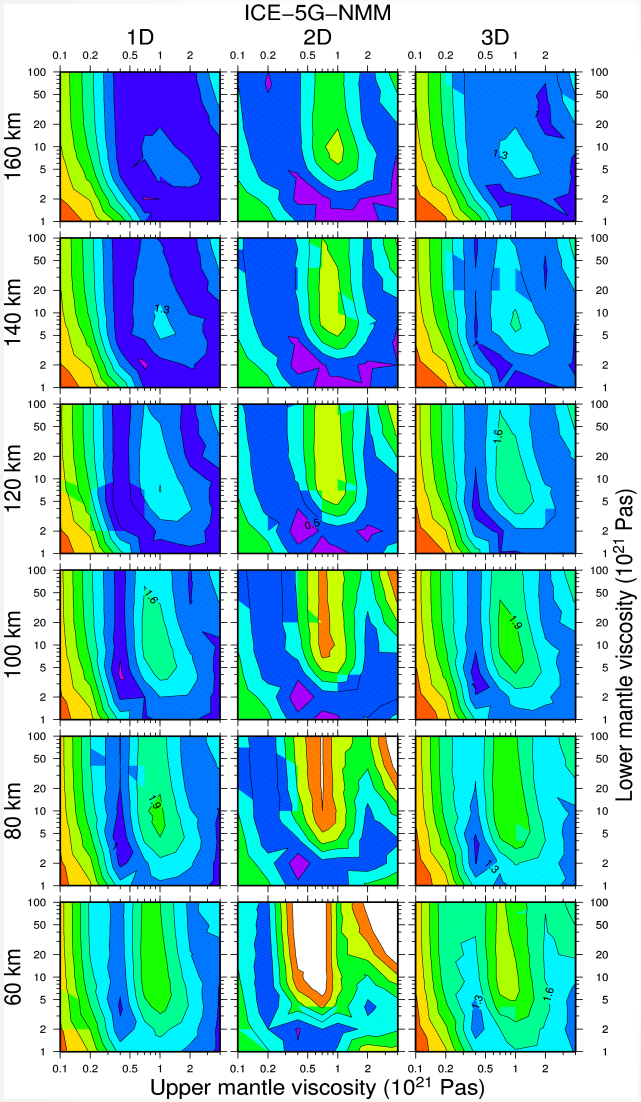
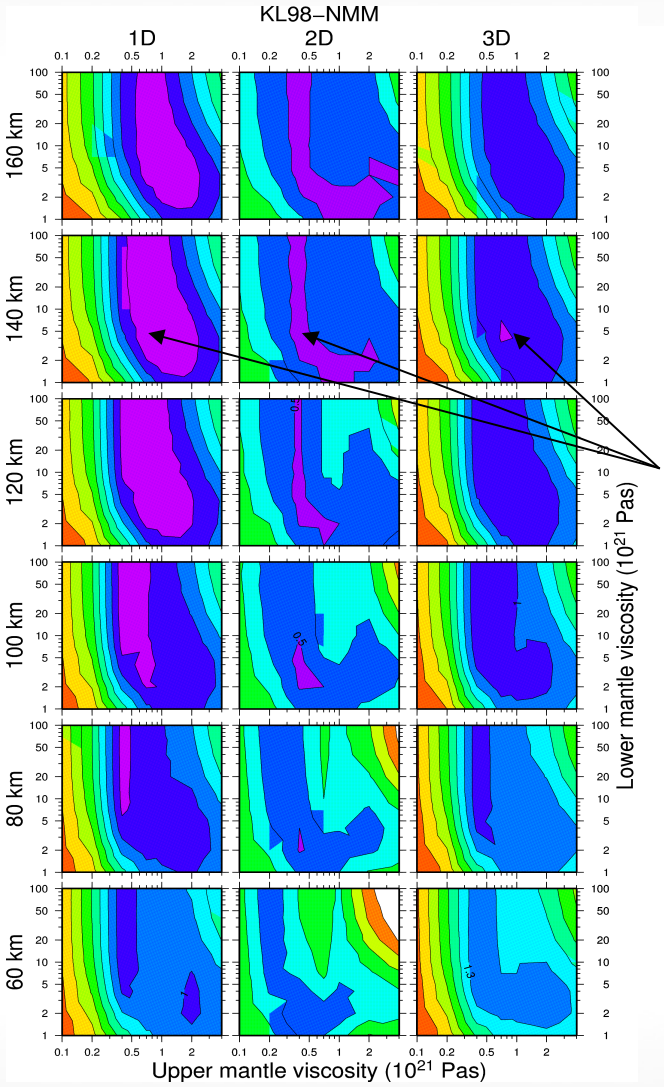
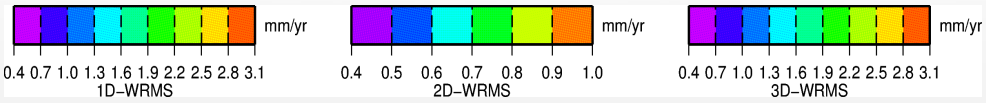
We can validate the GIA models using WRMS





$$WRMS = \sqrt{\frac{\sum_{i=1}^{n}\left(\frac{r_i}{\sigma_i}\right)^2}{\sum_{i=1}^{n}\left(\frac{1}{\sigma_i}\right)^2}}.$$

Ice model: KL98+ICE3g
Lithospheric thickness: 140 km
Upper mantle: 0.7x10^21 Pa s
Lower mantle: 4.0x10^21 Pa s



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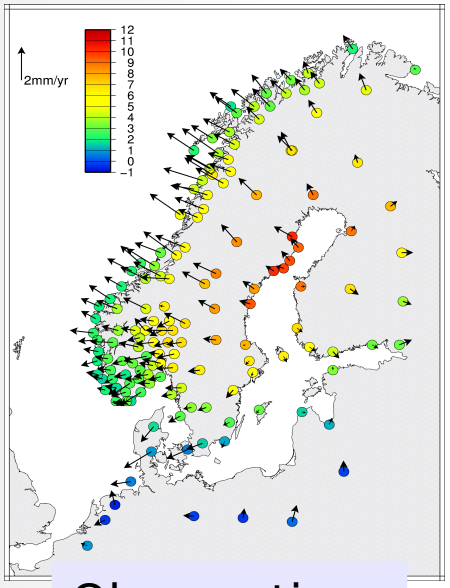
Results with best fitting 1D model and 3D model:



Observations

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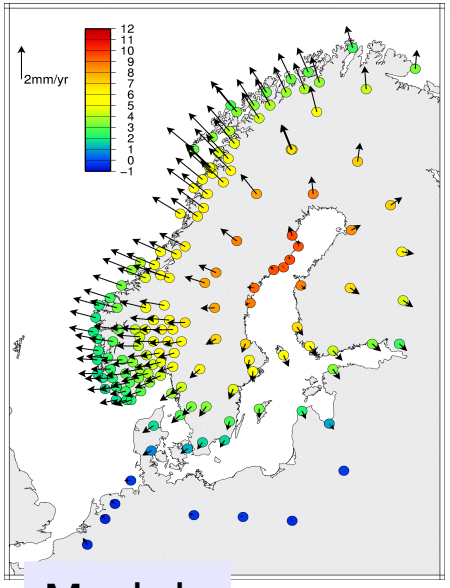

Models

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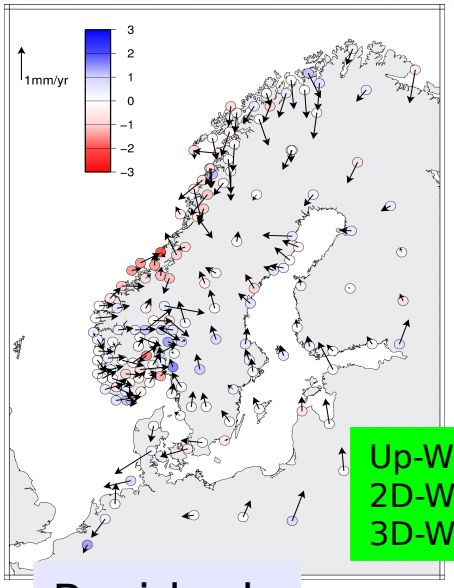
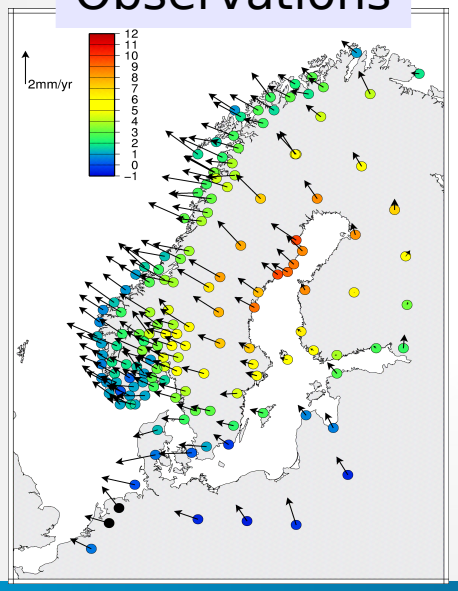


Residuals

KL98-1D
best-fit

Up-WRMS: 0.42 mm/yr
2D-WRMS: 0.52 mm/yr
3D-WRMS: 0.67 mm/yr



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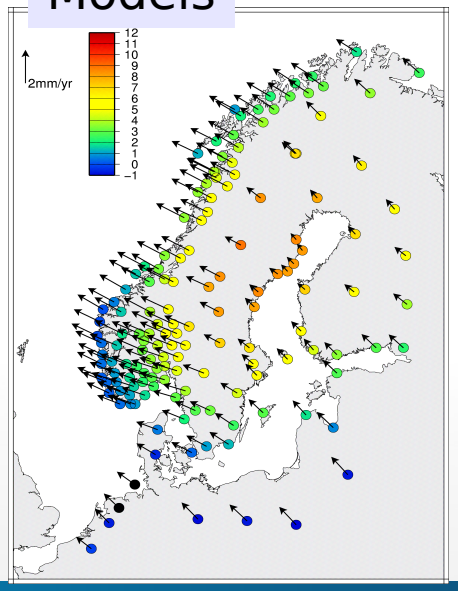

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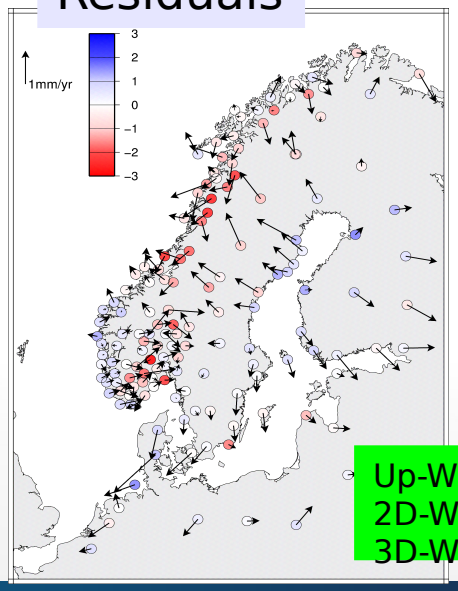

KL98-3D
Finite element

Up-WRMS: 0.63 mm/yr
2D-WRMS: 0.60 mm/yr
3D-WRMS: 0.90 mm/yr

Conclusions

-We have produced a new velocity field for Fennoscandia

-We have compared the velocity field with different GIA-models

-We have demonstrated how reference frame issues and tectonic motion may contaminate the comparison:

  -it makes the interpretation of geodetic results in GIA studies problematic

  -and may lead to wrong insight in earth models and ice history

-Uncertainties in the reference frame and plate tectonic motion increase the uncertainties in the GIA model

-We have demonstrated a method to overcome the problem

We have named this method: The GIA frame approach

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