

Effects of Different Antenna Phase Center Models on GPS-derived Reference Frames



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- Receiver and satellite antenna phase center models
- Reference frame solutions applying different phase center models
- Comparisons of reference frame solutions:
 - IGB00
 - Inter-comparison
 - VLBI reference frame solution
- Coordinate time series and discontinuities
- Conclusions

GPS Antenna Phase Center Models

Relative Phase Center Model



Photo: www.ngs.noaa.gov

- **Field calibrations**
- PCVs relative to the **reference antenna AOAD/M_T**
- Arbitrary assumption:
 $PCV(AOAD/M_T) = 0$
- Used within the IGS till today

Absolute Phase Center Model

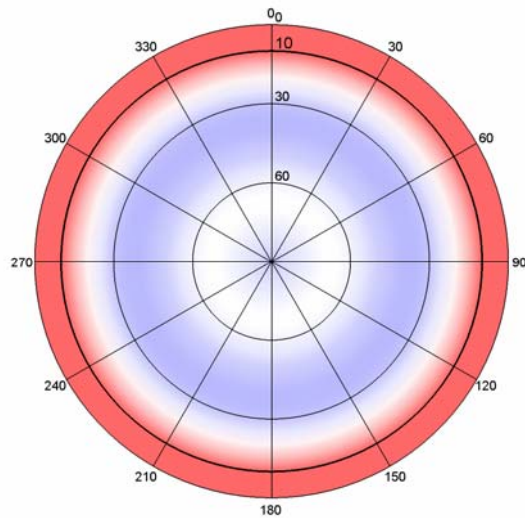


Photo: ife / Geo++ GmbH

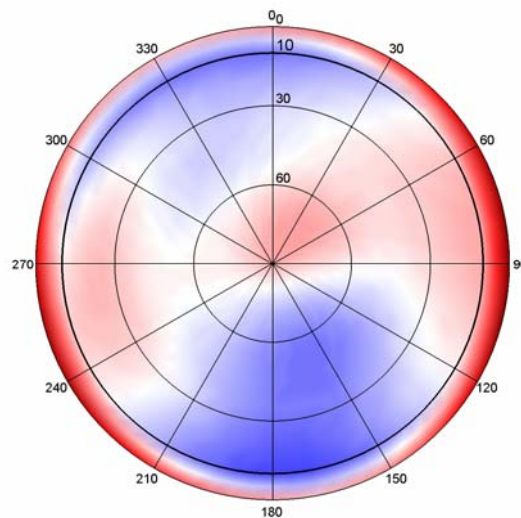
- **Robot calibrations**
- PCVs **down to 0°** elevation for different azimuth angles
- **Satellite antenna PCVs**
- Introduction within the IGS together with ITRF2005: GPS week 1400

Receiver Antenna Phase Center Model

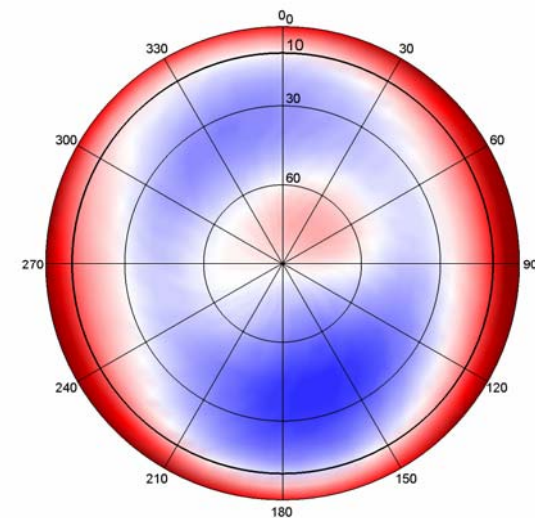
L2 phase center variations for TRM14532.00 NONE



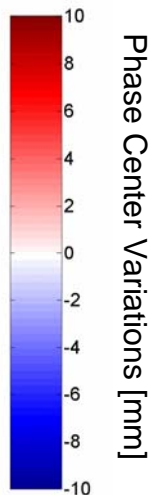
elevation-dependent



azimuth-dependent

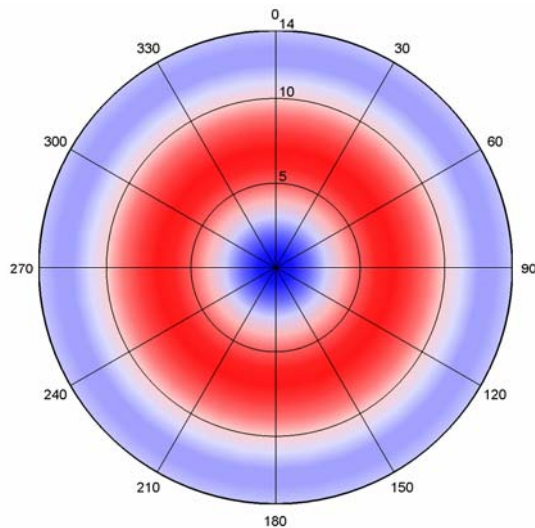


elevation- and
azimuth-dependent

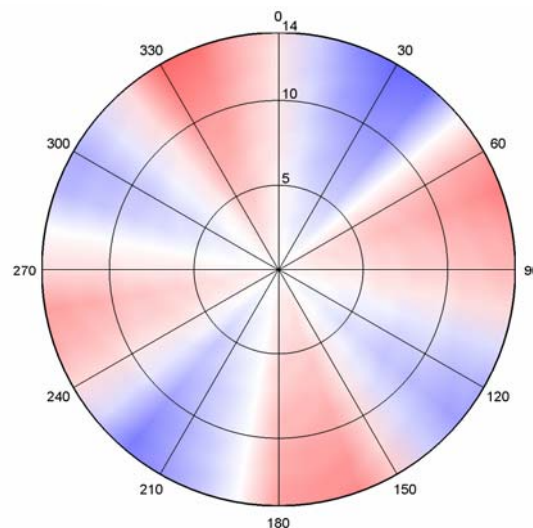


Satellite Antenna Phase Center Model

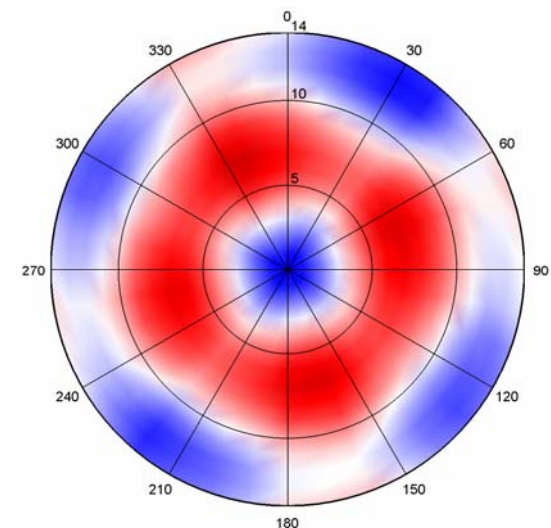
Phase center variations for Block IIR-A satellites



nadir-dependent



azimuth-dependent



nadir- and azimuth-
dependent

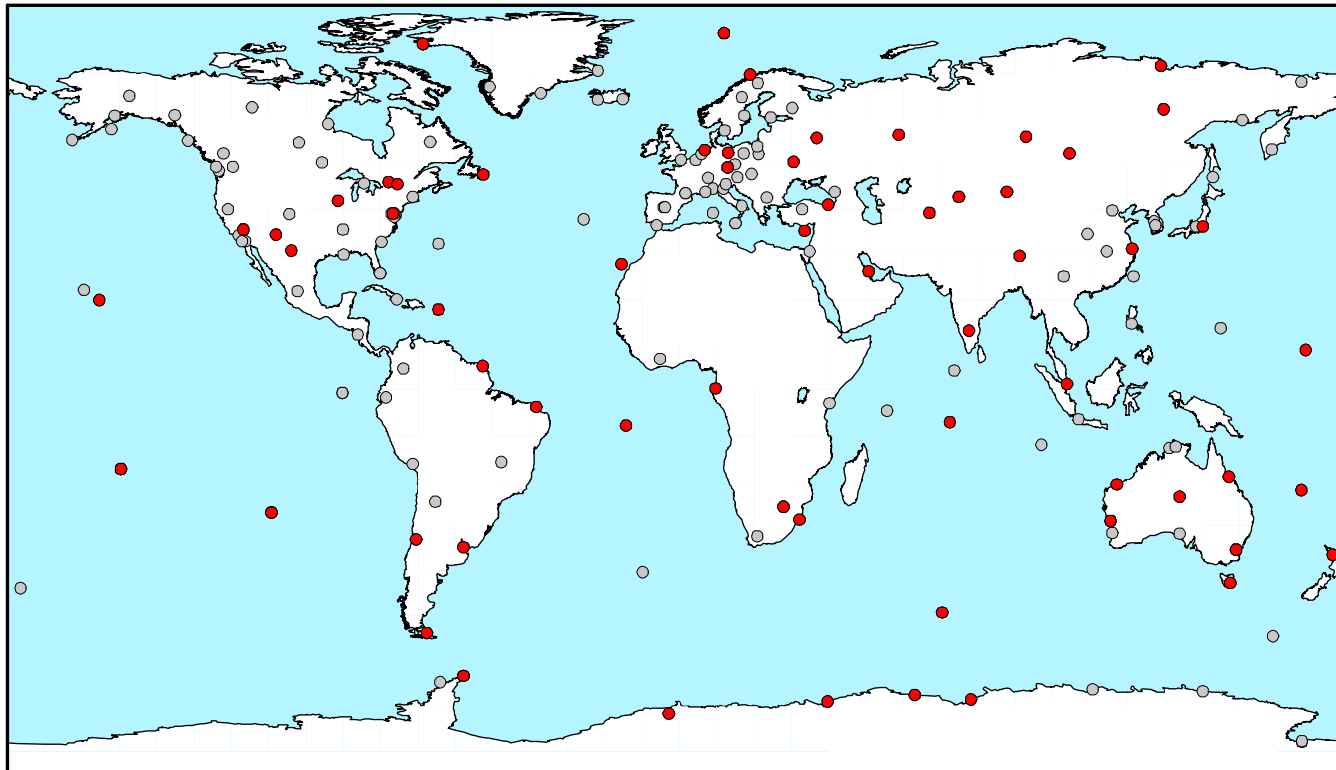
Phase Center Variations [mm]



Station Network

- Altogether 202 stations altogether, up to 160 per day
- Datum stations: subset of 66 stable IGB00 stations

Time interval: 1 January 1994 - 31 December 2004 (4018 days)

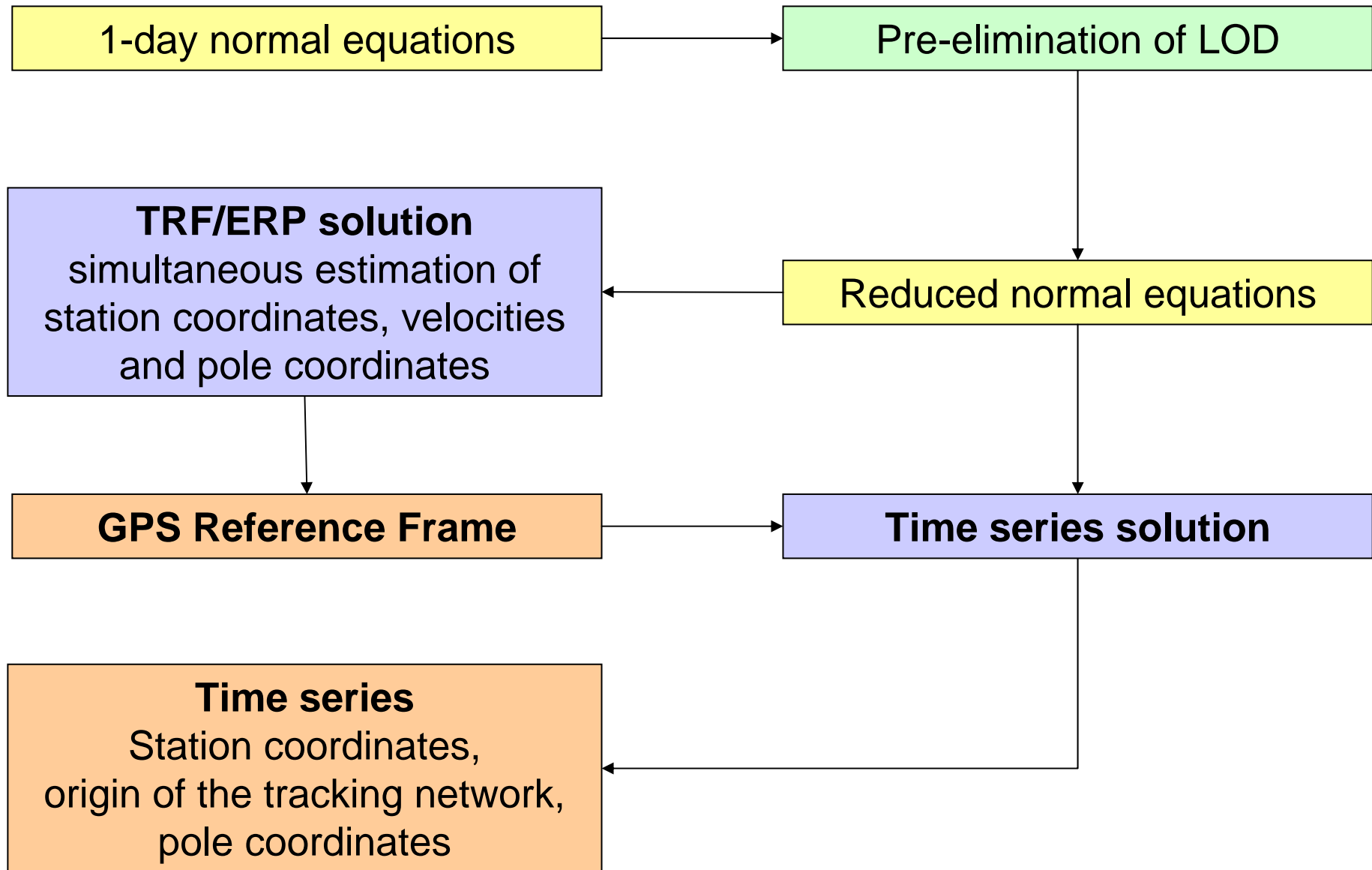


Reference Frame Solutions (1)

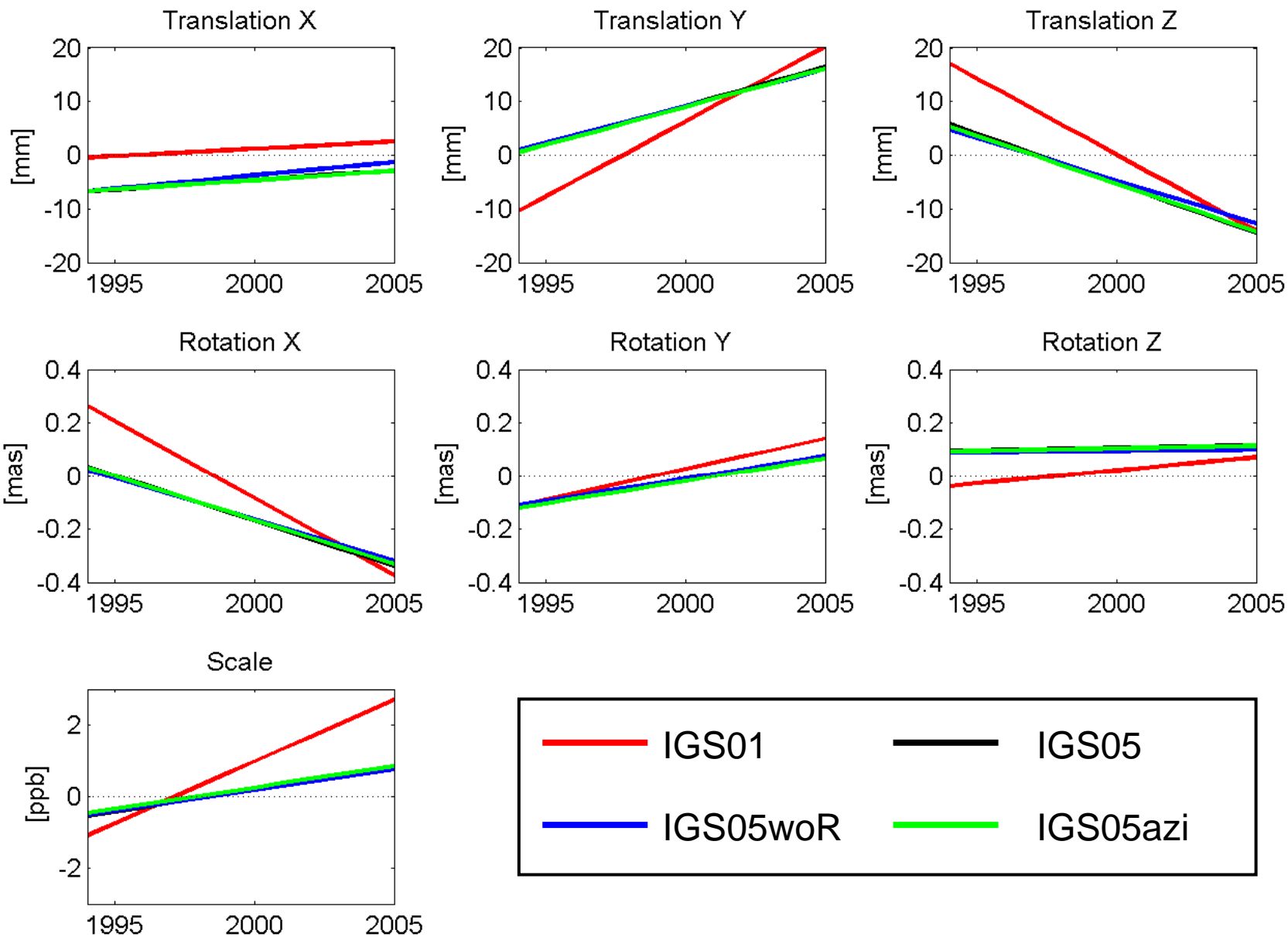
Solution	Type	Sat. PCV	Rec. PCV	Radomes
IGS01	relative	--	ele.	no
IGS05	absolute	ele.	ele.+azi.	yes
IGS05woR	absolute	ele.	ele.+azi.	no
IGS05azi	absolute	ele.+azi.	ele.+azi.	yes

- Completely and homogeneously reprocessed global GPS solutions (Bernese GPS Software)
- Normal equations with station coordinates and Earth rotation parameters
- Satellite orbits, troposphere zenith delays and gradients pre-eliminated

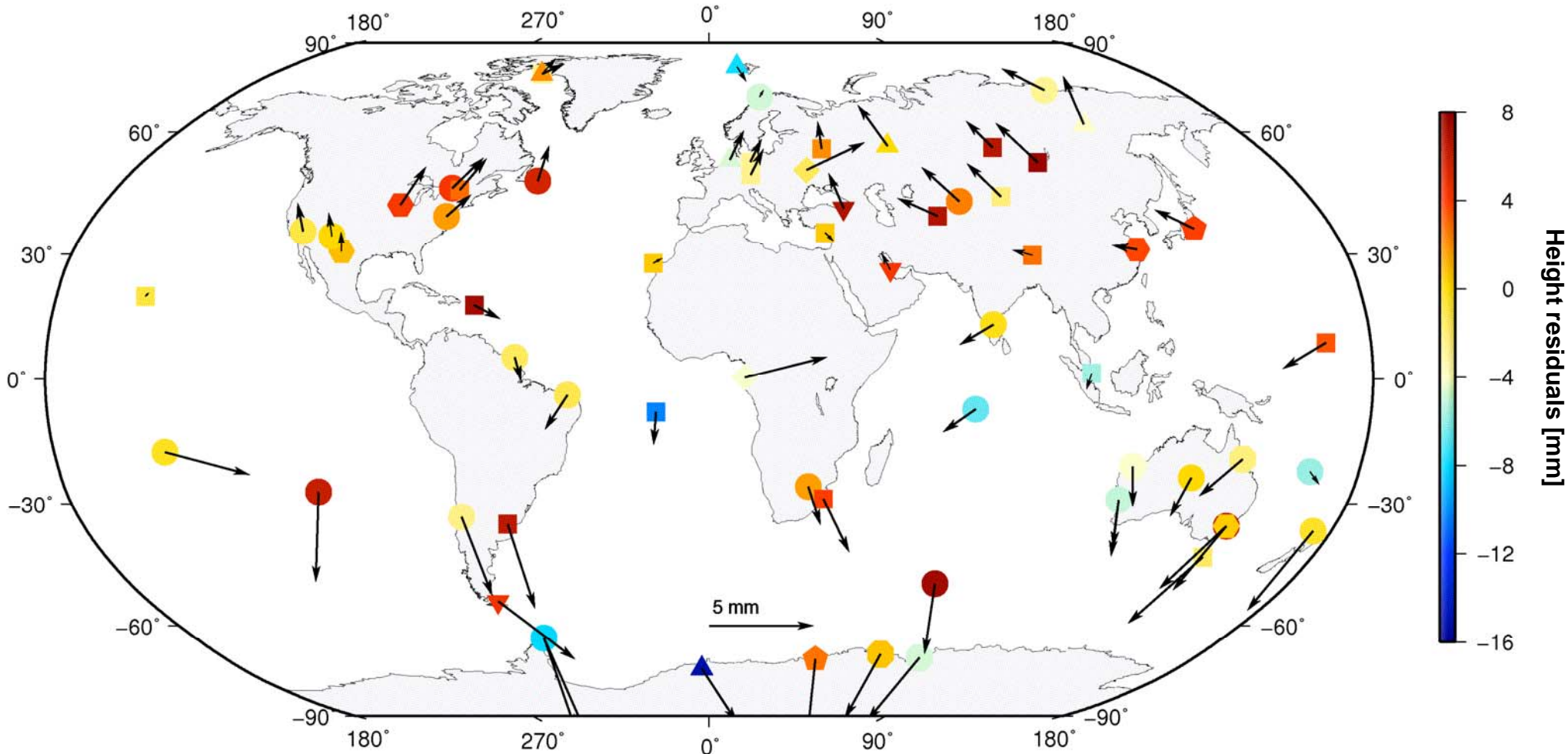
Reference Frame Solutions (2)



14-Parameter Transformations w.r.t. IGb00



Coordinate Residuals IGS01/IGS05



□ AOAD/M_T NONE

⬡ AOAD/M_T AUST

⬠ AOAD/M_T DOME

⬢ AOAD/M_T JPLA

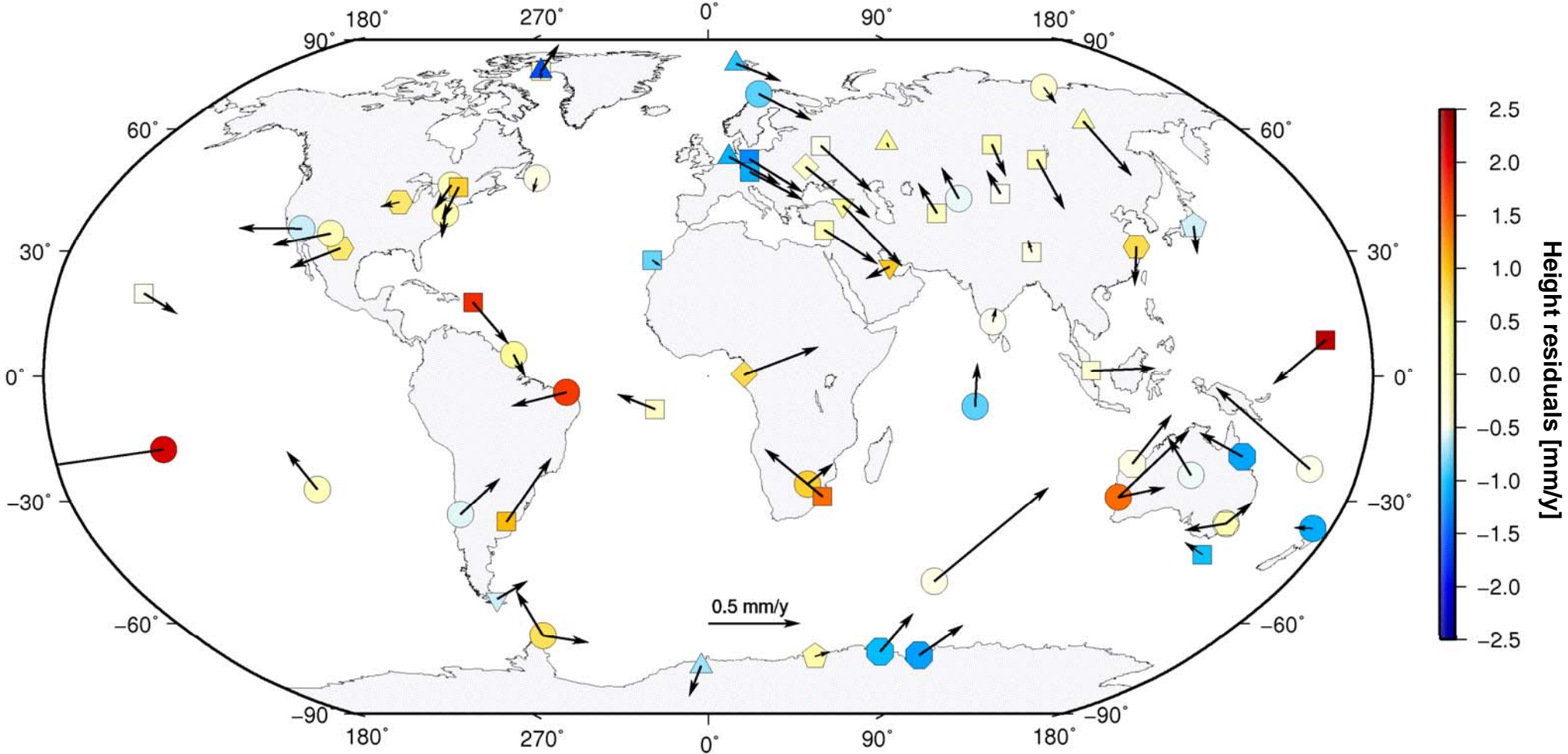
▽ ASH700936?_M SNOW

◇ TRM29659.00 NONE

△ Other Antennas

○ Different Antennas

Velocity Residuals IGS01/IGS05



□ AOAD/M_T NONE

⬡ AOAD/M_T AUST

⬠ AOAD/M_T DOME

⬢ AOAD/M_T JPLA

▽ ASH700936?_M SNOW

◇ TRM29659.00 NONE

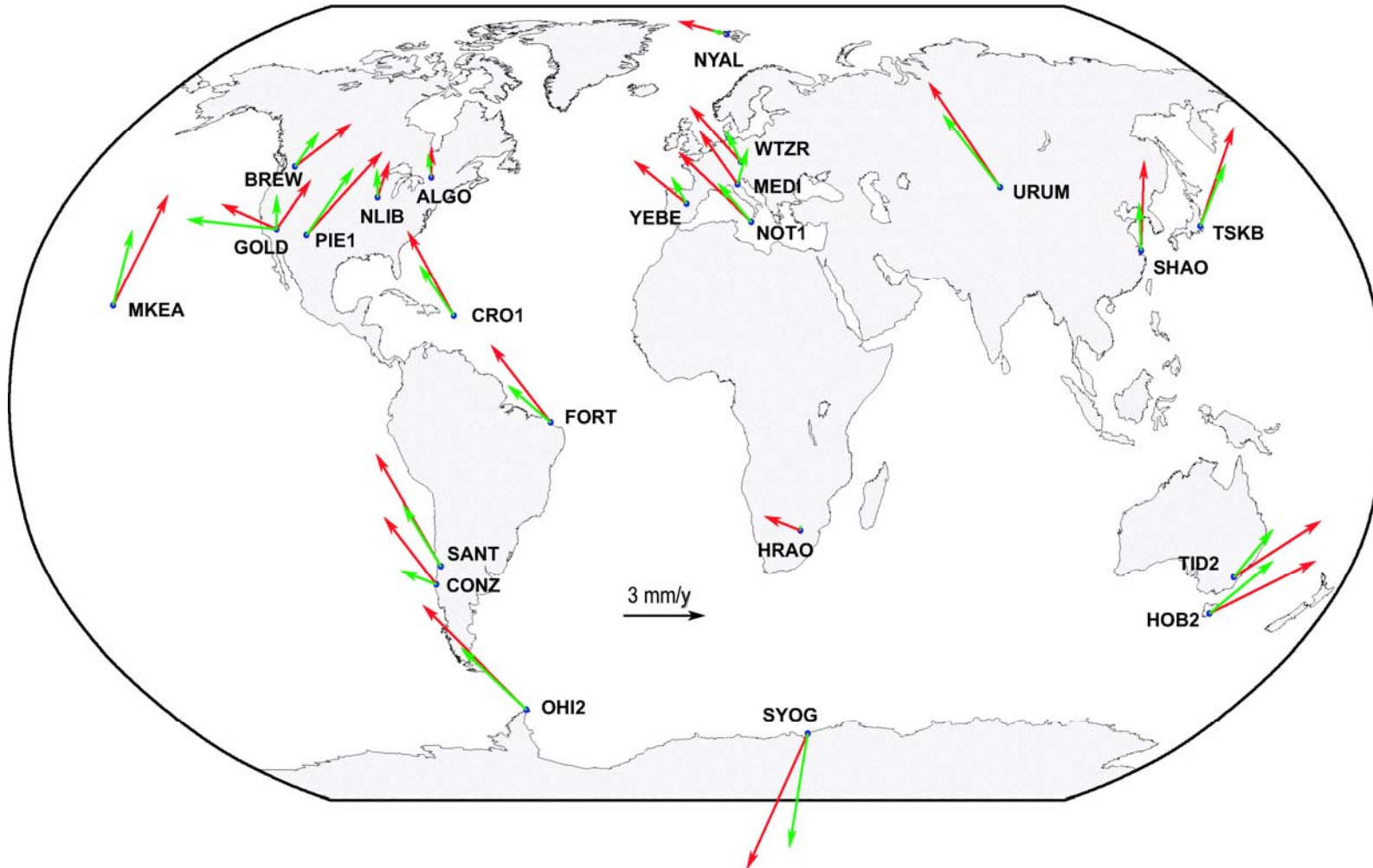
△ Other Antennas

○ Different Antennas



GPS/VLBI Horizontal Velocity Residuals

Velocity differences w.r.t. VLBI solution DGFI05R03

Mean differences



North
2.3 mm/y
1.5 mm/y
East
1.6 mm/y
0.9 mm/y

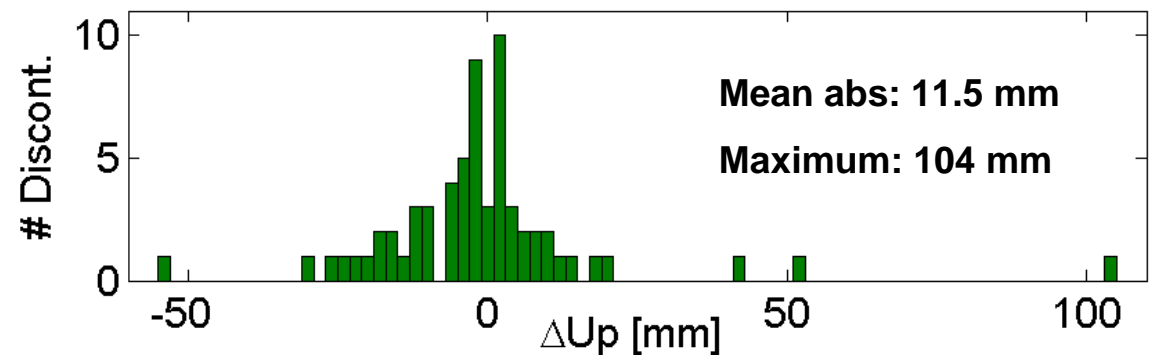
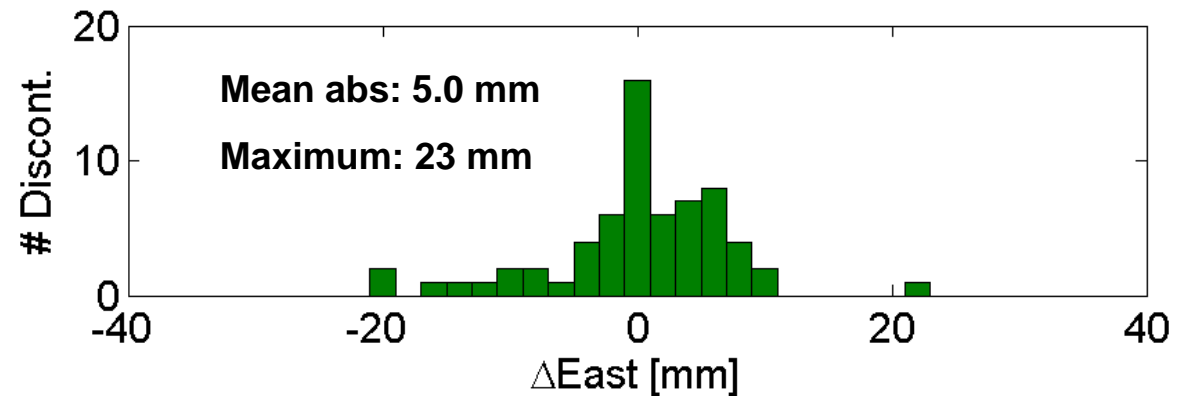
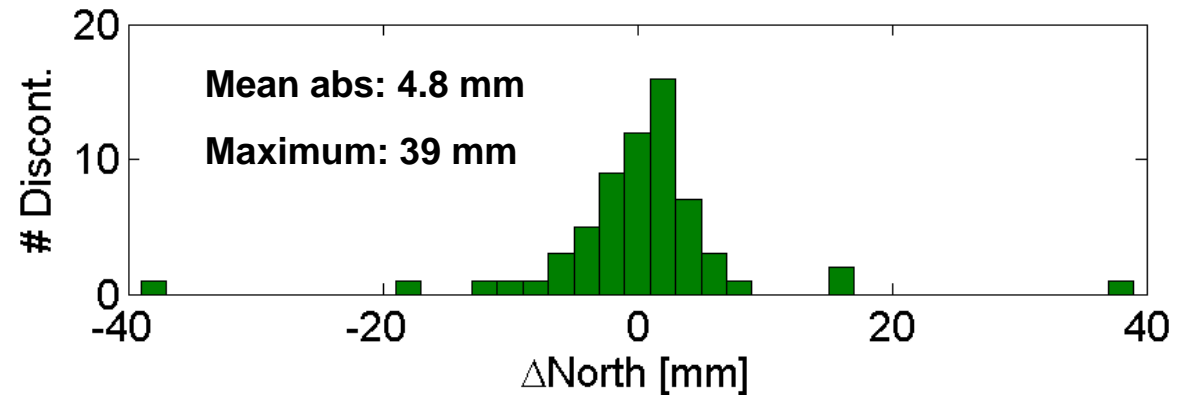
	IGS01
	IGS05

Differences primarily caused by datum effects

Discontinuities due to Equipment Changes (1)

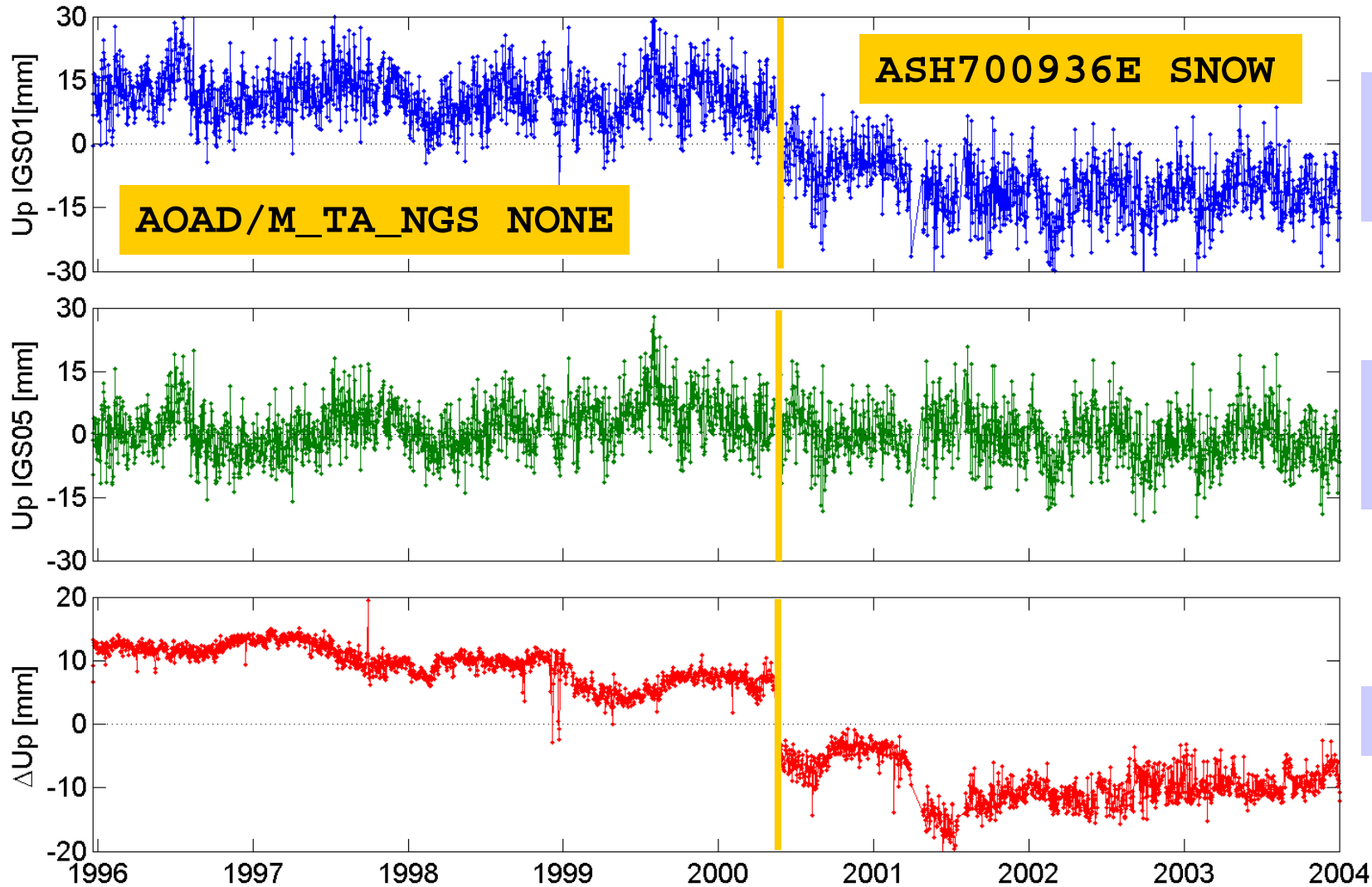
Altogether 124 discontinuities considered in the reference frame solutions

Type	#
Antenna/Radome change	32
Receiver change	5
Antenna & Receiver change	27
Earthquakes	17
Other	5
Unknown	38



Discontinuities due to Equipment Changes (2)

Antenna change at Horn Point (HNPT)



IGS01
 $\Delta U = -15.8$ mm

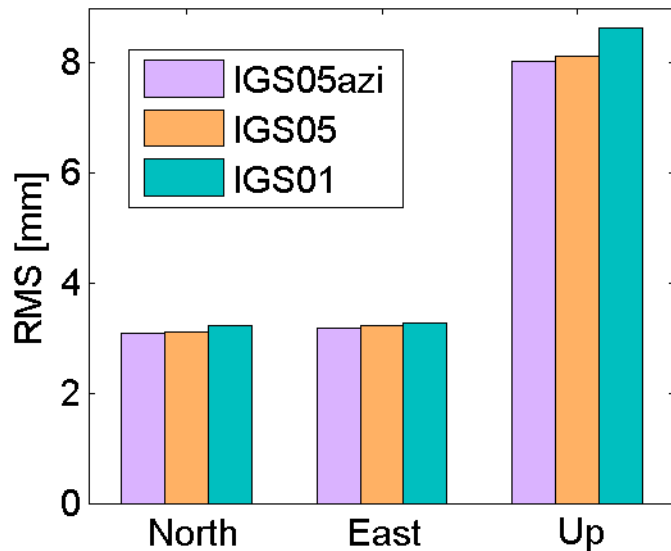
IGS05
 $\Delta U = -0.5$ mm

$\delta\Delta U = 15.3$ mm

Coordinate Time Series

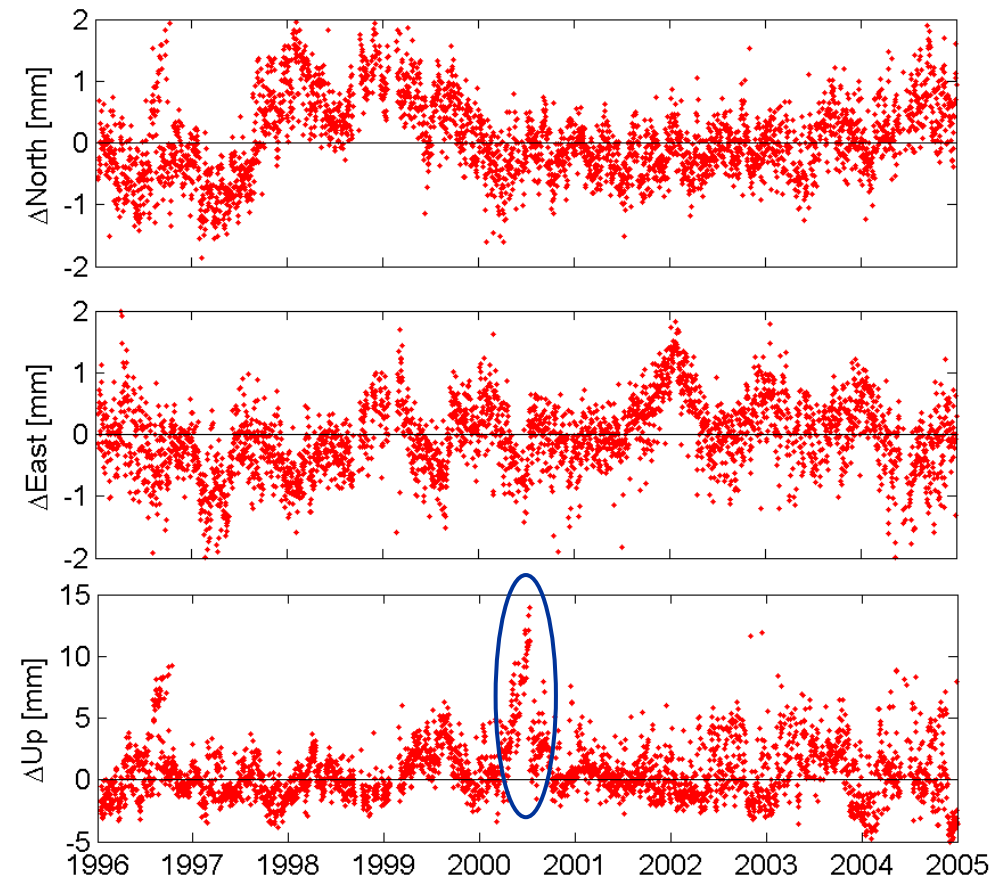
RMS of coordinate time series

- Time period 1996-2004
- annual signal removed
- stations with less than 1000 days excluded
- discontinuities corrected for



Coordinate differences IGS05/IGS01

Reykjavik (REYK)



Conclusions

- The **absolute antenna phase center model** including radome calibrations
 - provides a **more stable reference frame** than the relative model (in particular scale drift)
 - **reduces the number/size of discontinuities**
 - **reduces the RMS** of the coordinate time series
 - provides a **better agreement** with **VLBI-derived velocities**
- **Change** from the **relative** to the **absolute** phase center model has a **significant influence** on the reference frame (**coordinates + velocities**)
- **Complete** and **homogeneous reprocessing** essential for the realization of an accurate and consistent GPS reference system
- The **IGS reprocessing effort** will hopefully start soon