



# Report from EUREF w.g. on Deformation models

**Martin Lidberg**, Zuheir Altamimi, Carine Bruyninx,  
Alessandro Caporali, Jan Dousa, Rui Manuel Fernandes,  
Ambrus Kenyeres, Günter Stangl, Holger Steffen

[Martin.Lidberg@lm.se](mailto:Martin.Lidberg@lm.se)



# Outline for this presentation

- Some background for this working group
- What do we understand as a “model”
- Proposed activities
- Done so far..
- Update of roadmap for further work!
- Summary and outlook



# Background

- The w.g. on Deformation models was established in 2012
- It has a long term goal to establish a velocity model of the crustal deformations present in the EUREF area of interest
- I.e. both intra-plate and inter-plate velocities are of interest
- Tectonic events (earth quakes) are considered complicated and are therefore not yet of 1<sup>st</sup> priority



# The dual purposes of this working group

The purposes of this working group are twofold:

- There are pure scientific interests in improving the knowledge of surface deformations in Eurasia and adjacent areas

*and*

- Knowledge of the crustal deformations are of importance for maintenance and use of e.g. national realizations of the ETRS89, which motivates this w.g. within EUREF.



# **Models of crustal deformations**

## **- so what is a model?**

a model:

provides explanations to observations, and allows for predictions also where observations are not available

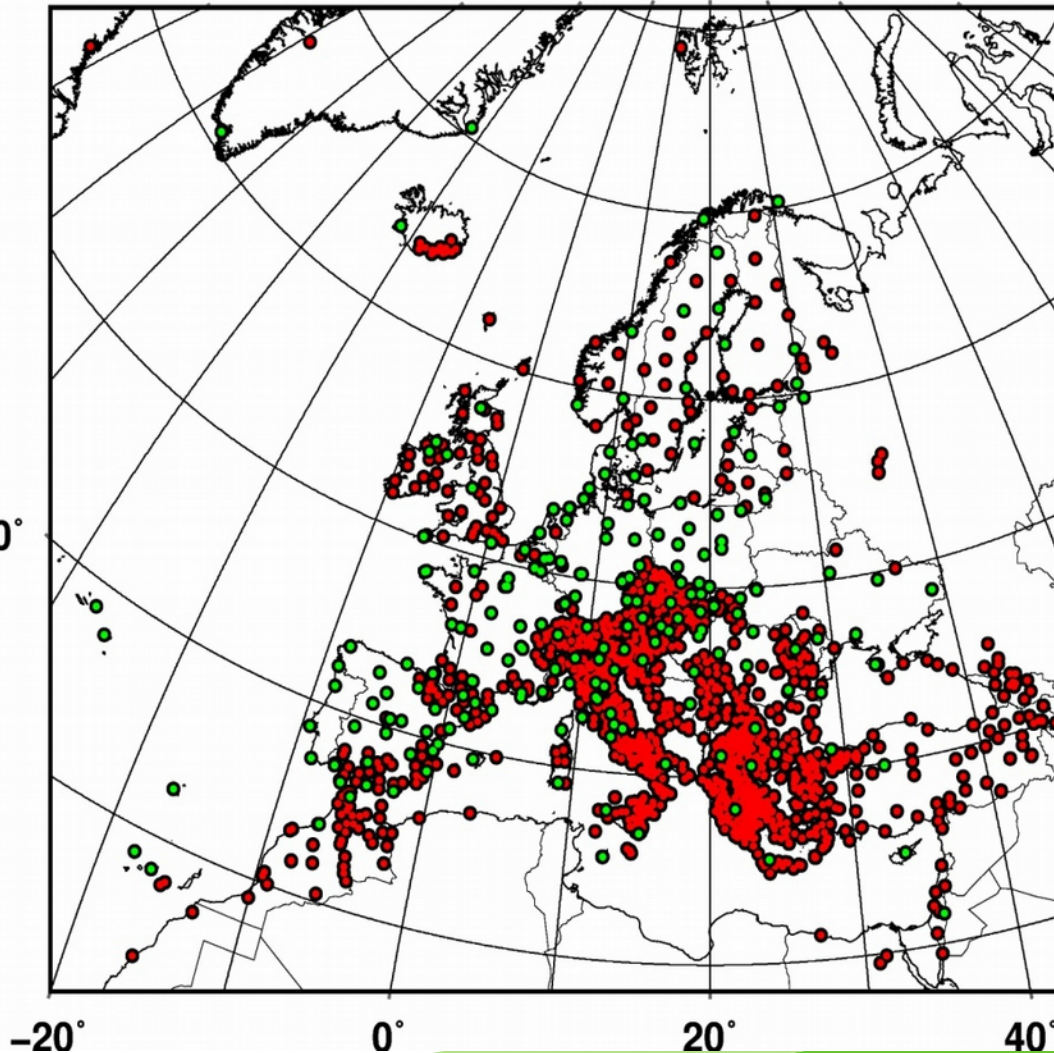
in geodesy the model should also include estimated uncertainty of the model



# The proposed activities

1. Evaluation of GNSS station velocities (*to find out to what extent observed velocity at a station represent the crustal deformation in the area*)
2. Work towards models of crustal deformations in Europe
3. Consideration of a deformation model in maintenance and use of national realizations of ETRS89
  - As a first step, an inventory and analysis of published work on crustal deformations has been done -some 60 papers (*Steffen et al, EUREF symposium in Budapest 2013*)
  - and a mini-workshop in Marsh in connection to the TWG meeting in Gävle

# Inventory of published work!



Some 60 papers studied!

GNSS sites from publications in **red**, EPN stations in **green**.

The published work is of course very valuable to read for understanding of crustal deformations and geophysical processes,

But a common EUREF deformation model may not be based on merging models from publications!






# Example Western Alps: Alpine Uplift determined from levelling

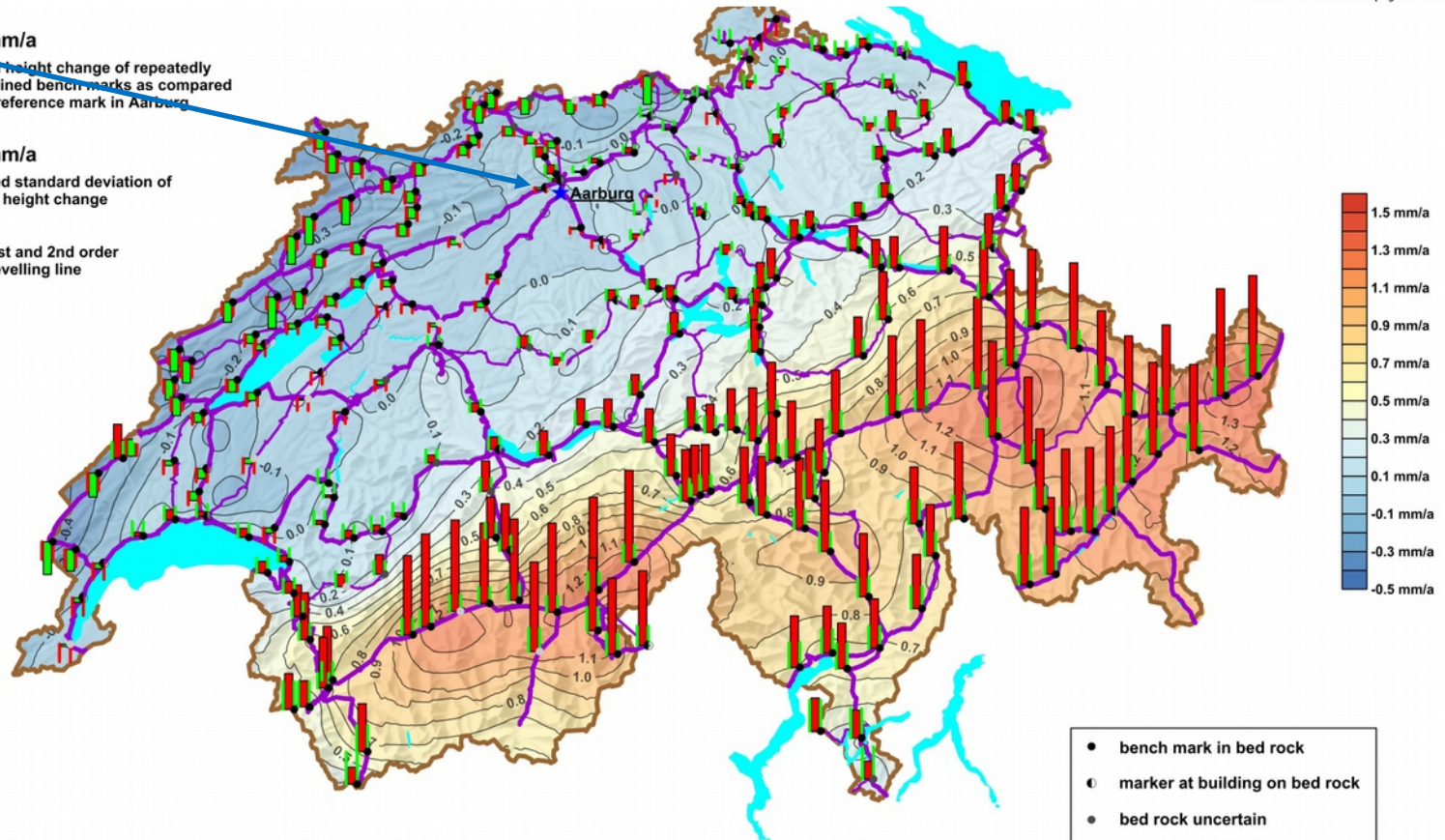
## Alpine Uplift model RCM12

(E. Brockmann, D. Ineichen, U. Marti, S. Schaer, A. Schlatter)

Defined with  
zero vertical  
motion

-  1.0 mm/a  
Annual height change of repeatedly  
determined bench marks as compared  
to the reference mark in Aarburg
-  0.5 mm/a  
Doubled standard deviation of  
annual height change
-  1st and 2nd order  
levelling line

Levelling:  
Alps are rising  
1.5 mm/yr

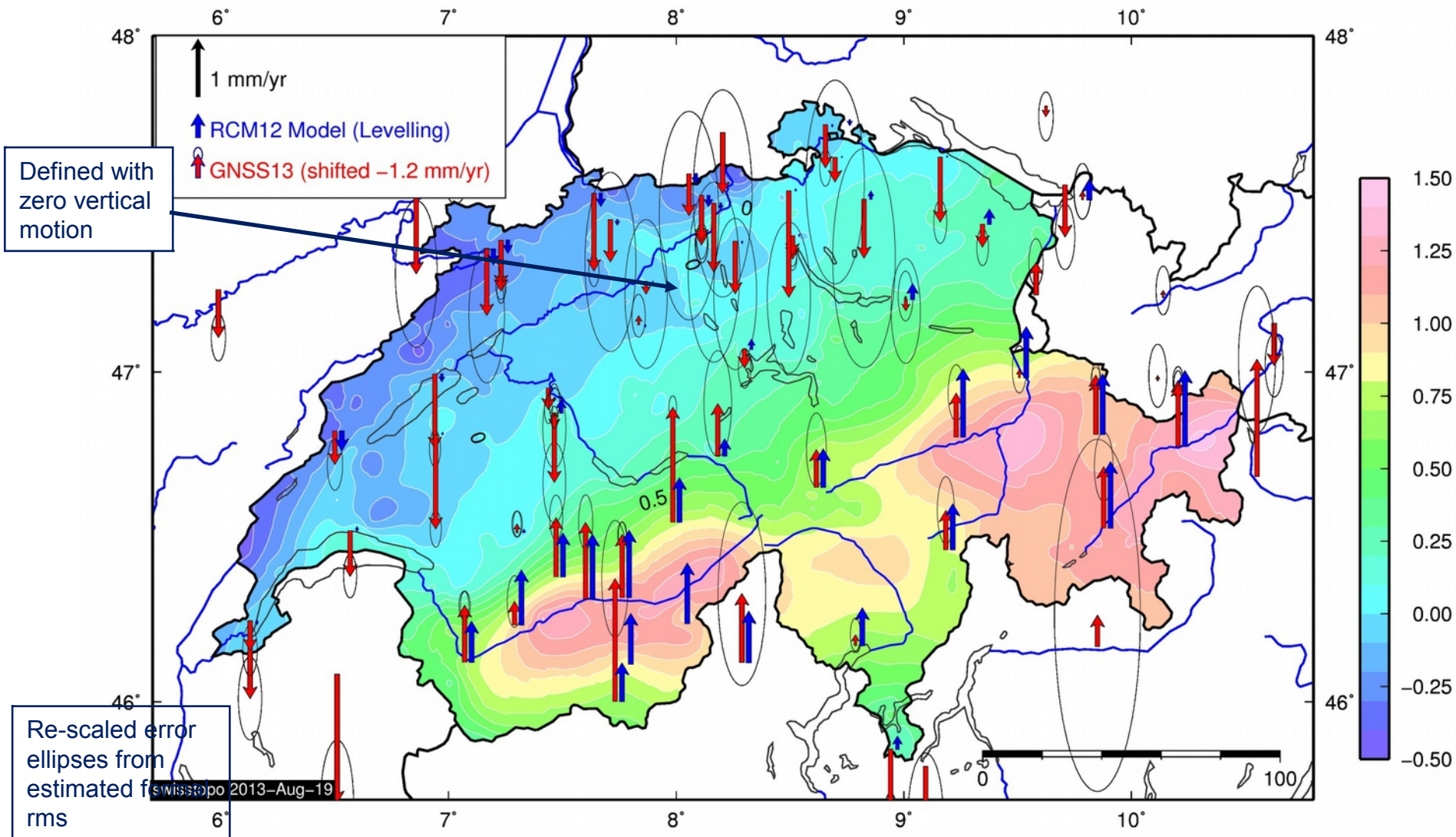


0 km 25 km 50 km 75 km 100 km



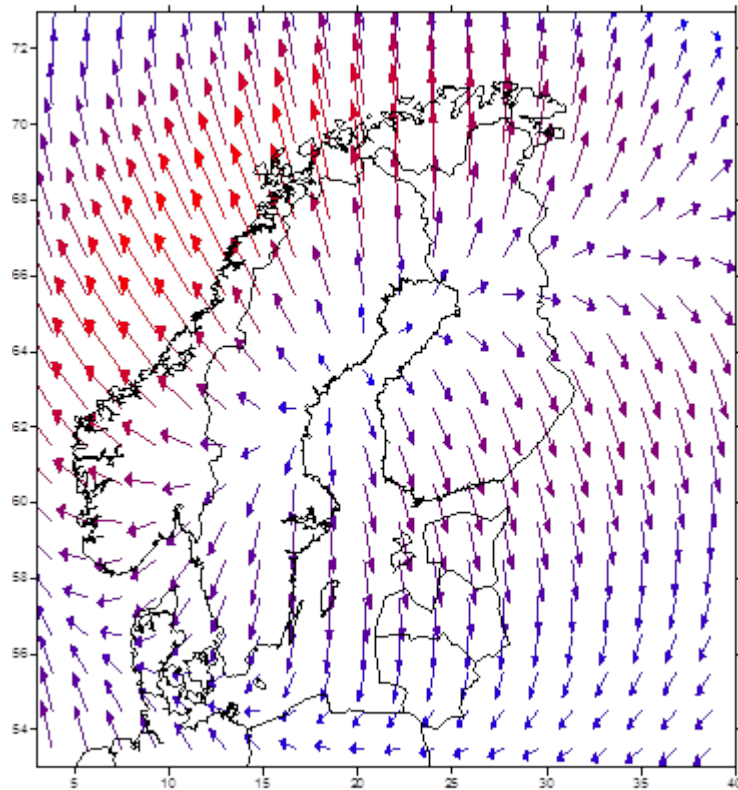


# Comparison: GNSS / Model (Levelling) vertical velocities: status 2013

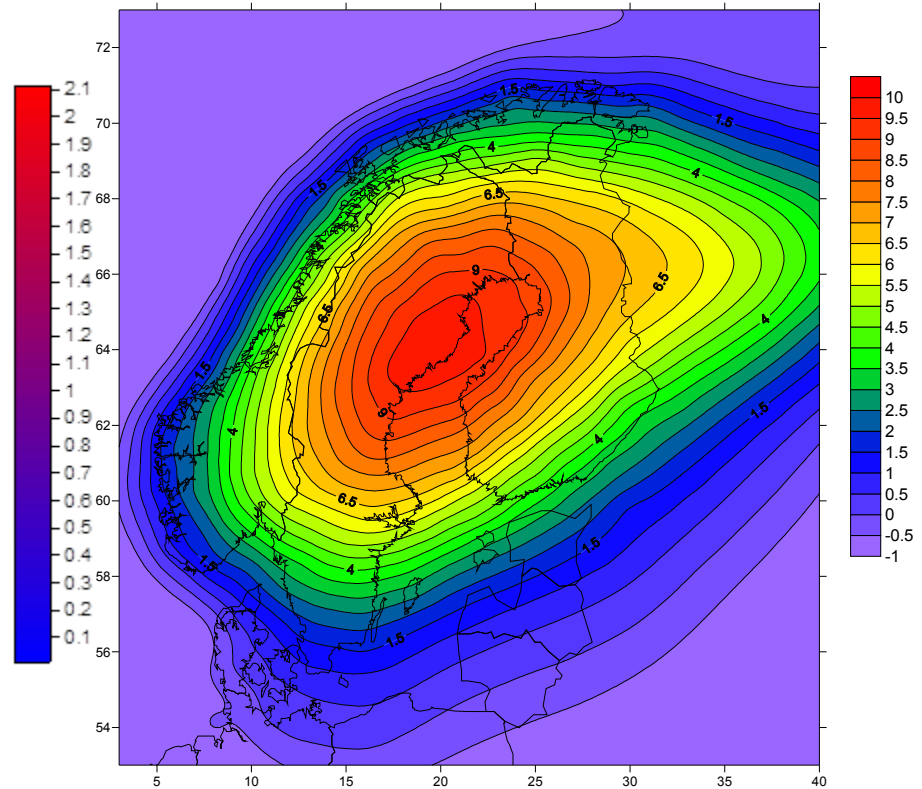




# Example from Fennoscandia/Baltic area: The deformation model NKG\_RF03vel (*NKG2005LU*)



Horizontal:  
Milne 2001 transformed to Lidberg  
2004

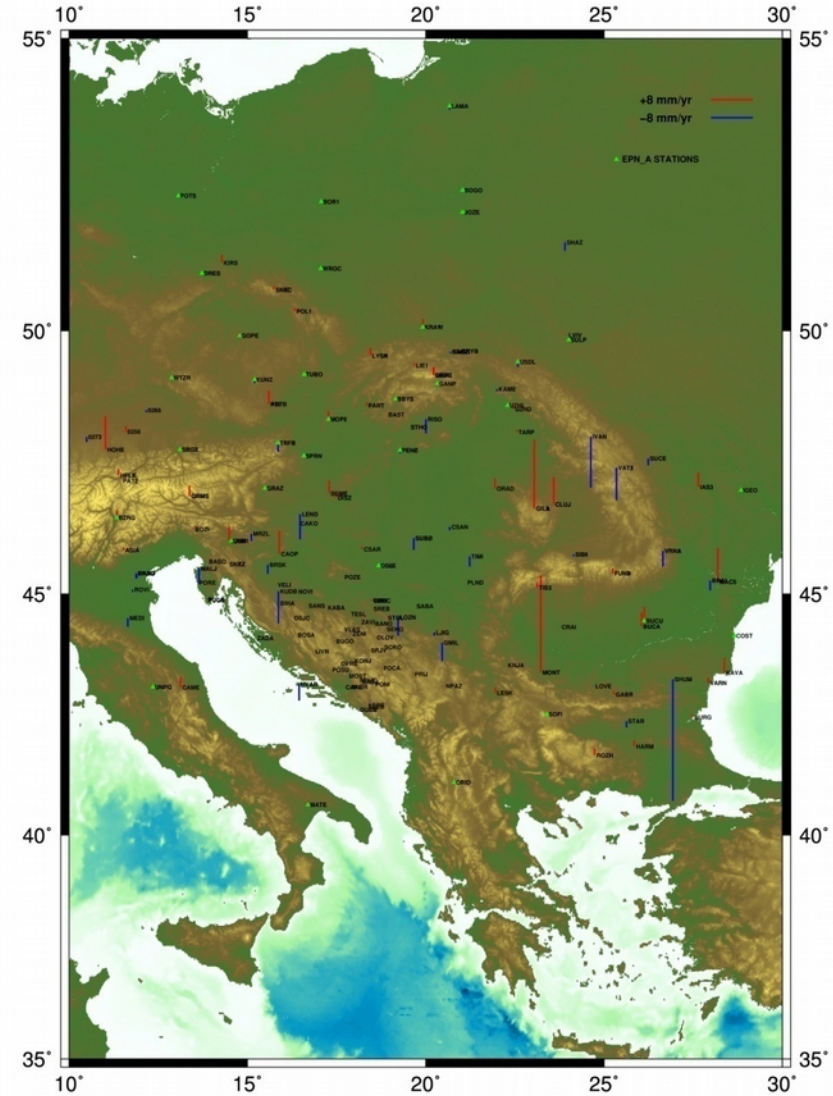
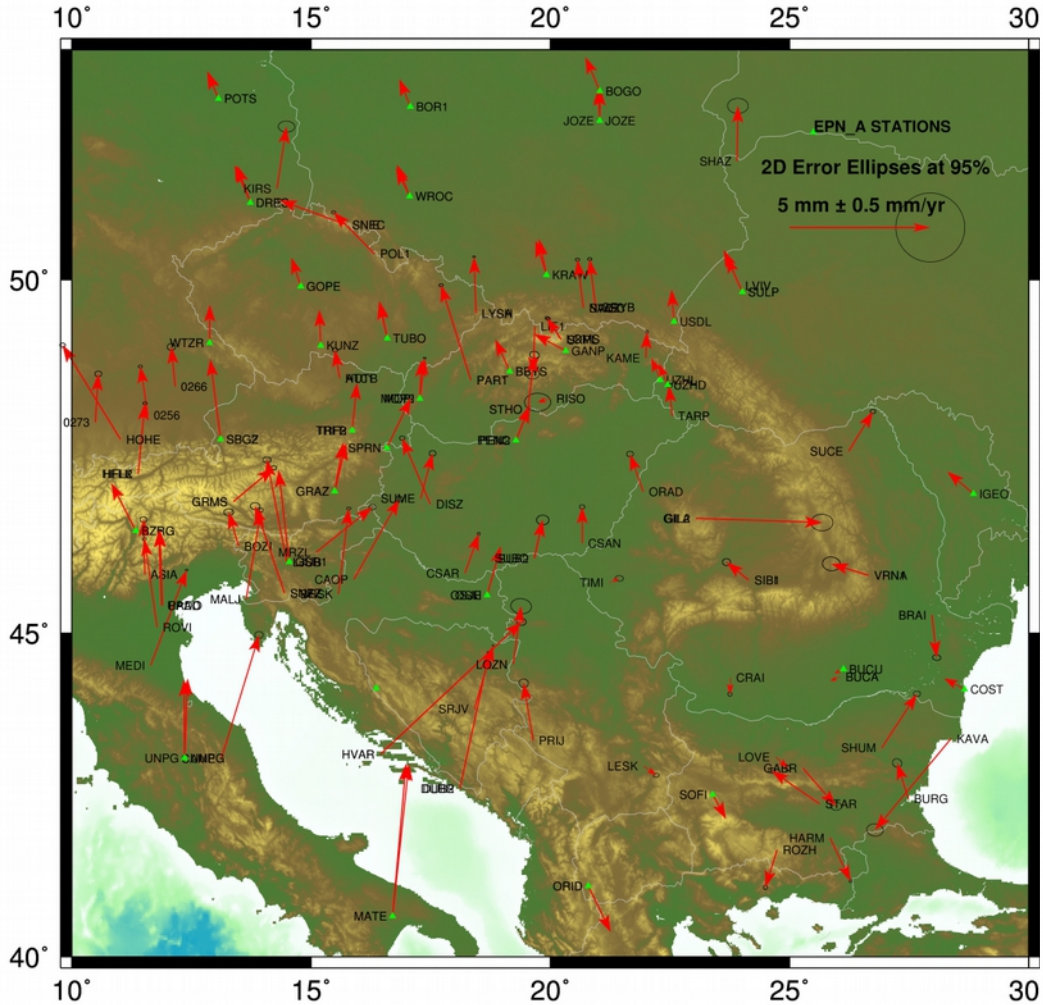


Vertical:  
NKG2005LU(ABS)  
Ågren&Svensson 2006

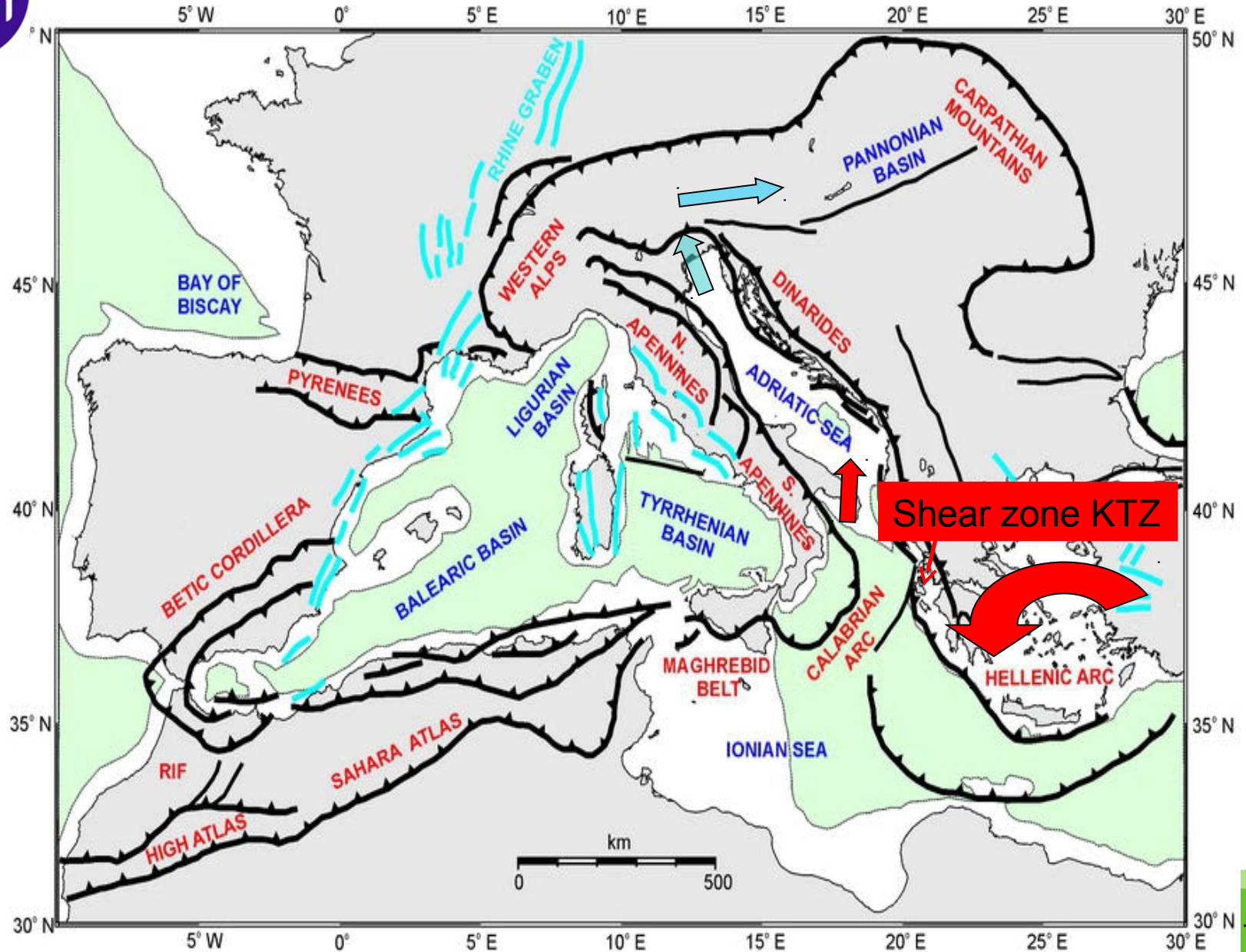




## Velocity Map ETRF2000



# Tectonic setting and expected kinematics



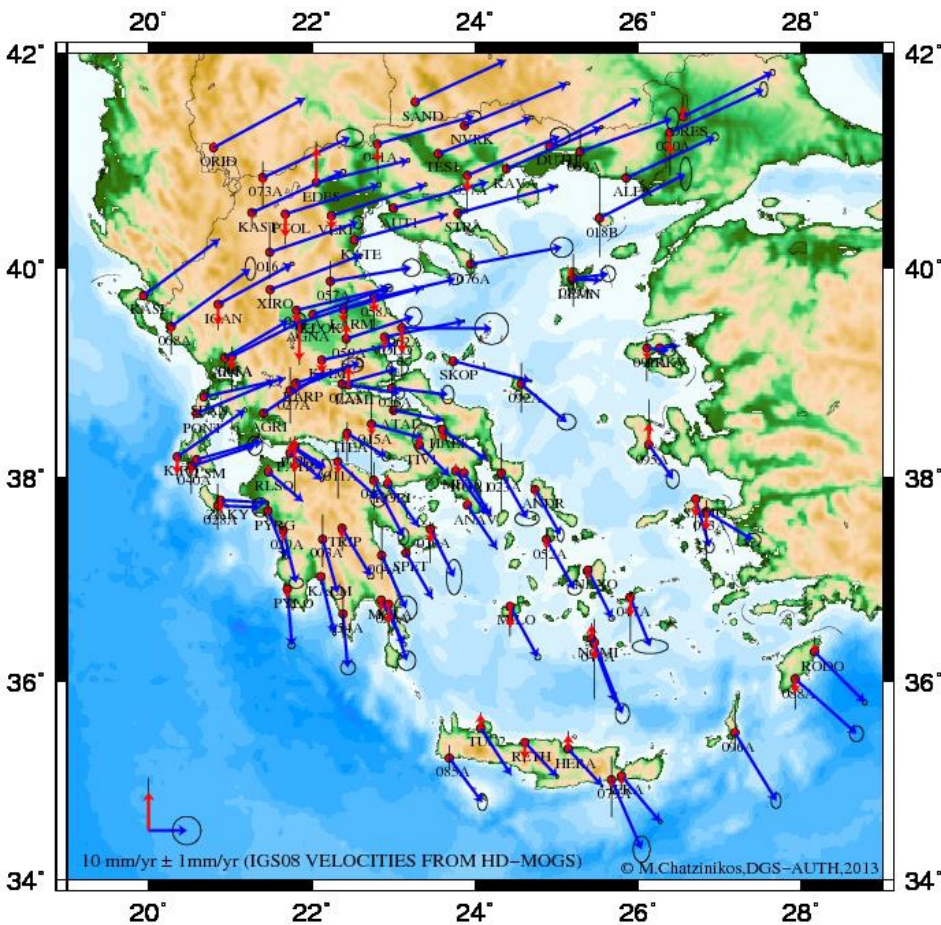




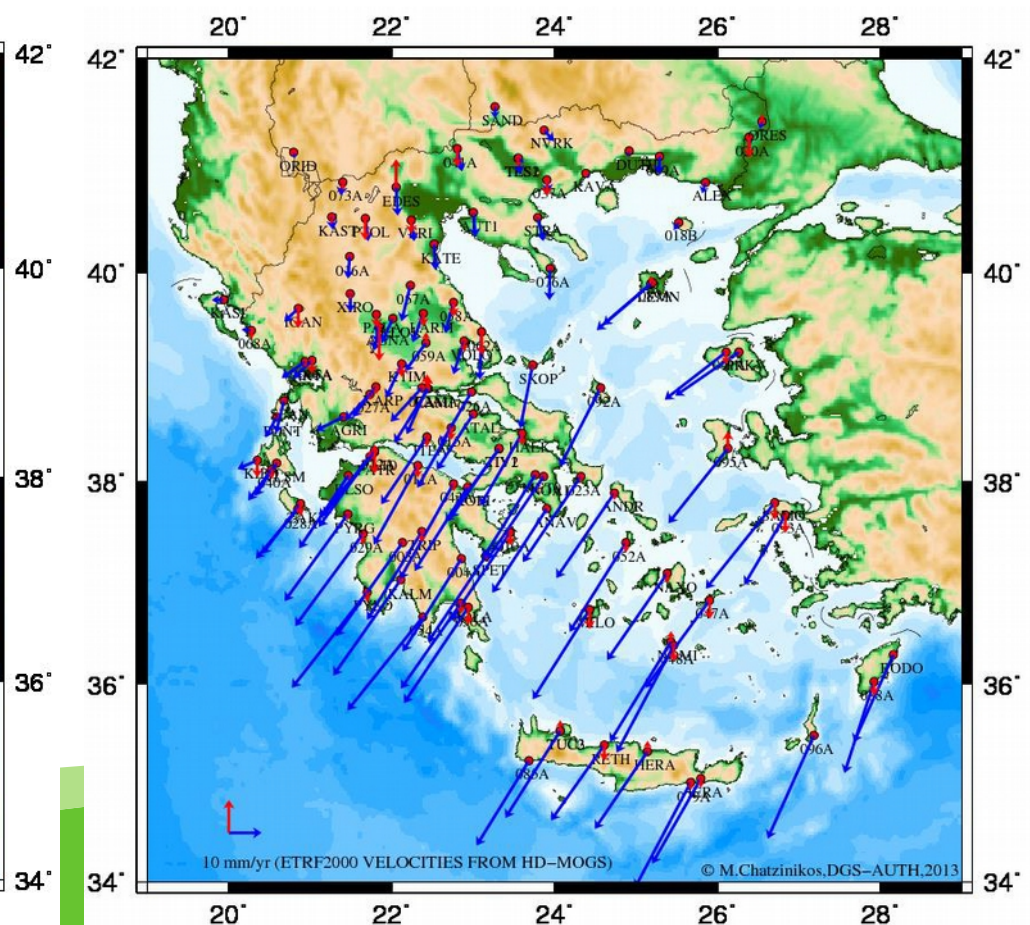
# Example from Greece (1)

(M. Chatzinikos, A. Fotiou, C. Pikridas and D. Rossikopoulos,  
EUREF Symposium Budapest 2013)

## IGS08 site velocities



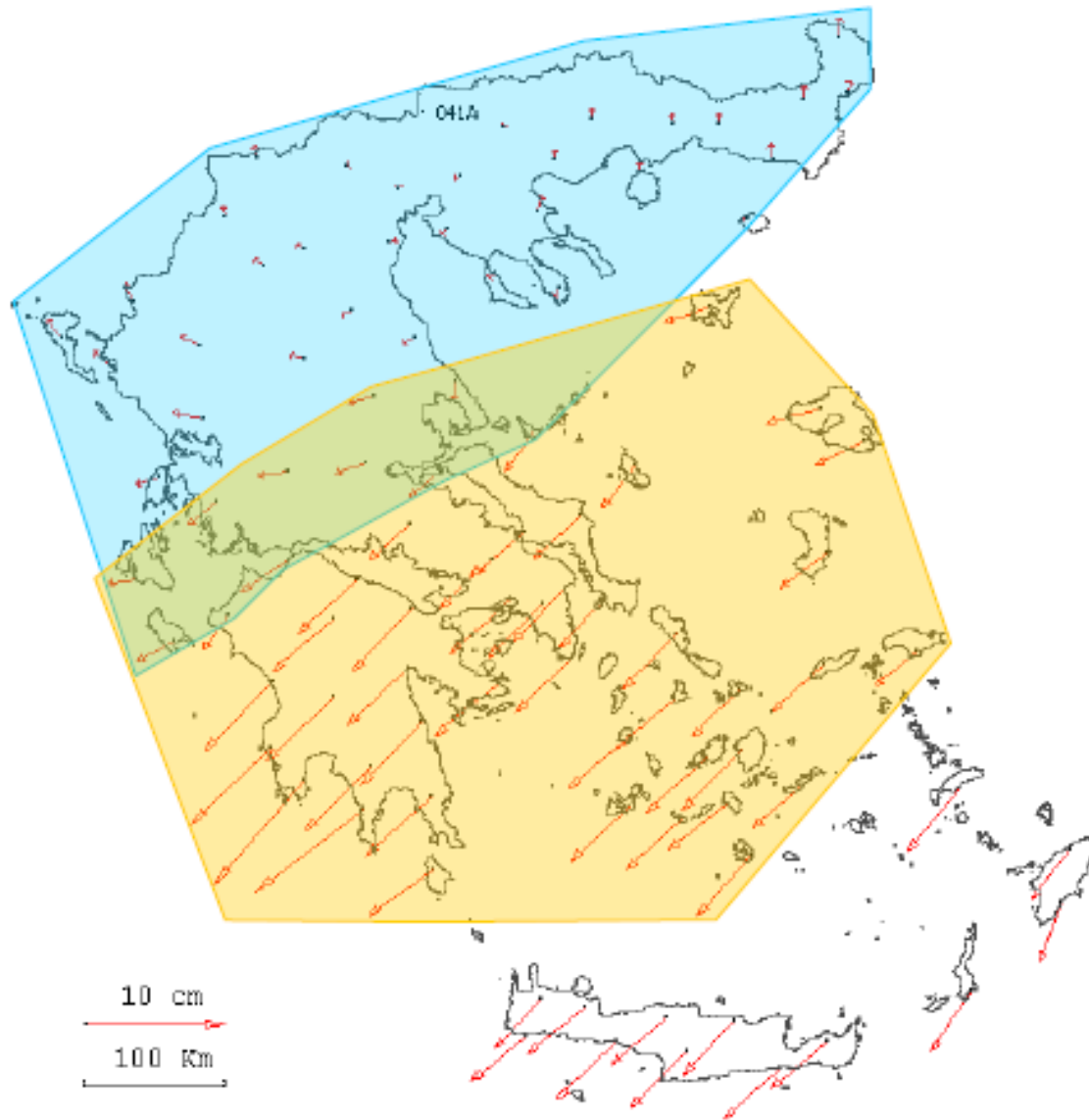
## Velocities in ETRF2000





## Example from Greece (2)

*(M. Gianniou, E. Mitropoulou, I. Stavropoulou, EUREF Symposium Budapest 2013)*



**Differential  
displacements of the  
HEPOS stations over  
two years(w.r.t. station  
041A, 11/2007 -11/2009)**  
*(Gianniou, 2010)*

*Implementation of 2 plate  
rotation models for use in  
RTK-services!*

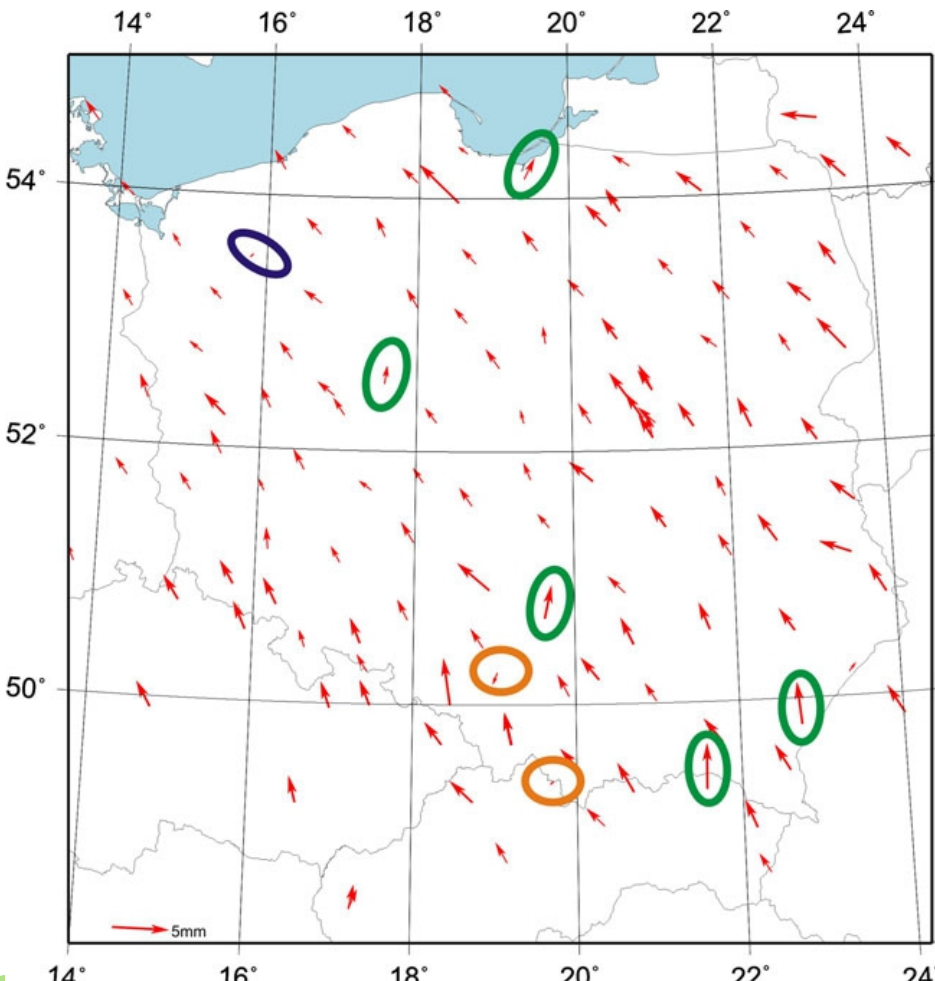




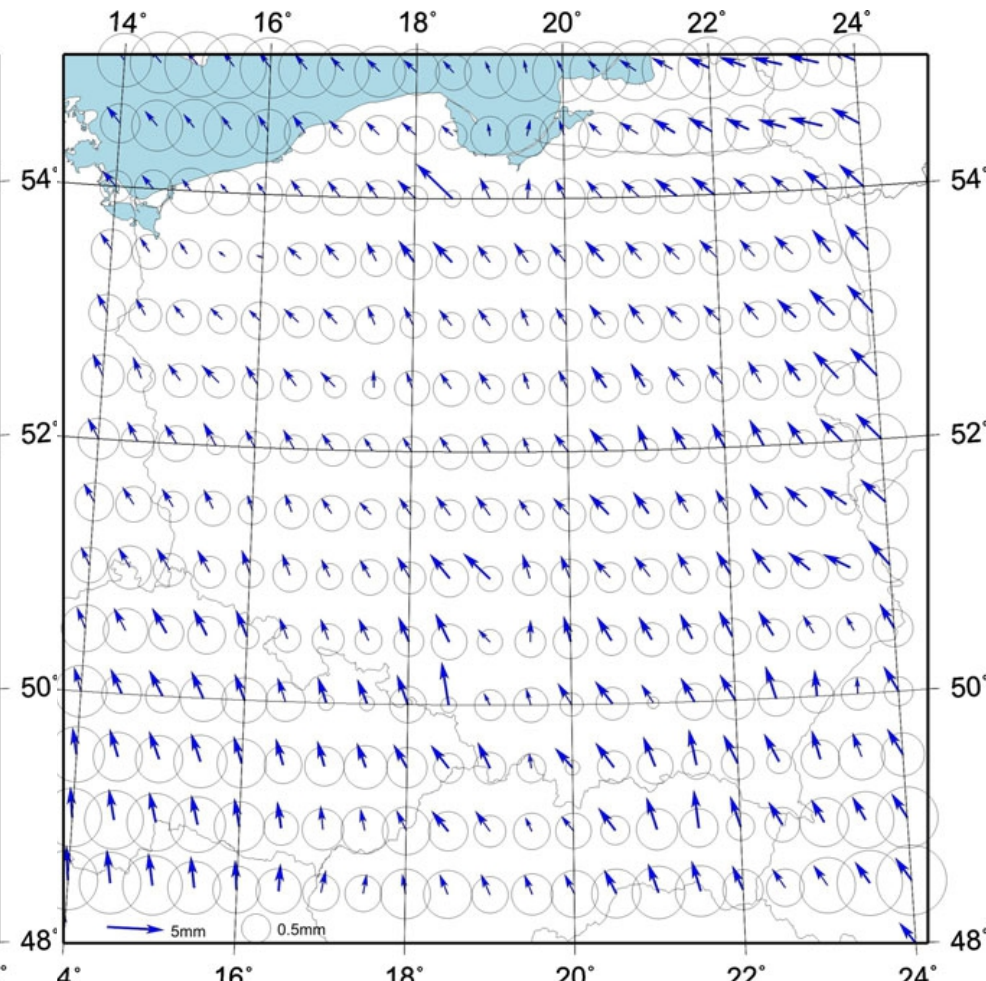
# Example from Poland on interpolation methods

(J Bogusz, A Kios, P Grzempowski, and B Kontny, Pure and Applied Geophysics, 2013)

Intraplate velocities of the ASG-EUPOS stations



Kriging with the linear variogram model, the interpolated values and the interpolation errors

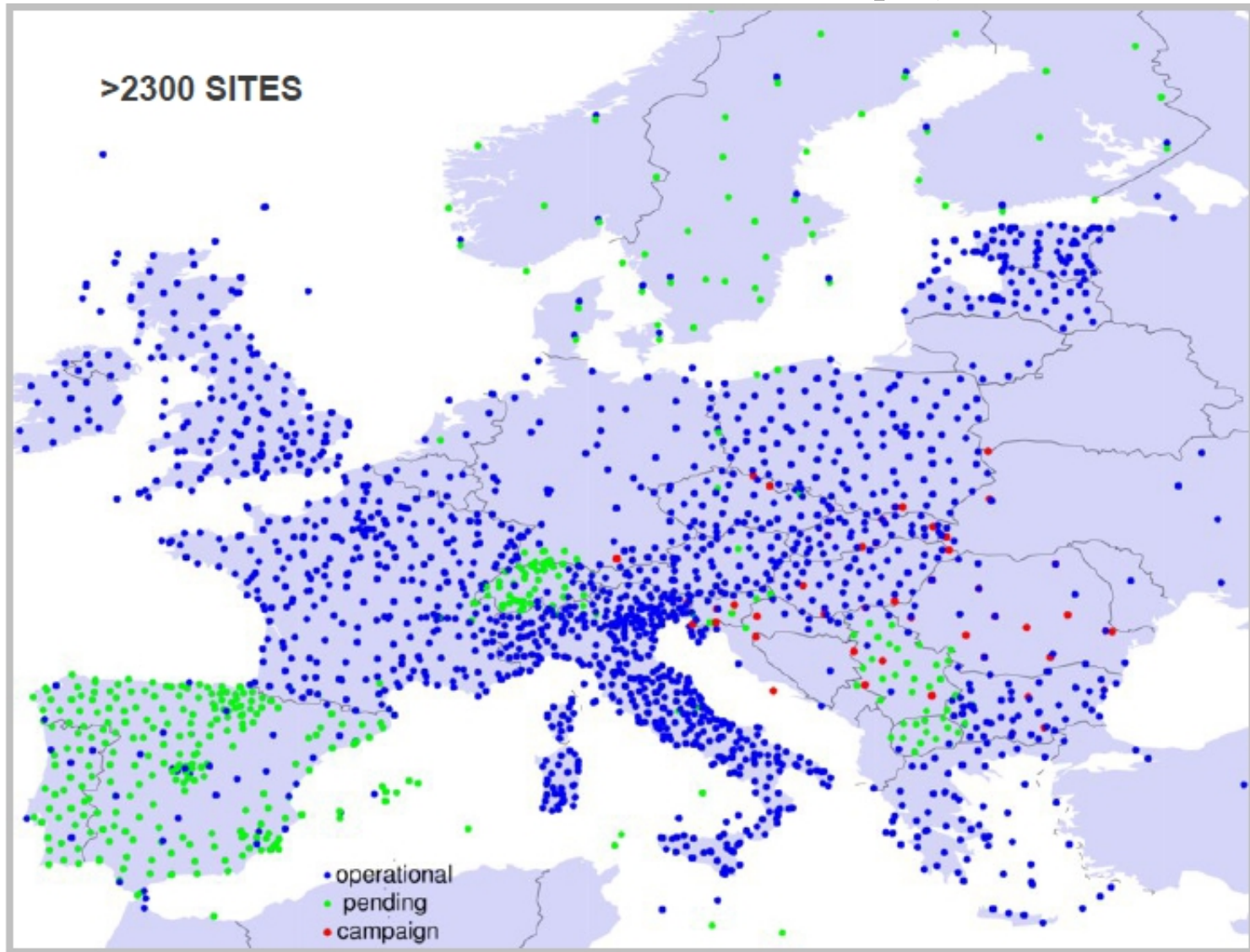








# The EPN Densification activity (status March 2013)



- The “Integration of dense velocity fields into the ITRF” (<http://iagvf.oma.be/>) activity will be completed to the IUGG 2015.
  - Then “evaluation of station velocities” should be done ([how well do the computed GNSS velocity represent the crustal deformation in the area](#))
- EPN-Repro2 have started some activities and will deliver improved station velocities of the EPN stations, possibly in 2015 (or 2014)?
  - But many activities in the updated roadmap do not need to be dependent on EPN-Repro2
- Continue with the inventory of work regarding crustal deformations in the EUREF area of interest

- Models are developed and used (e.g. Fennoscandia, Switzerland (developed –not used), Greece).
  - Would be of value to collect these models, and see how they could be used in the development of a European model of crustal deformations
  - May require some study on how to handle possible differences in reference frame between the models and ETRF2000
- Methods for interpolation and gridding would be needed probably. The Kriging/Collocation method seems promising!
- Consideration of a deformation model in maintenance and use of national realizations of ETRS89



## Summary and outlook

The EPN alone are not enough to get the complete picture of crustal deformations within the geographical scope of EUREF

“WG on deformation models” will rely on results from the EPN densification activity. So please contribute with your dense GNSS network solutions! (contact to EUREF / Ambrus Kenyeres)

“WG on deformation models” are aiming for a high resolution velocity field model for Europe and adjacent areas, **together with uncertainty estimates**. The model should preferably be geophysical meaningful.

The fulfilment of the objectives of this w.g. will benefit from a successful implementation and operation of EPOS.

Most important are contributions from scientists working on this topic, so when You are interested, please join the w.g.!!