

Mapping functions for atmospheric delay modelling in GNSS analysis

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Contents

- Mapping functions for the neutral atmosphere
(main focus on hydrostatic part)
- Terrestrial reference frame and scale
- Precision
- Availability
- Recommendations

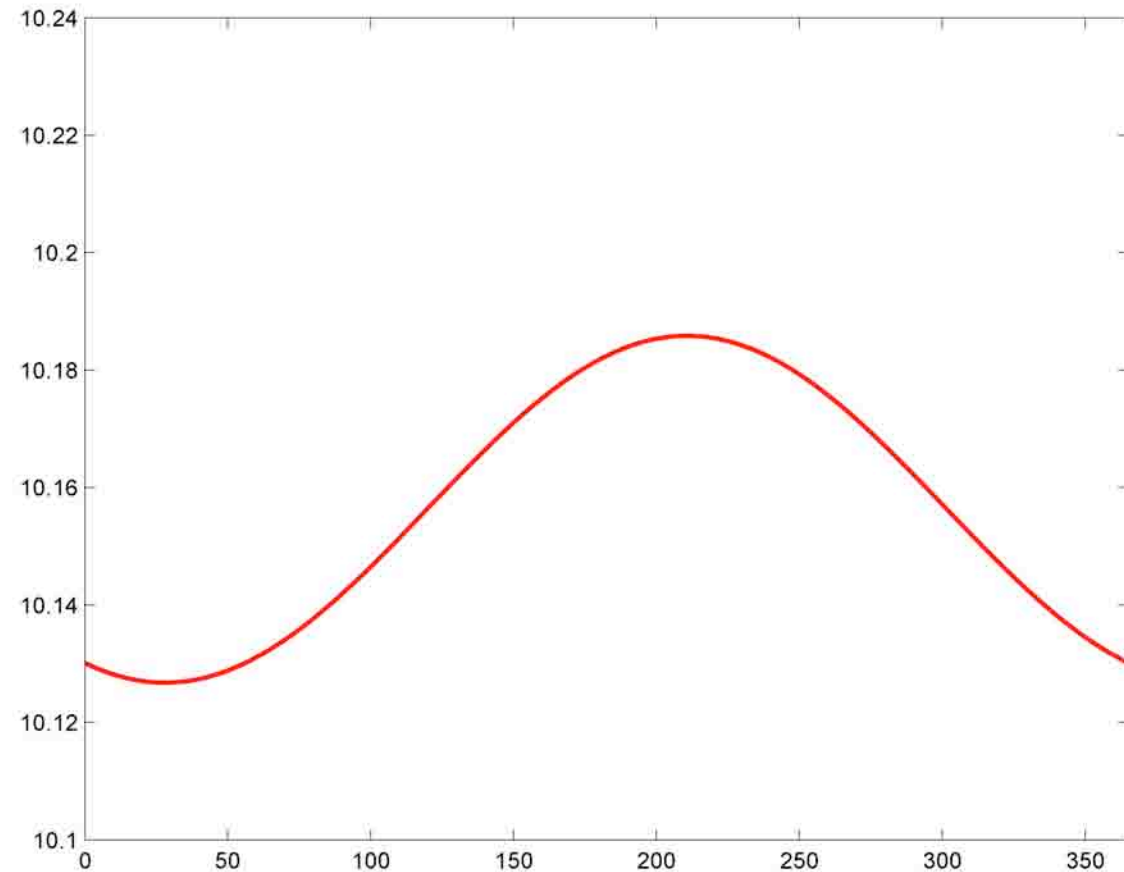
Niell Mapping Functions NMF

NMF

Niell (1996)

empirical mf (doy, φ)

symmetric wrt equator



hydr. mf at 5° at O'Higgins in 2005

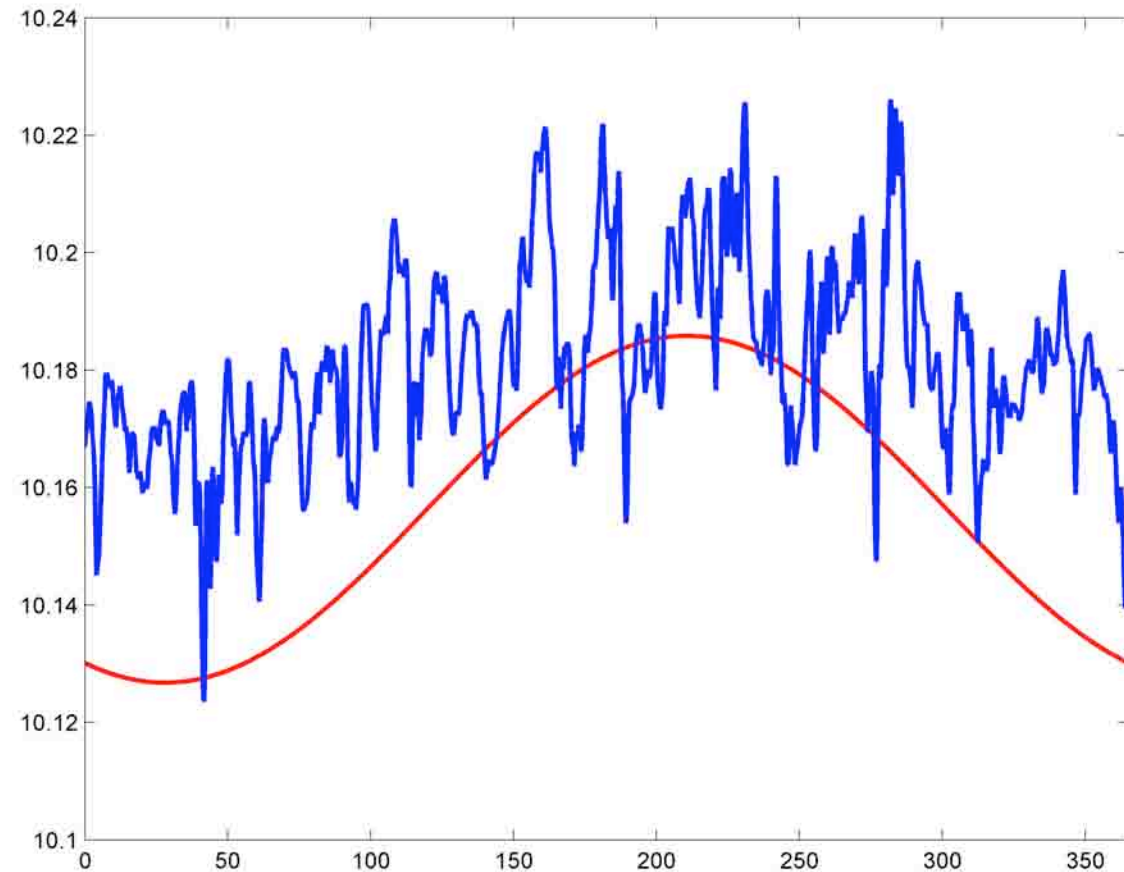
Isobaric Mapping Functions IMF

IMF

Niell (2001)

NWM-based mf
(z200, smfw3)

provided on a grid



hydr. mf at 5° at O'Higgins in 2005

NMF

Vienna Mapping Functions 1 VMF1

VMF1

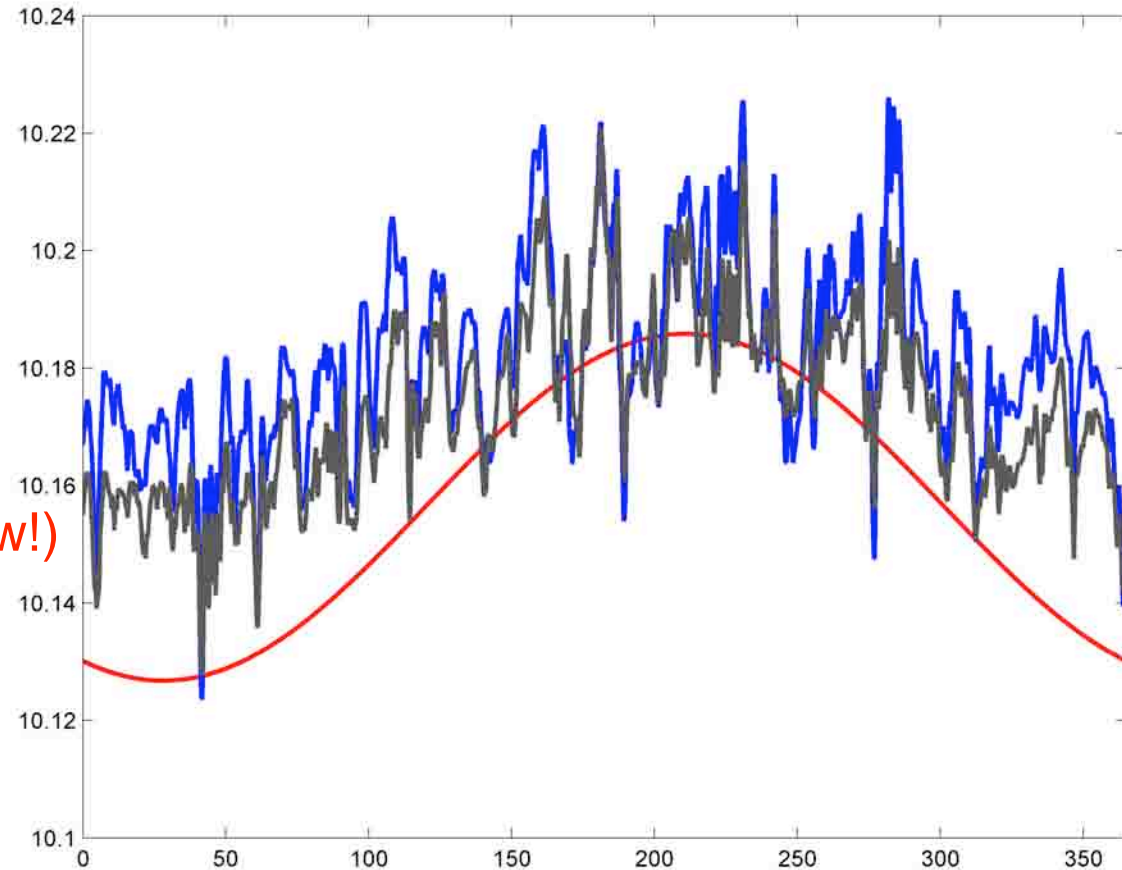
Boehm et al. (2006a)

NWM-based mf
(raytrace at 3°)

provided at sites

and on a grid (new!)

new b and c coefficients



IMF

NMF

hydr. mf at 5° at O'Higgins in 2005

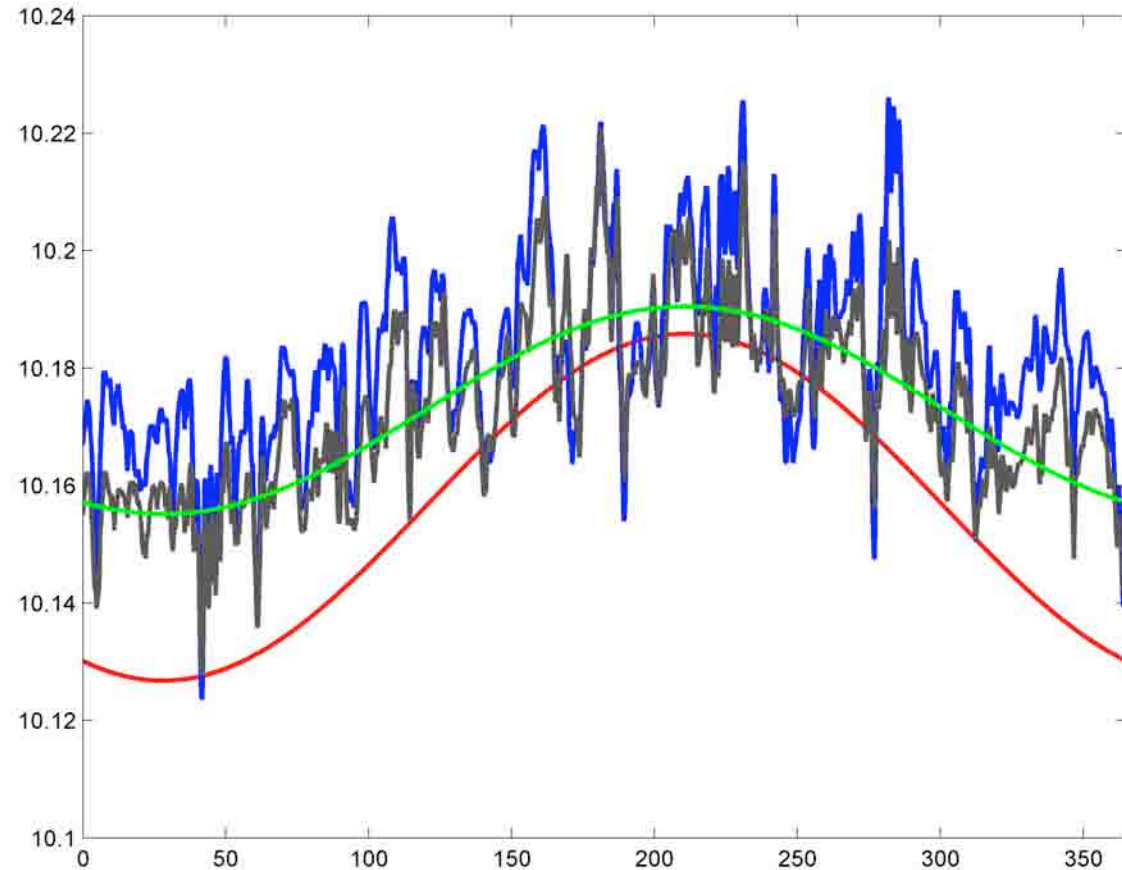
Global Mapping Functions GMF

GMF

Boehm et al. (2006b)

'averaged' VMF1

spherical harmonics (9/9)



VMF1

IMF

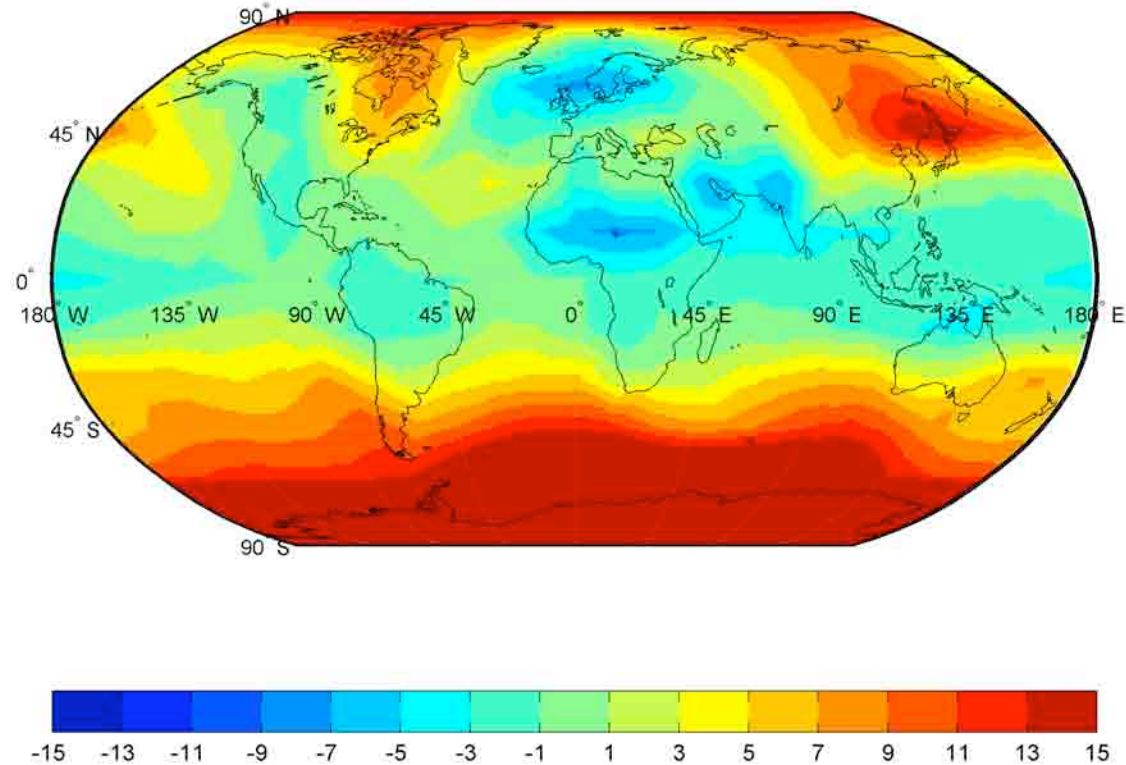
NMF

hydr. mf at 5° at O'Higgins in 2005

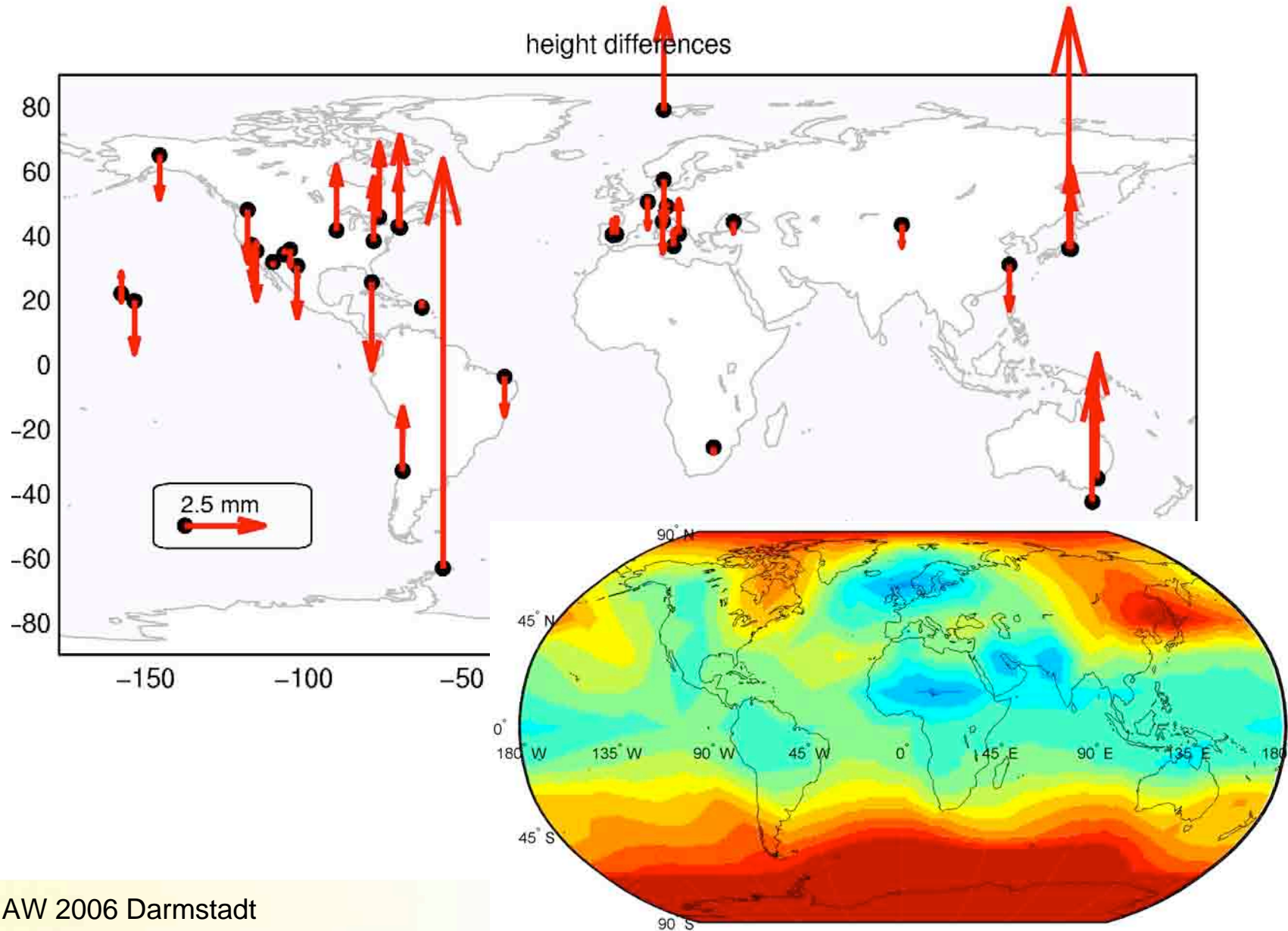
Terrestrial reference frame and scale

- Predicted station height changes for 15° x 15° ECMWF re-analysis data (rule of thumb)
- VLBI station height changes from VLBI global solutions (1984-2005)
 - 5° cutoff elevation angle
 - no down-weighting of low observations
 - 49 radio telescopes
- GPS station height changes (June 2004 - July 2005)
 - GAMIT/GLOBK
 - 7° cutoff, no downweighting

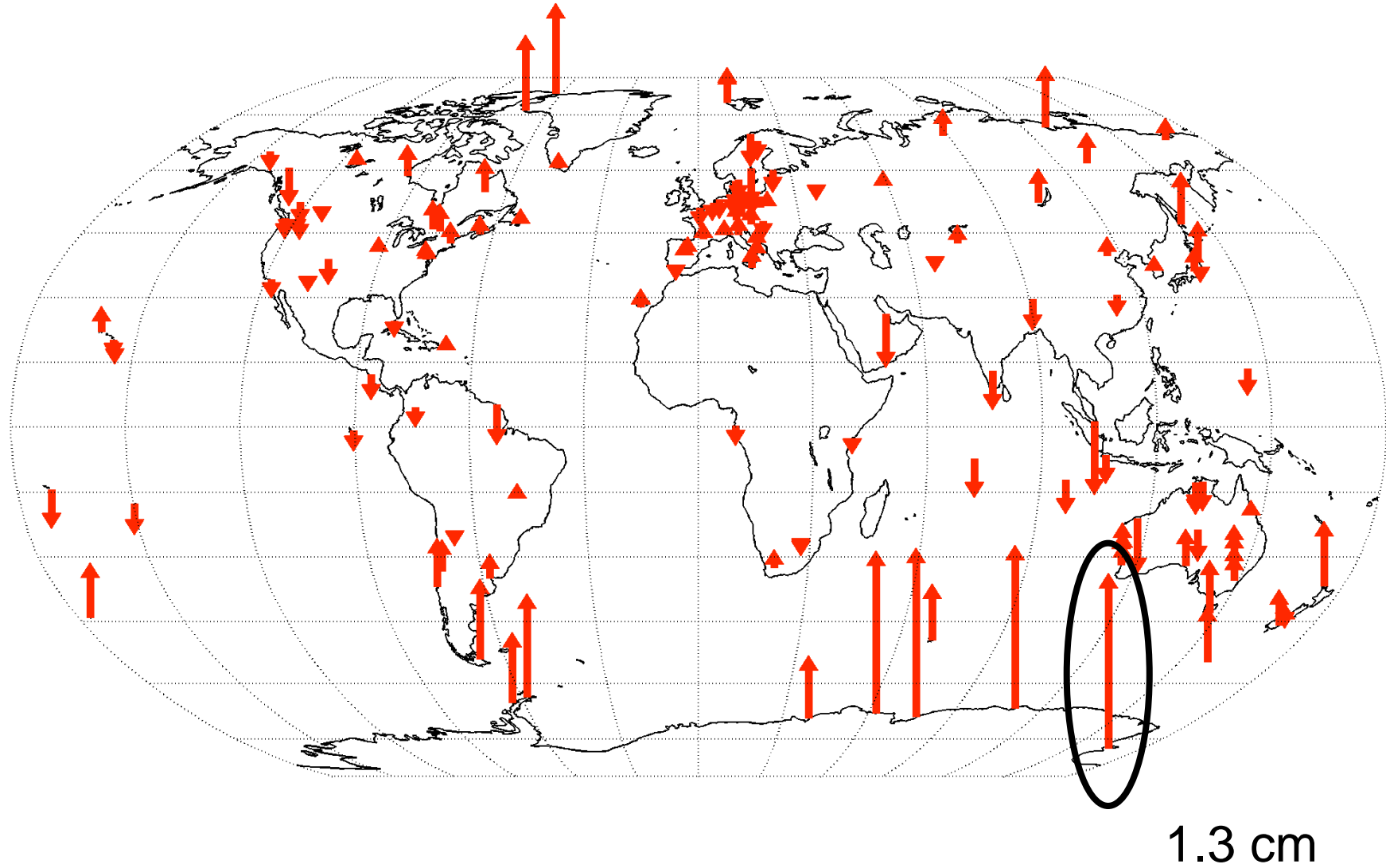
Predicted 15° x 15° VMF1 - NMF heights in mm



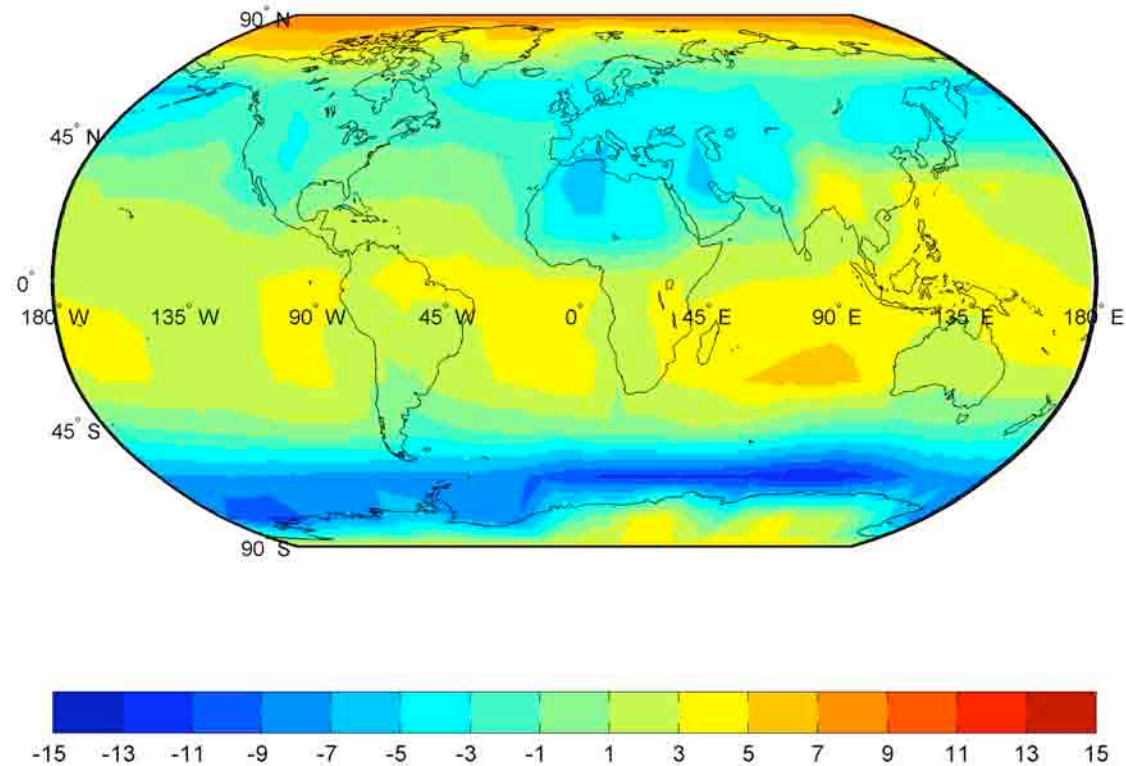
VLBI VMF1 - NMF heights



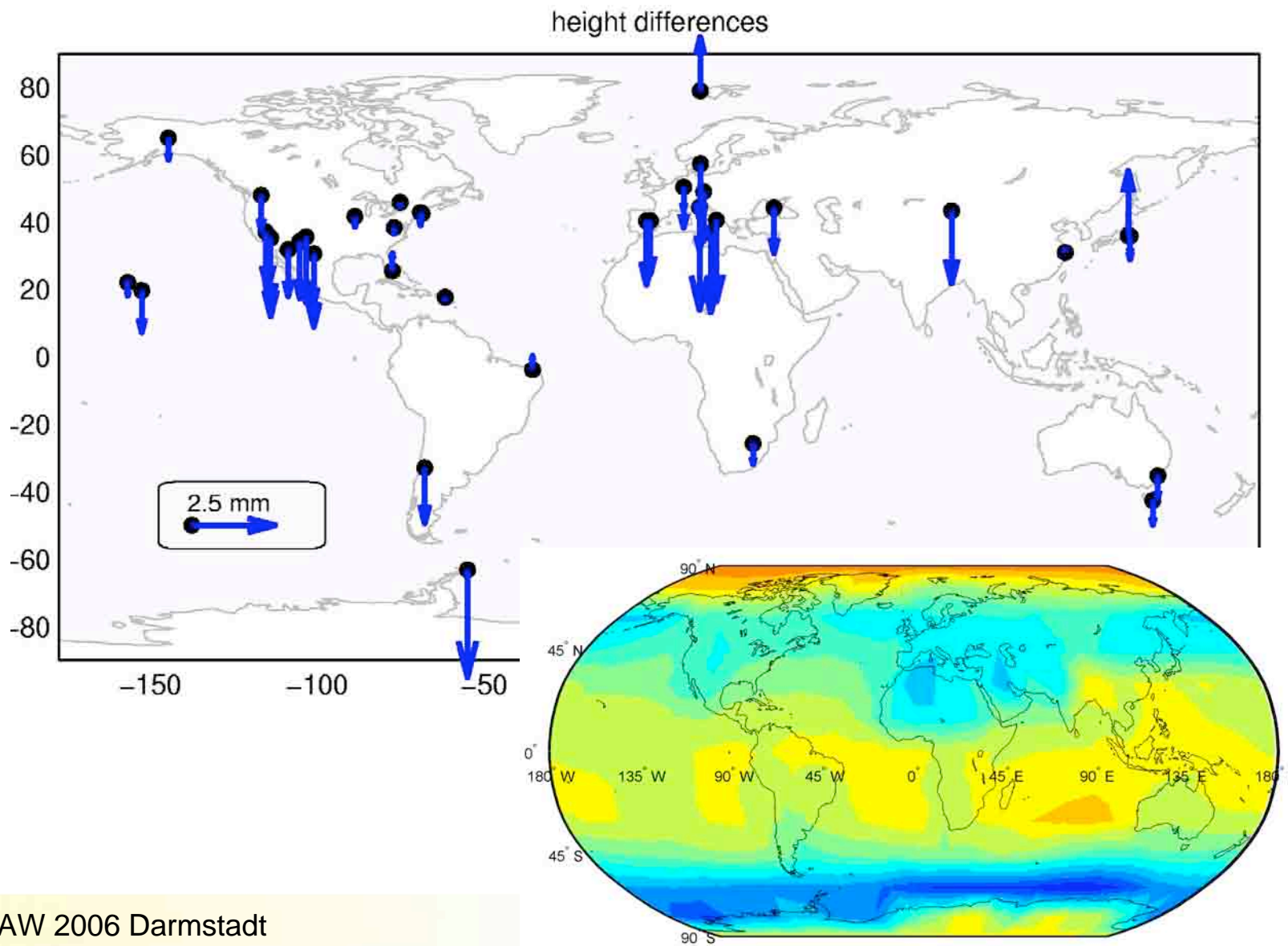
GPS VMF1 - NMF heights



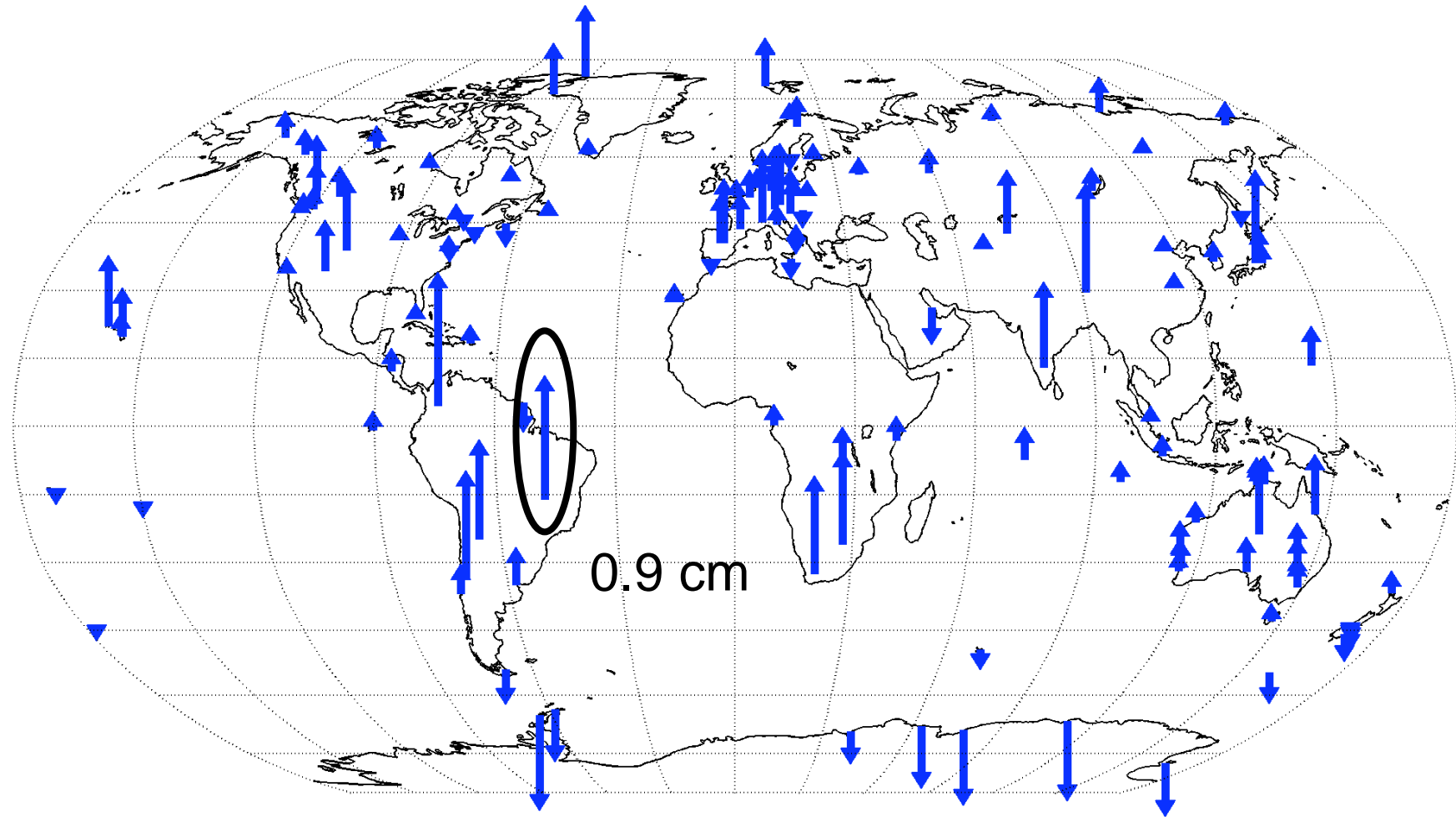
Predicted 15° x 15° VMF1 - IMF heights in mm



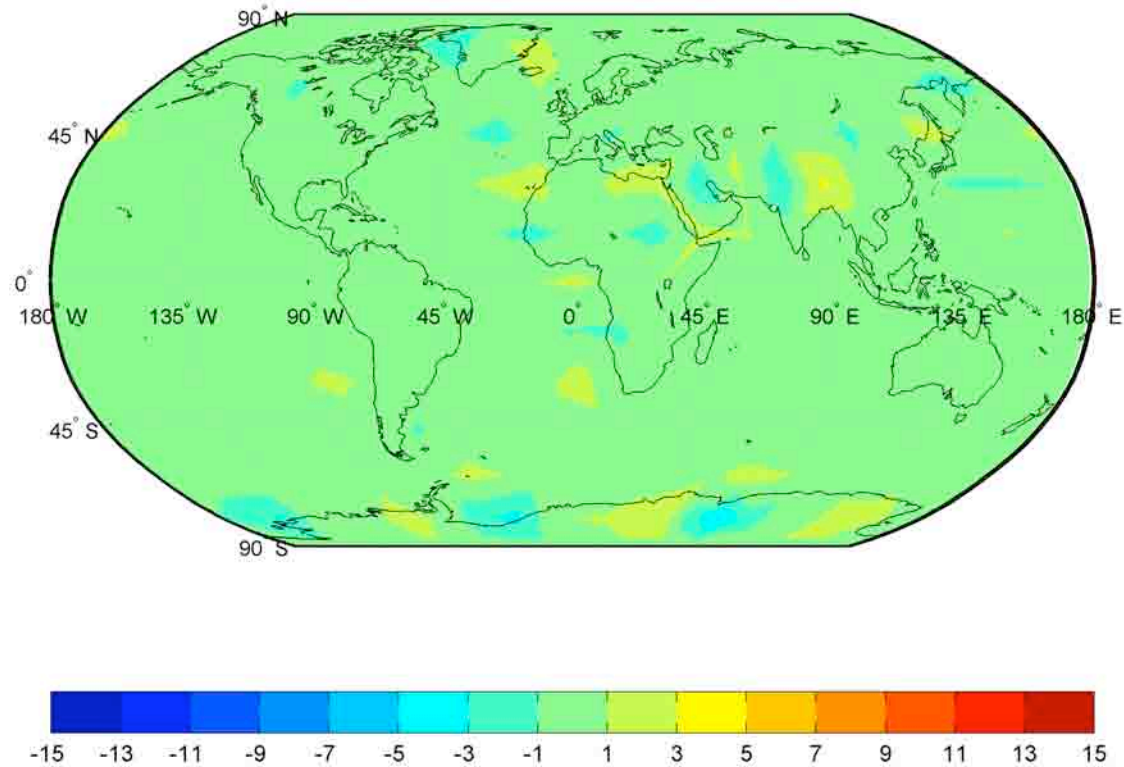
VLBI VMF1 - IMF heights



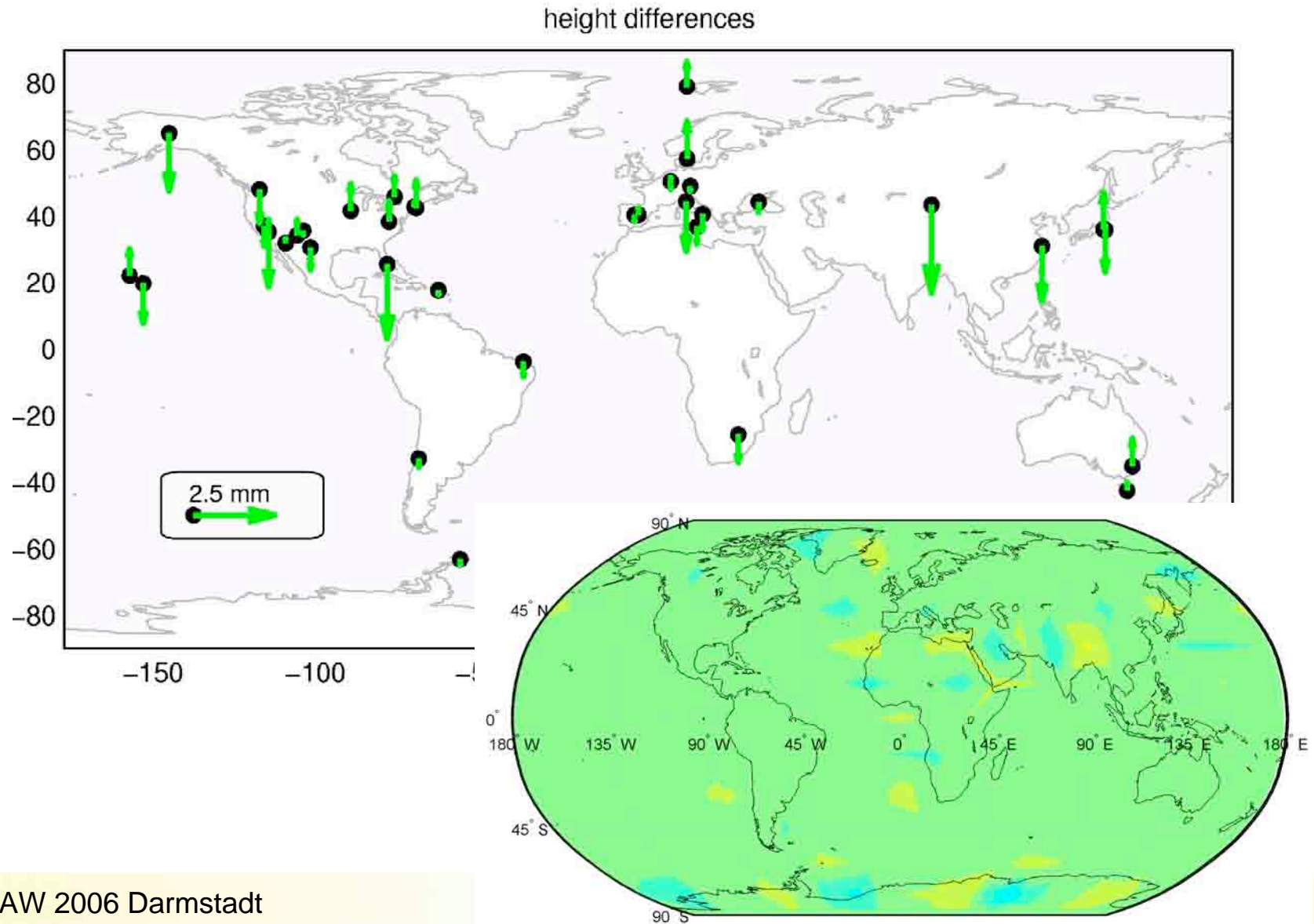
GPS VMF1 - IMF heights



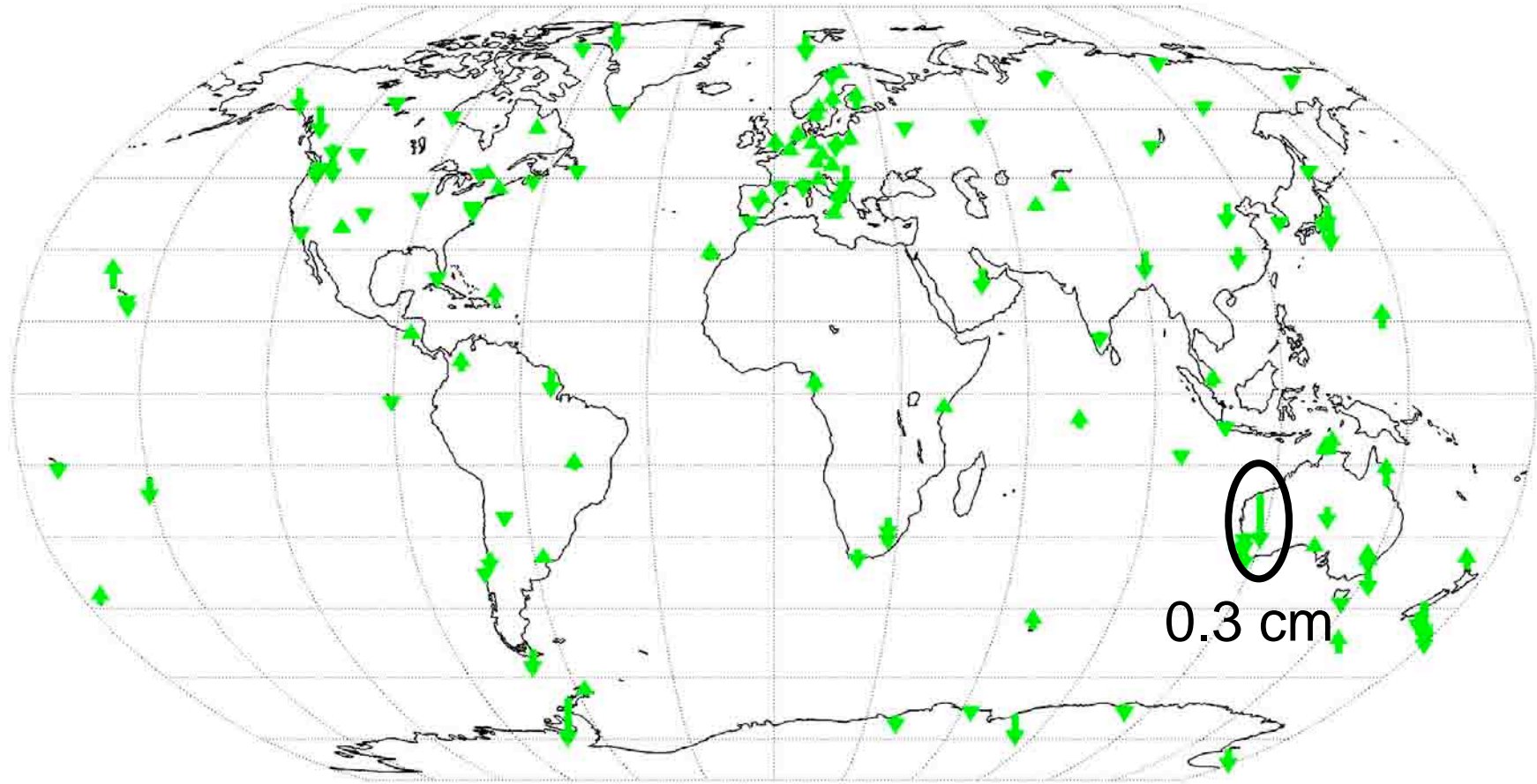
Predicted 15° x 15° VMF1 - GMF heights in mm



VLBI VMF1 - GMF heights



GPS VMF1 - GMF heights



VLBI Scale

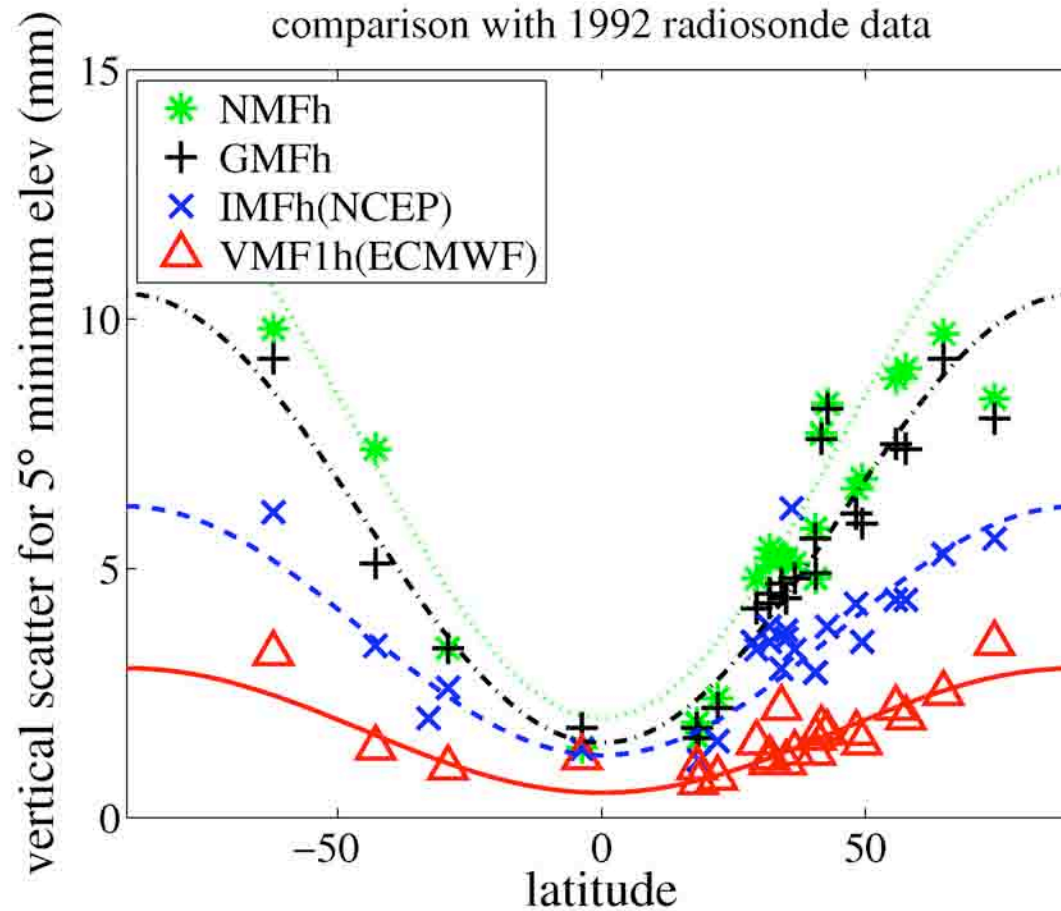
Scale differences for TRF computed with data from 1984 to 2005
(transformed on all stations, weighted)

VMF1 - NMF	0.05 ± 0.02 [ppb]	(0.03 cm)
VMF1 - IMF	-0.20 ± 0.01 [ppb]	(-0.13 cm)
VMF1 - GMF	-0.02 ± 0.01 [ppb]	(-0.01 cm)

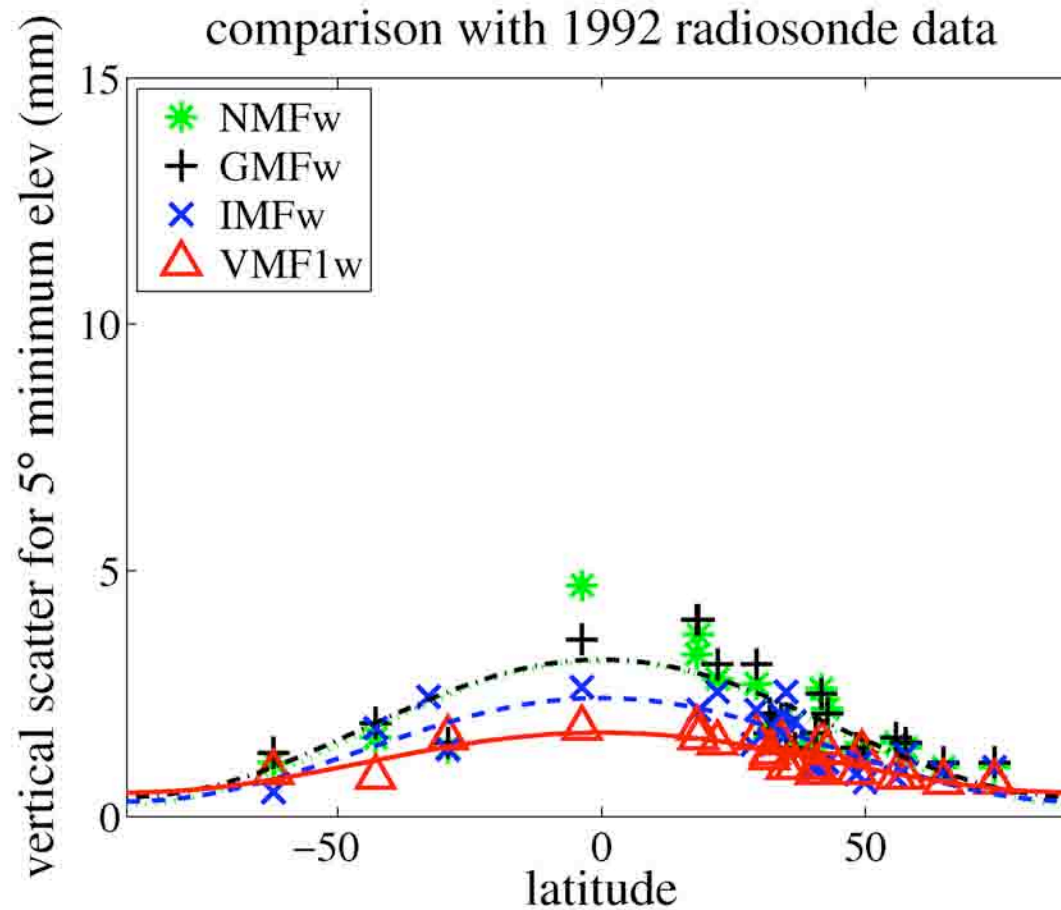
Precision of mapping functions

- Comparison with radiosonde data in 1992
- Repeatability of station coordinate time series of VLBI global solutions (1984-2005) after removing annual signals

Height standard deviations (hydrostatic)

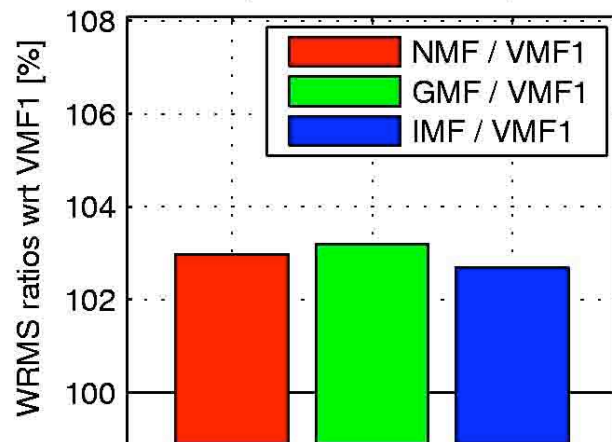


Height standard deviations (wet)

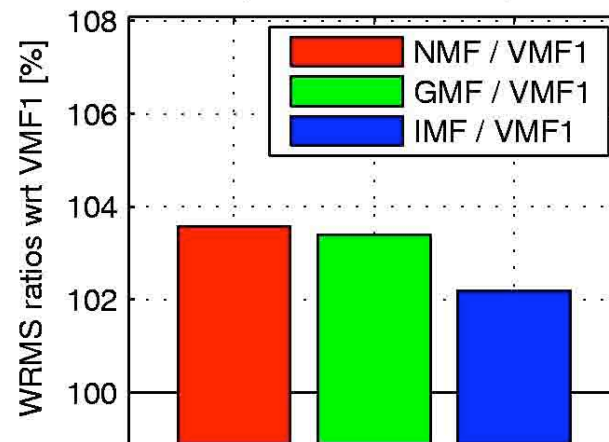


WRMS of station coordinate time series

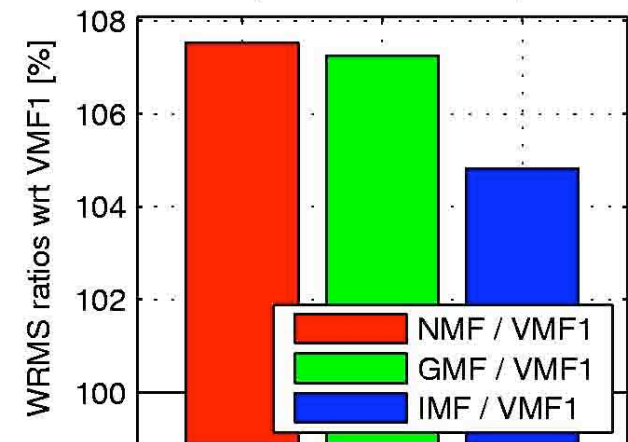
latitude WRMS repeatability
(VMF1: 2.7 mm)



longitude WRMS repeatability
(VMF1: 2.6 mm)



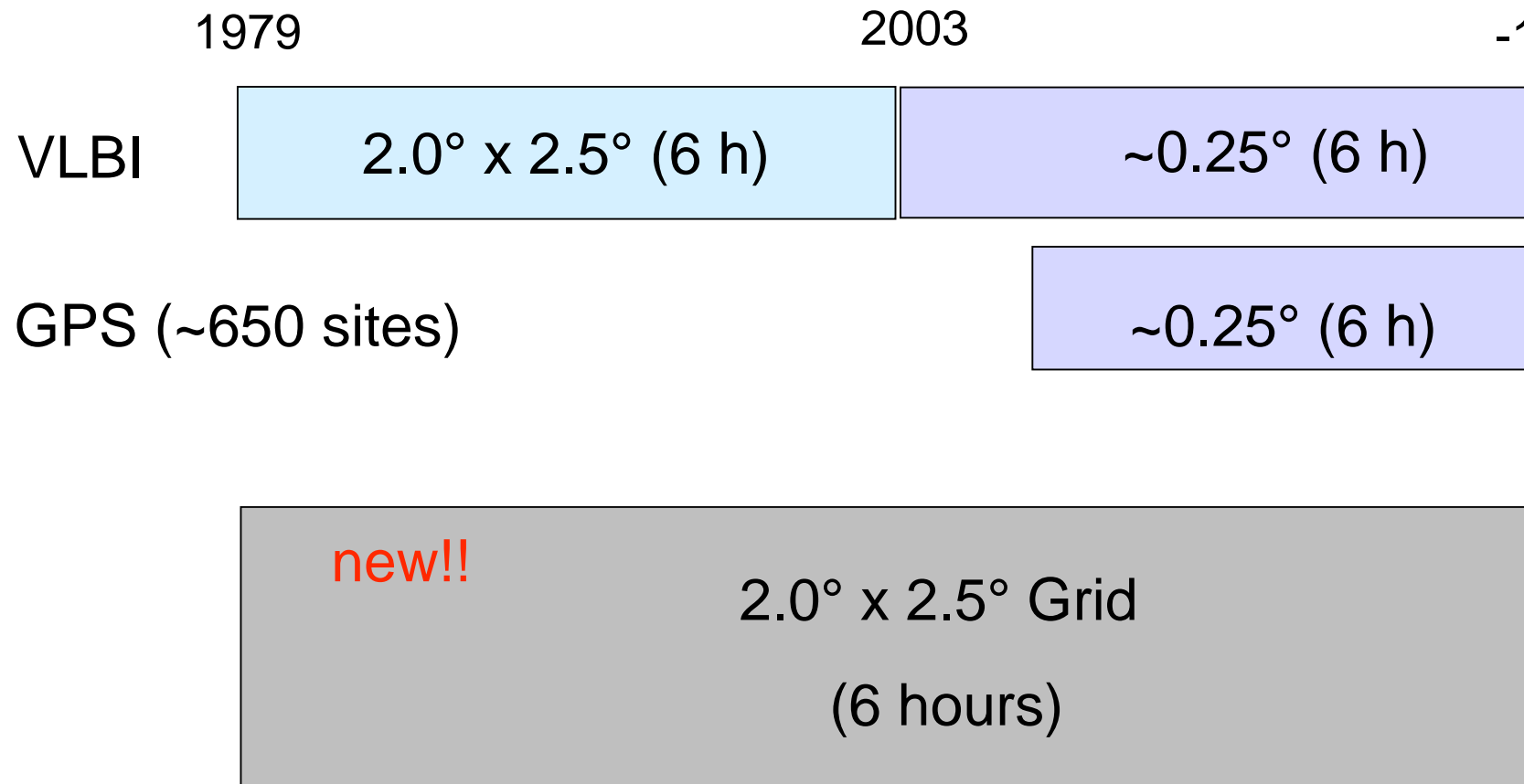
height WRMS repeatability
(VMF1: 4.9 mm)



Availability

- GMF is an empirical mapping function using latitude, longitude, height, and day of year
- IMF is provided on a global grid
 - at www.hg.tuwien.ac.at/~ecmwf we provide IMF on a global $2.0^\circ \times 2.5^\circ$ grid determined from data of the ECMWF with 6 hour time resolution
 - at ... ?

Availability of VMF1



www.hg.tuwien.ac.at/~ecmwf1

Recommendations

✓ Reference Frame:

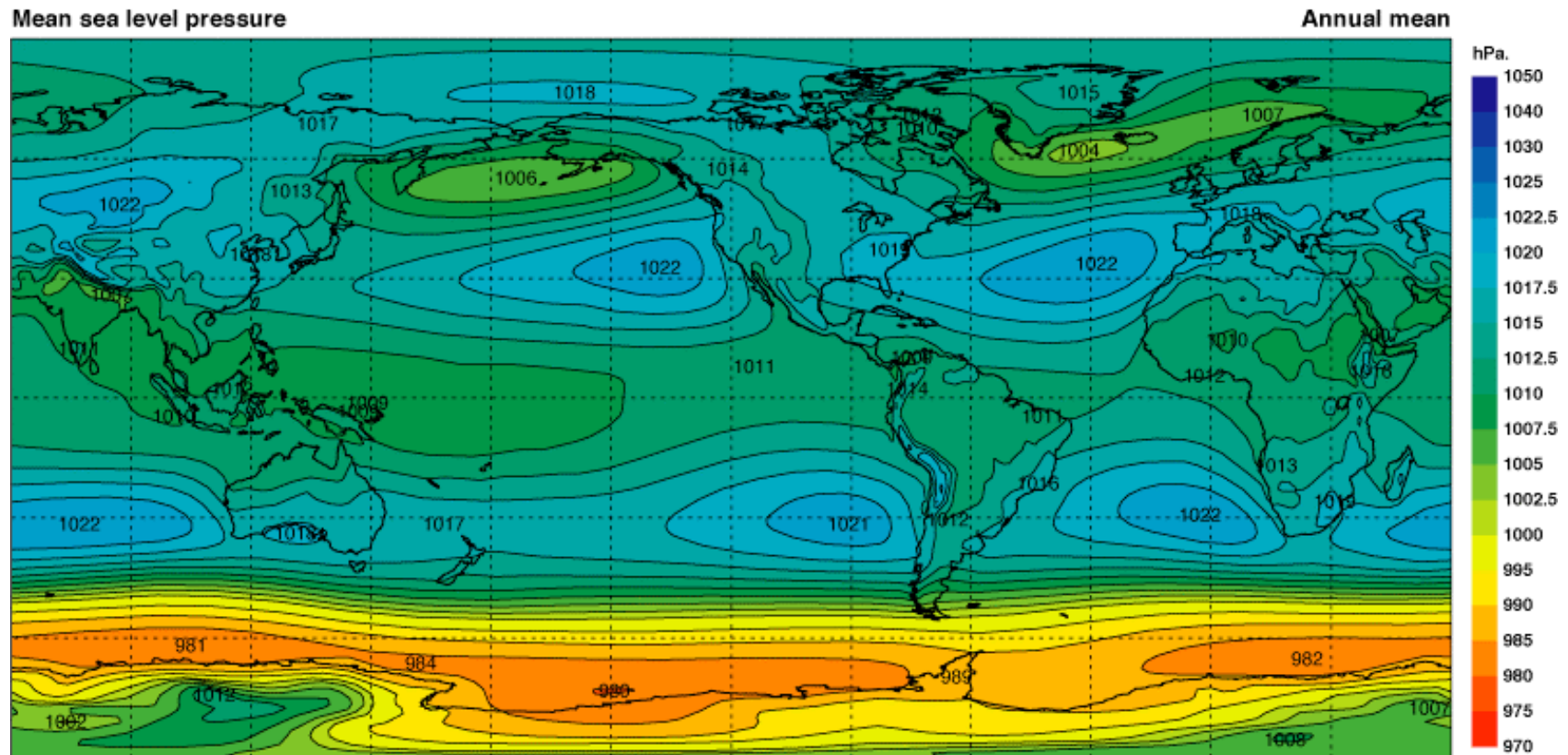
- use VMF1
- or use GMF which is consistent with VMF1
 - especially with cutoff angles of 10° (or higher) or down-weighting of low elevations

✓ Geophysical Studies:

- use VMF1
- or other (regional) mapping functions based on NWM

Recommendations

- use hydrostatic (and wet) zenith delays which are provided together with VMF1 (site and grid)



20 hPa → 5 mm height change



Thanks for your attention !

References:

Niell A (1996) Global Mapping Functions for the Atmosphere Delay at Radio Wavelength. Journal of Geoph. Research 101(B2), pp 3227-3246

Niell A (2001) Preliminary Evaluation of Atmospheric Mapping Functions Based on Numerical Weather Models. Phys. Chem. Earth 26 No. 6-8, pp 476-480

Boehm J, B Werl, H Schuh (2006a) Troposphere mapping functions for GPS and very long baseline interferometry from European Centre for Medium-Range Weather Forecasts operational analysis data. Journal of Geophysical Research 111 B02406 DOI: 10.1029/2005JB003629

Boehm J, A Niell, P Tregoning, H Schuh (2006b) The Global Mapping Function (GMF): A new empirical mapping function based on data from numerical weather model data. Geophysical Research Letters 33 L07304 DOI:10.129/2005GL025546