A priori gradients in the analysis of GPS and VLBI observations

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Troposphere Gradients in IERS Conventions

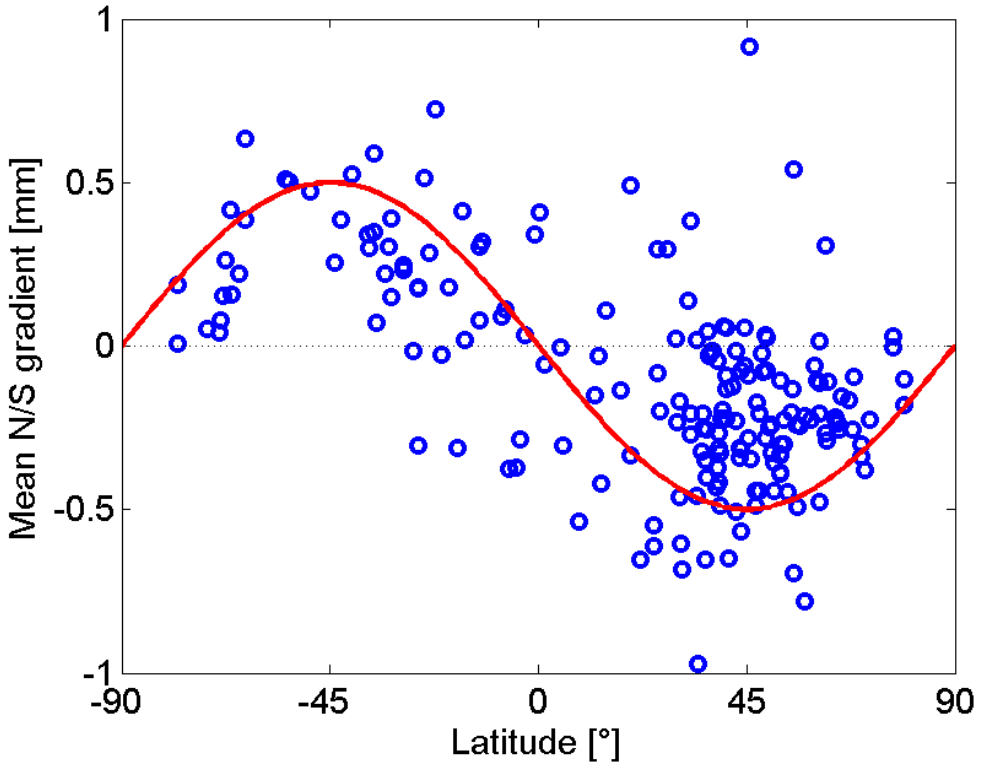
$$D_L = m_h(e)\cdot D_{hz} + m_w(e)\cdot D_{wz} +$$

$$m_g(e)\cdot\left[G_N\cdot\cos(a) + G_E\cdot\sin(a)\right]$$

$m_{h,w}$	hydrostatic, wet mapping function
$D_{hz,wz}$	hydrostatic, wet zenith delay
m_g	gradient mapping function
$G_{N,E}$	north, east gradients
a	azimuth

Hydrostatic Troposphere Gradient Model

- Troposphere gradients in N/S direction show a latitude-dependent pattern.

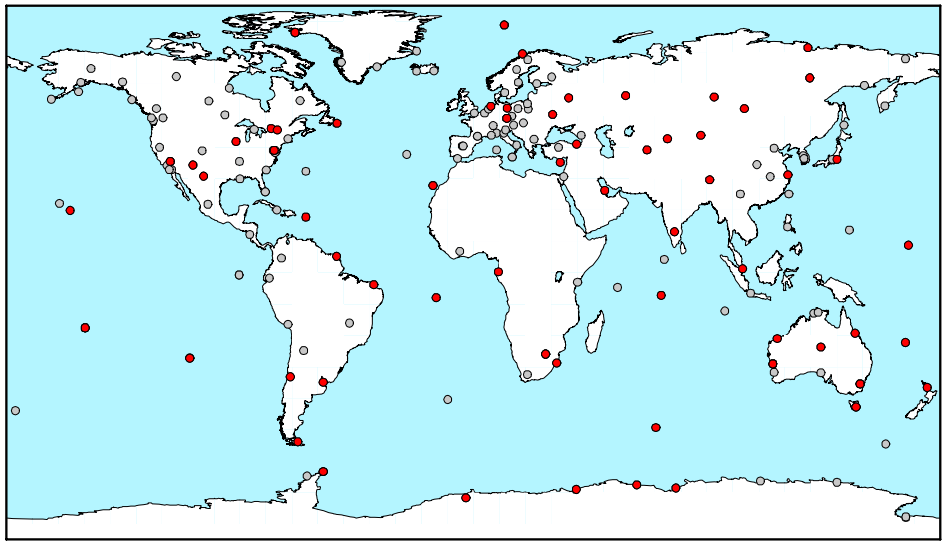


Mean N/S gradients from 12 years of GPS data

Simple latitude-dependent gradient model:

$$N_h = -0.5 \sin(2\lambda)$$

Global GPS Solutions (1)



- Global GPS network of 202 stations
- 1-day solutions for January 1994 – October 2005
- no-net-rotation condition of up to 98 stations w.r.t. IGb00

- Complete and homogeneous reprocessing with Bernese GPS Software by GFZ Potsdam and TU Dresden
- Pre-processing identical, final parameter estimation step repeated with different handling of troposphere gradients

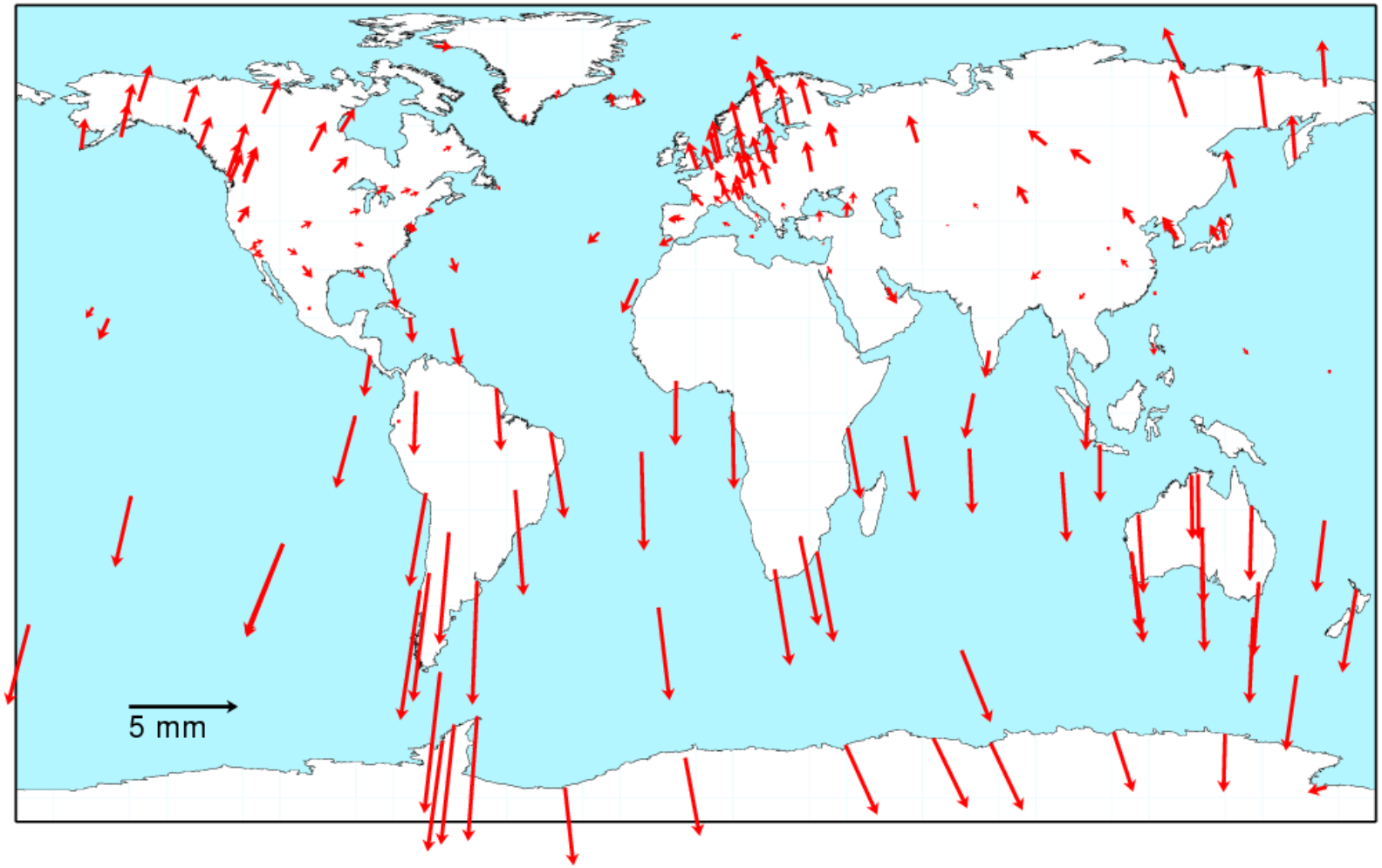
Global GPS Solutions (2)

- Hydrostatic gradients mapped with GMFh
- Wet gradients mapped with GMFw
- Wet gradients are determined as piecewise linear functions with 24 hours parameter spacing (no constraints)

Solution	hydr. gradients	wet gradients	Time period
grdEST	—	✓	12 years
grdNO	—	—	1 year (2004)
grdMOD	✓	—	1 year (2004)
grdAPR	✓	✓	12 years

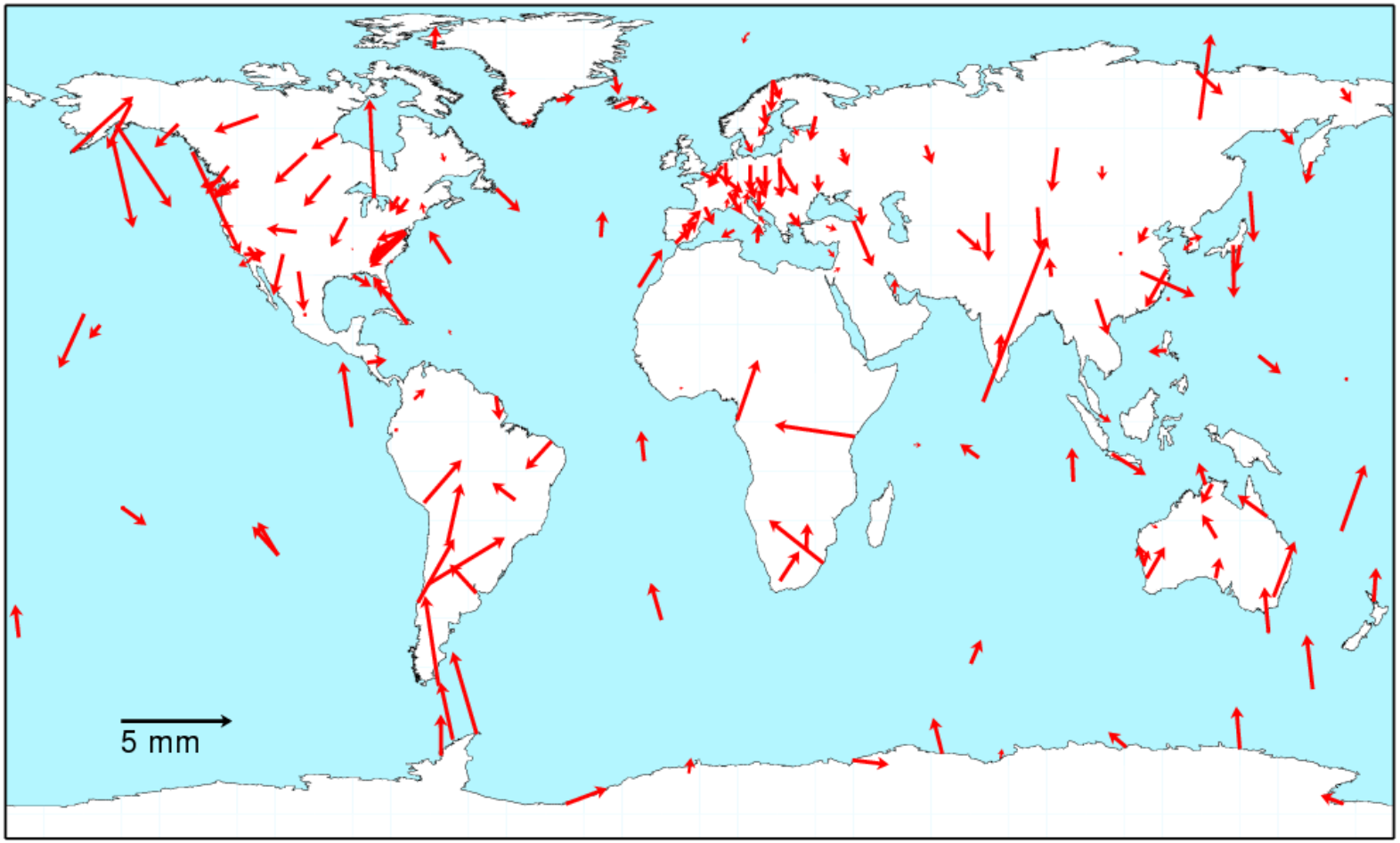
Hz Coordinate Differences: grdNO vs. grdMOD

Mean residuals of 7-parameter similarity transformations for 2004



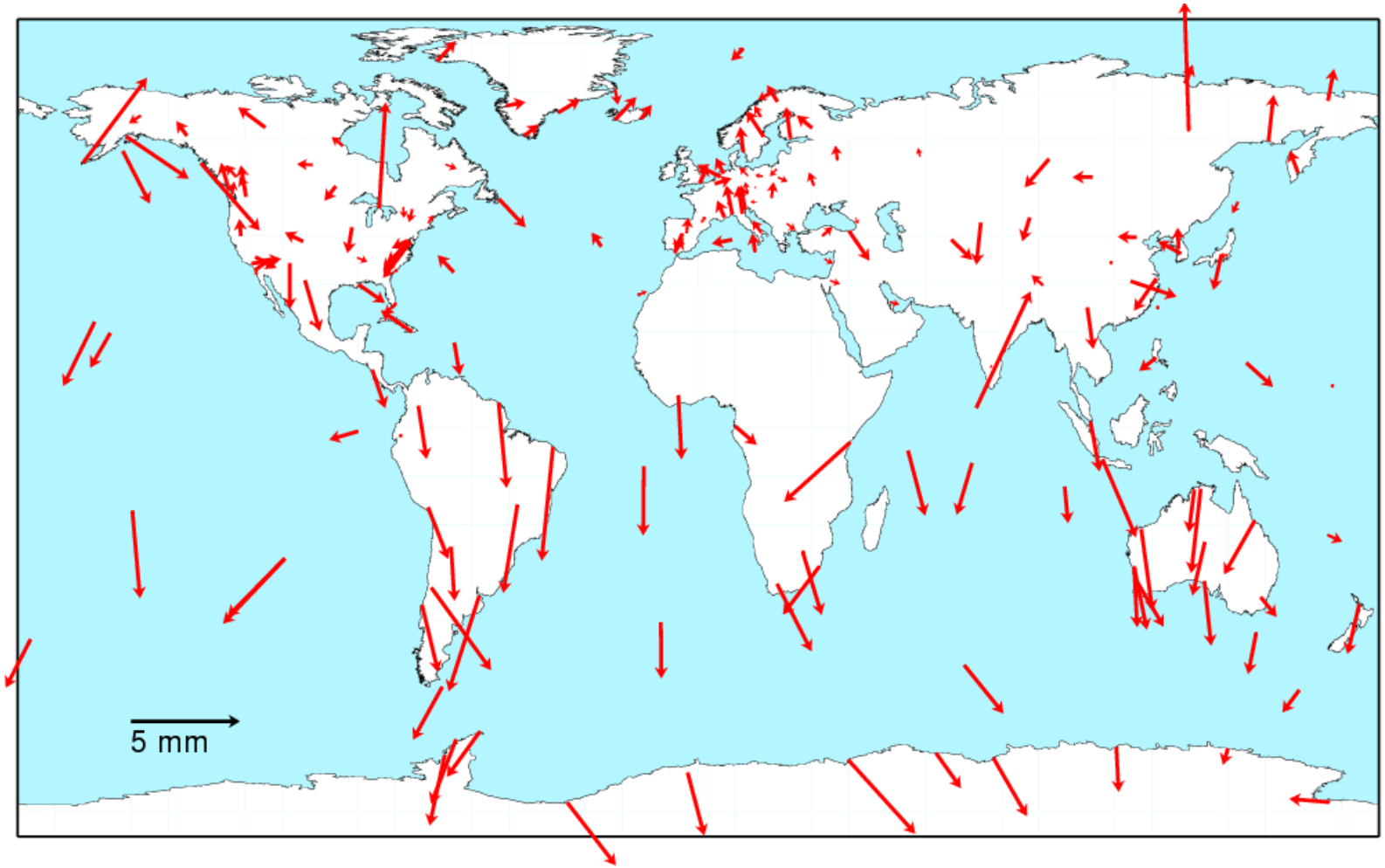
Hz Coordinate Differences: grdEST vs. grdNO

Mean residuals of 7-parameter similarity transformations for 2004



Hz Coordinate Differences: grdEST vs. grdMOD

Mean residuals of 7-parameter similarity transformations for 2004



Repeatabilities/TRF Solution

Mean coordinate **repeatabilities** of weekly solutions in 2004

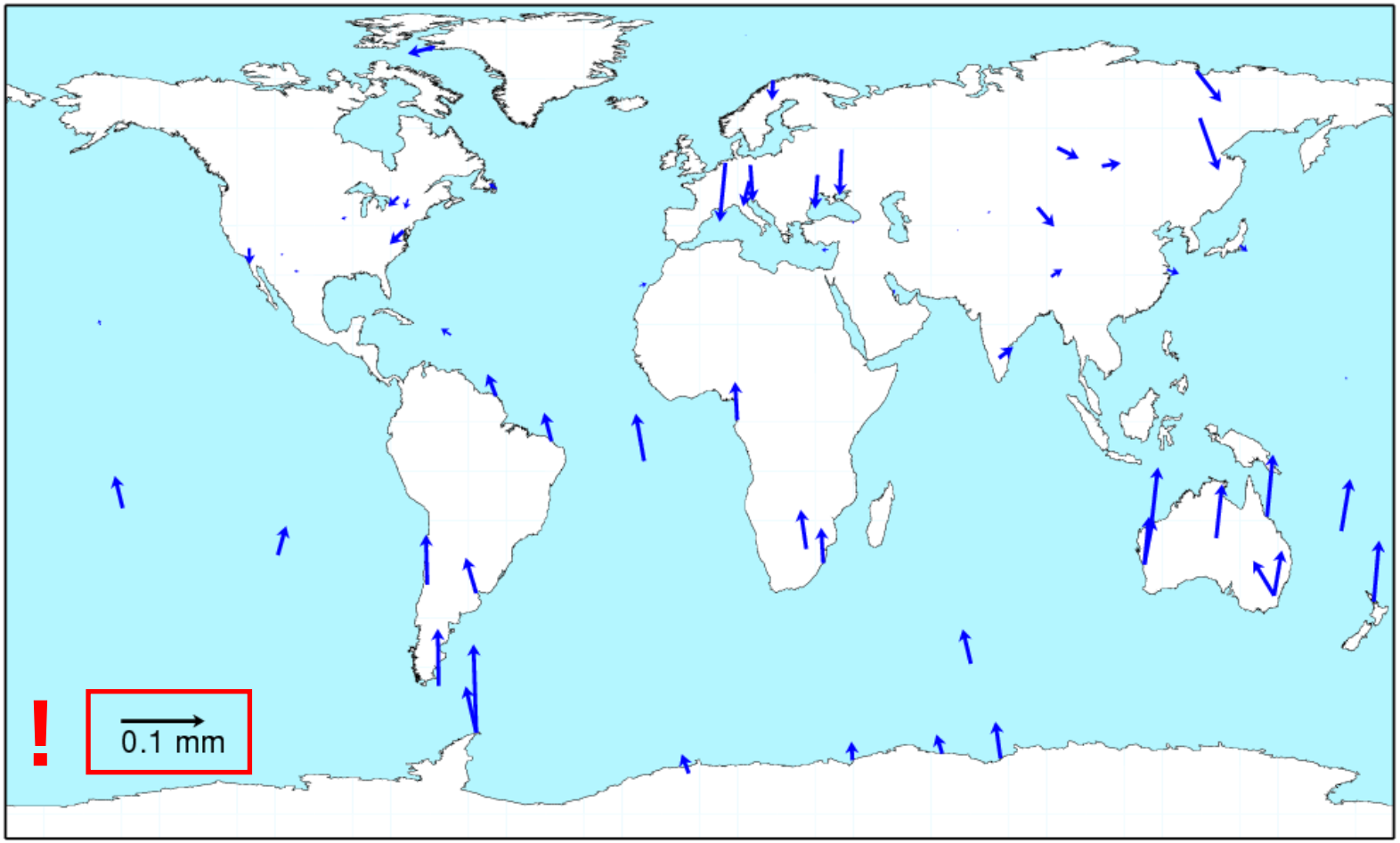
	N [mm]	E [mm]	U [mm]
grdEST	**1.6**	**1.6**	**5.4**
grdNO	**2.1**	**2.0**	**5.7**

Terrestrial Reference Frame solution for grdEST and grdAPR

- Accumulation of 12 years of daily normal equations (station coordinates and polar motion)
- Datum definition:
  - no-net-rotation condition for coordinates and velocities w.r.t. IGb00
  - subset of stable IGb00 stations (without discontinuities)

Hz Coordinate Differences: grdEST vs. grdAPR

Residuals of a 14-parameter similarity transformation of the datum stations

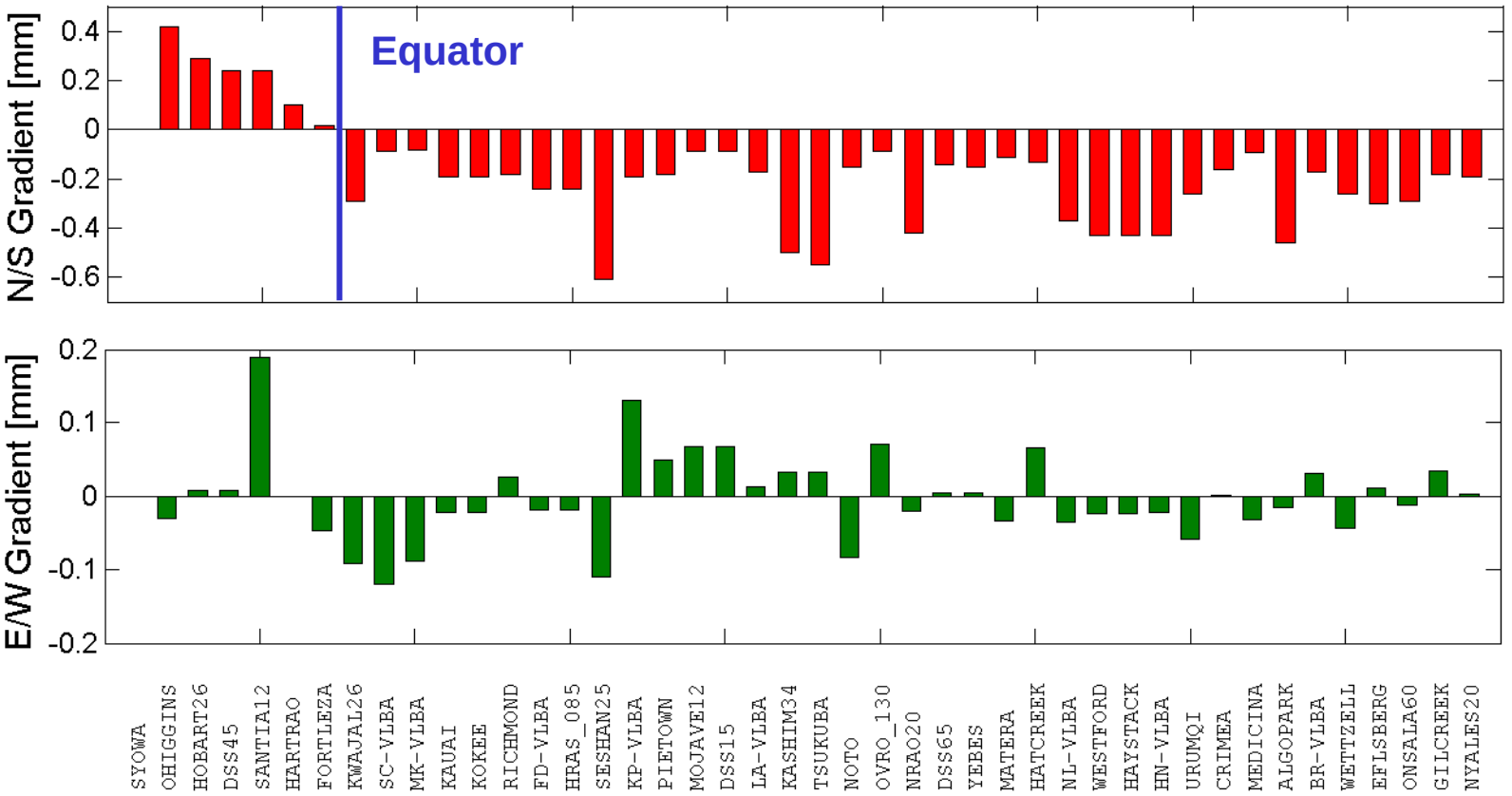


Global VLBI Solutions

- VLBI software OCCAM 6.1 (LSM)
- 2699 daily sessions between 1984 and 2005
- 49 telescopes observing 1954 sources
- normal equations set up per sessions, accumulated with DOGS-CS
- NNT and NNR of 25 telescopes w.r.t. ITRF2000
- NNR of 199 stable sources (Feissel 2003) w.r.t. ICRF-Ext1
- Vienna Mapping Functions 1

Hydrostatic Gradients in VLBI Solutions

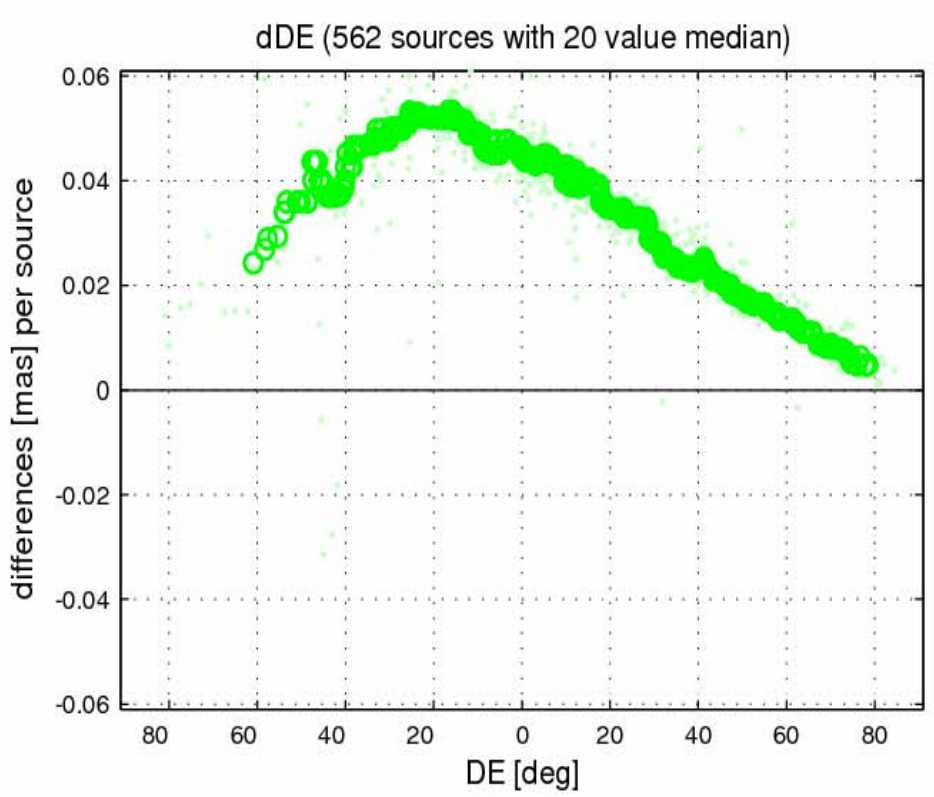
- Constant a priori gradients per station (GSFC, DAO 90-95)

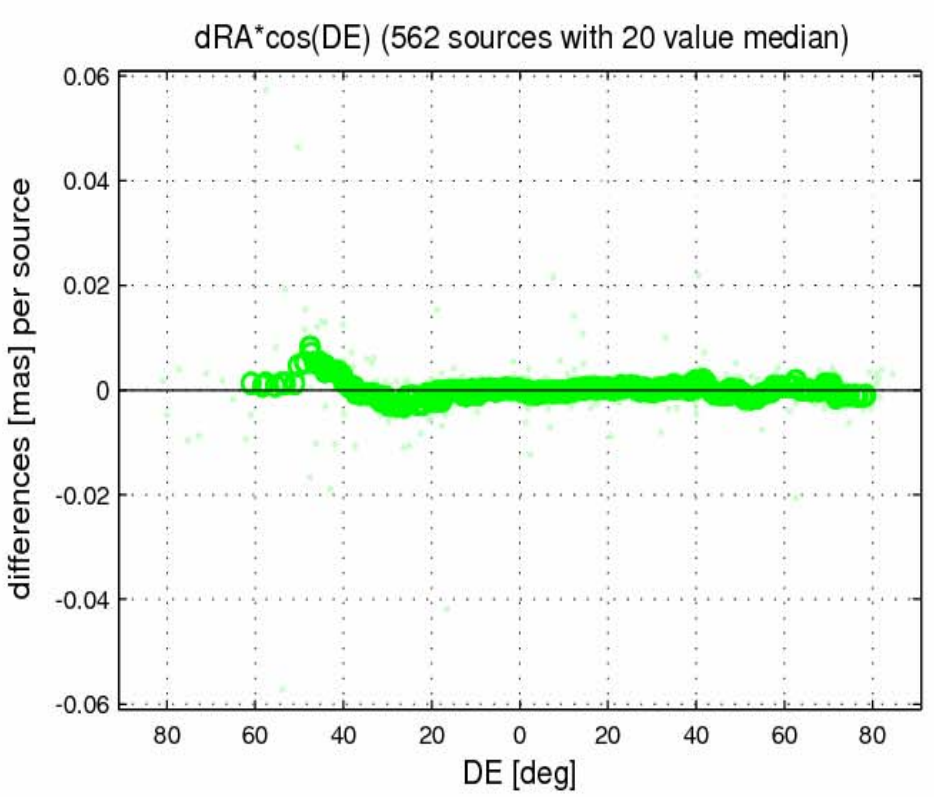


- Residual (wet) gradients estimated as offset and rate per session with constraints of 0.5 mm and 2.0 mm/d

Estimation of Source Coordinates

Declinations and right ascensions of sources

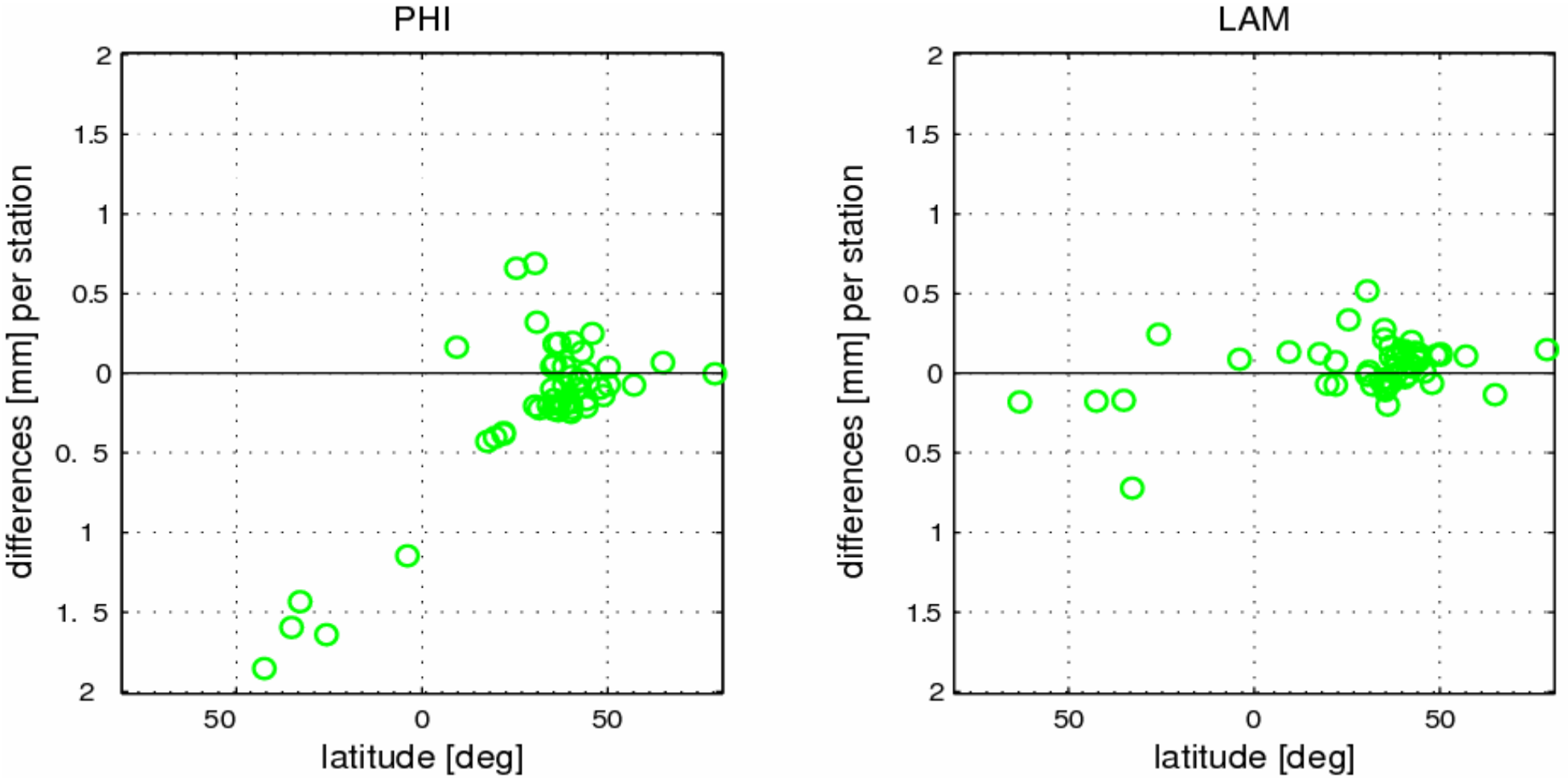




Differences between DAO 90-95 and zero a priori gradients

Station Coordinates

Latitude and longitude components of stations



Differences between DAO 90-95 and zero a priori gradients

Summary

- Tropospheric **gradients** have a **significant influence** on the **estimated station positions**

- In **GPS** solutions, gradients are estimated **unconstrained**. Therefore, the **impact of hydrostatic a priori gradients** on estimated station positions is **very small** (0.1 mm) but systematic.

- In **VLBI** solutions, gradients are usually **constrained** to stabilize the equation system (in particular older sessions). Therefore, applying mean hydrostatic a priori gradients from a numerical weather model instead of using 0 a priori gradients yields to:

  - small (40 μasec) but systematic effect on declinations of source coordinates

  - small (< 2mm) effect on latitude components of southern hemisphere stations