

IGS Workshop 2004, Bern

***Estimation and Validation of the IGS Absolute
Antenna Phase Center Variations***

Maorong Ge and Gerd Gendt

GeoForschungsZentrum Potsdam
Potsdam, February 2004

➤ *Goal*

- **Validate IGS proposed absolute PCV**
pcv_abs_proposed.tst for stations
pcv_tum for satellites

➤ *Strategy*

- **Estimate independent absolute PCVs for satellites**
- **Assess their impact on GFZ's IGS final products**

➤ *Model*

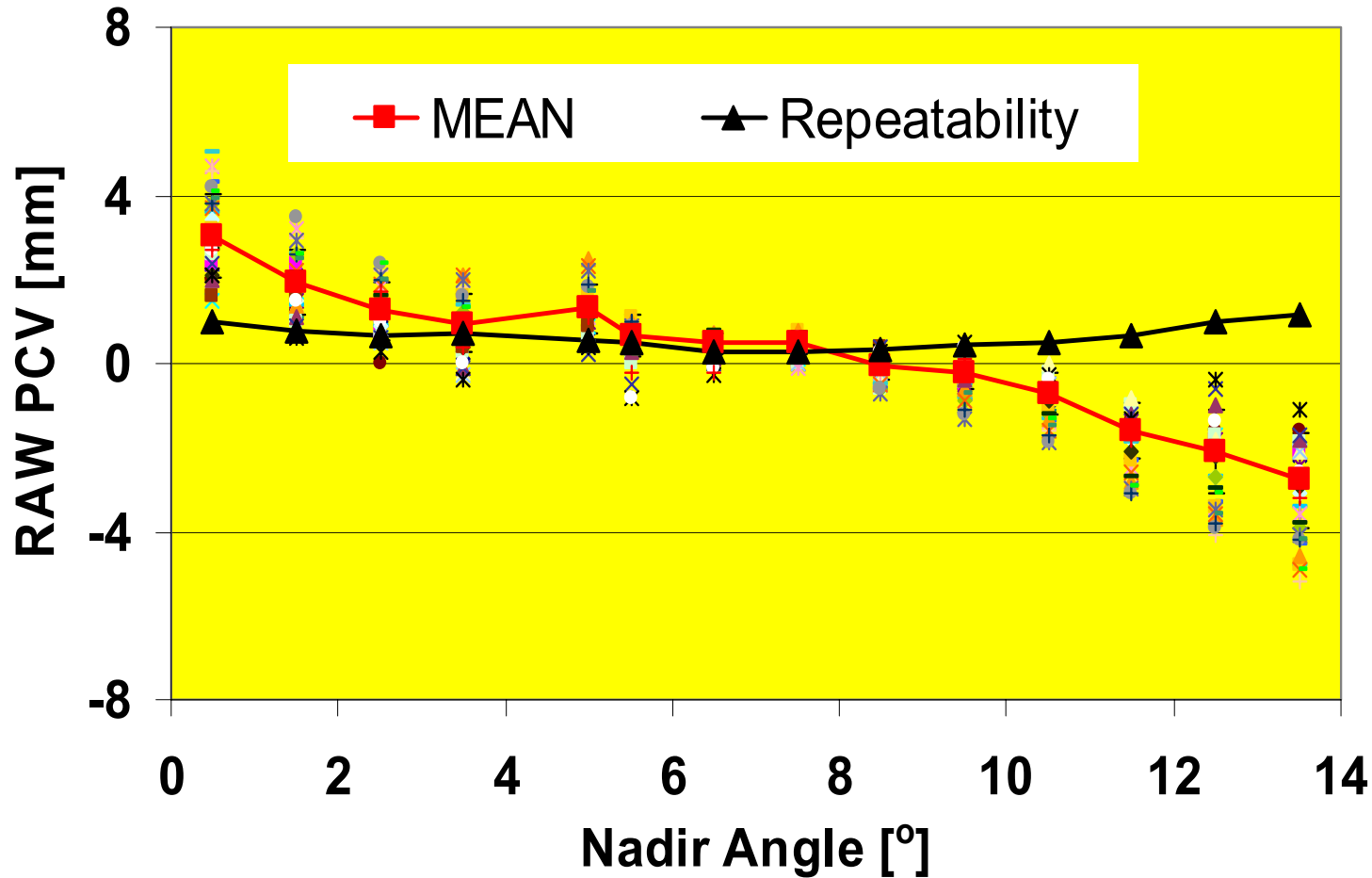
- PCV&Offset, Sat.&Rec PCV, Scale&Offset, PCV&Clock are correlated
- Estimate PCV and offset effect together by fixing rec. PCVs and station coordinates with a special constraint on PCV parameters.

➤ *Data*

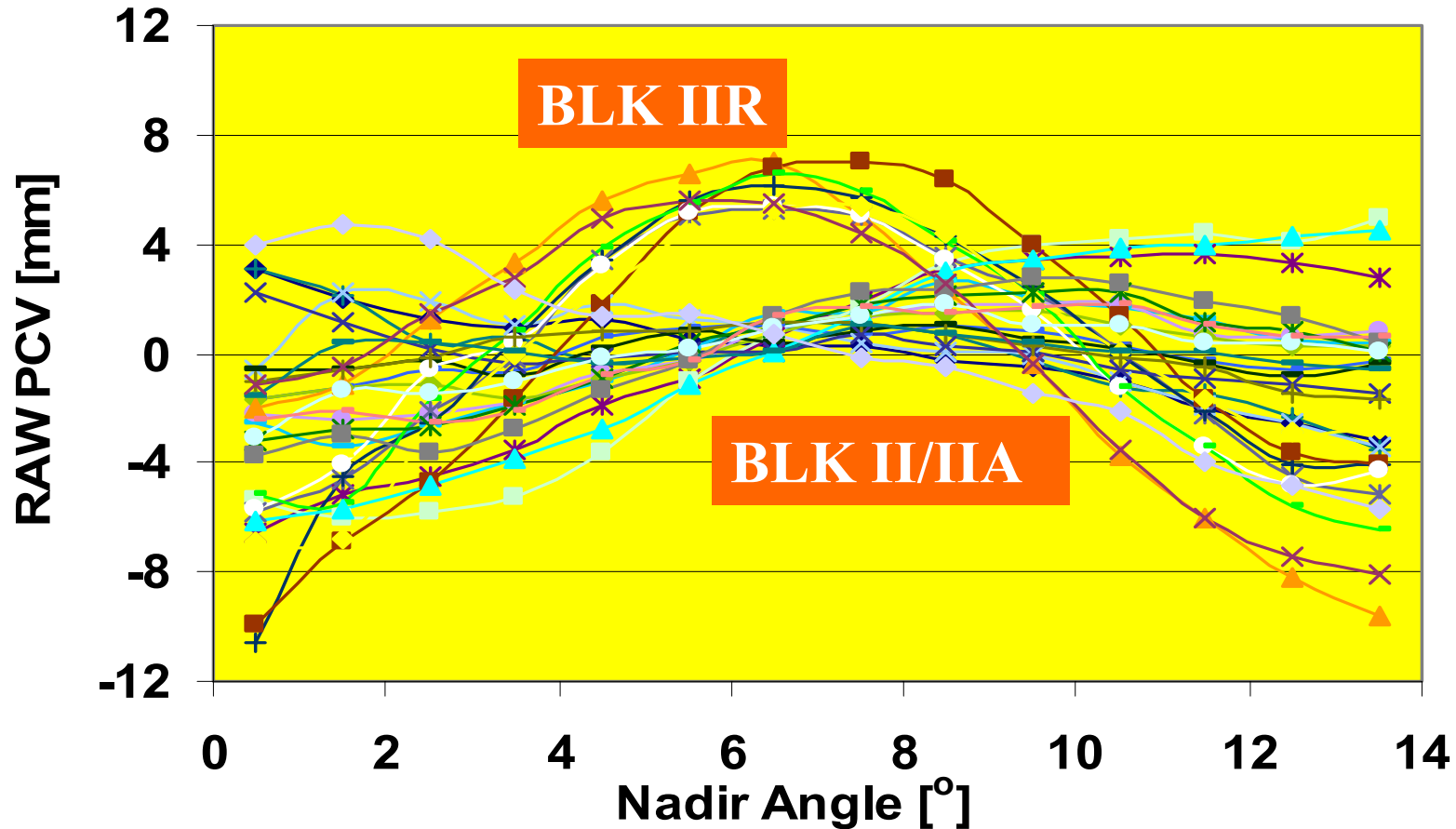
- 5 minute sampling rate, 7° cutoff elevation angle
- Days 291-327 of 2003 (5 weeks), 90 IGS stations
- elevation dependent weighting ($2 \cdot \sin(E)$, $E < 30$)

➤ *Estimation*

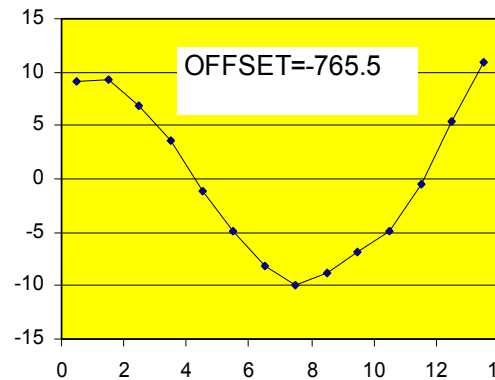
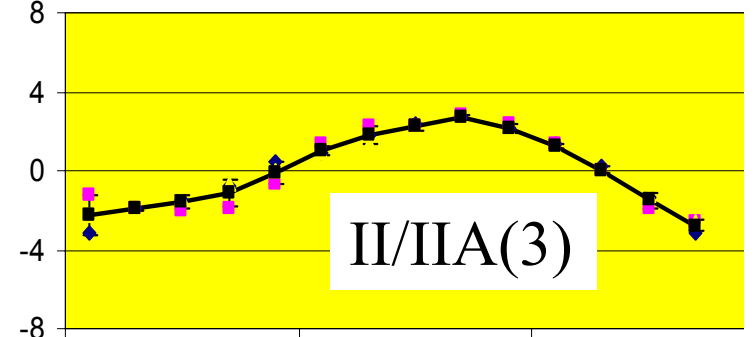
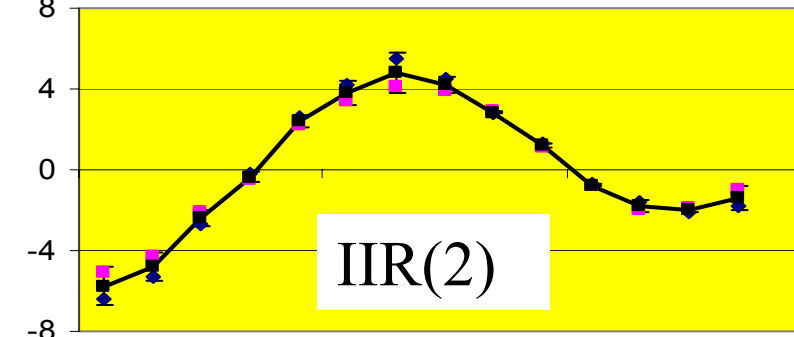
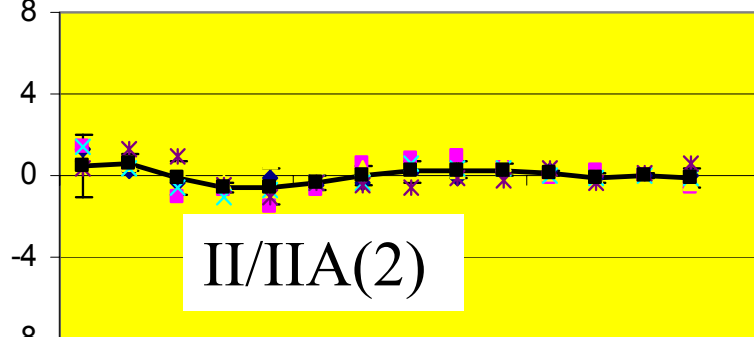
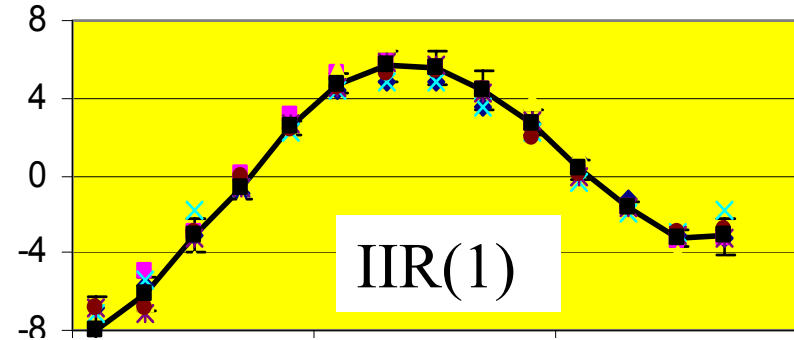
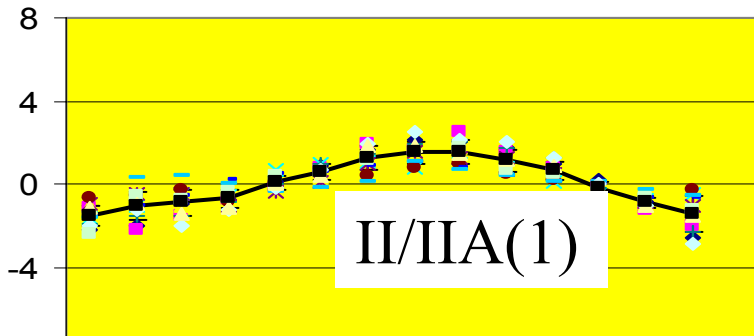
- Parameters: Orbits, ERP, Clocks, ZTD(4h)+GRD, PCV satellite by satellite as piece-wise constants
- Initial offset of 2.3384 and 1.3326m for II/IIA and IIR



Daily RAW PCV for PRN01 over the 35 days. Black triangles show the daily repeatability, 0.6mm in average and up to 1mm at the boundaries where observations are few or deweighted.

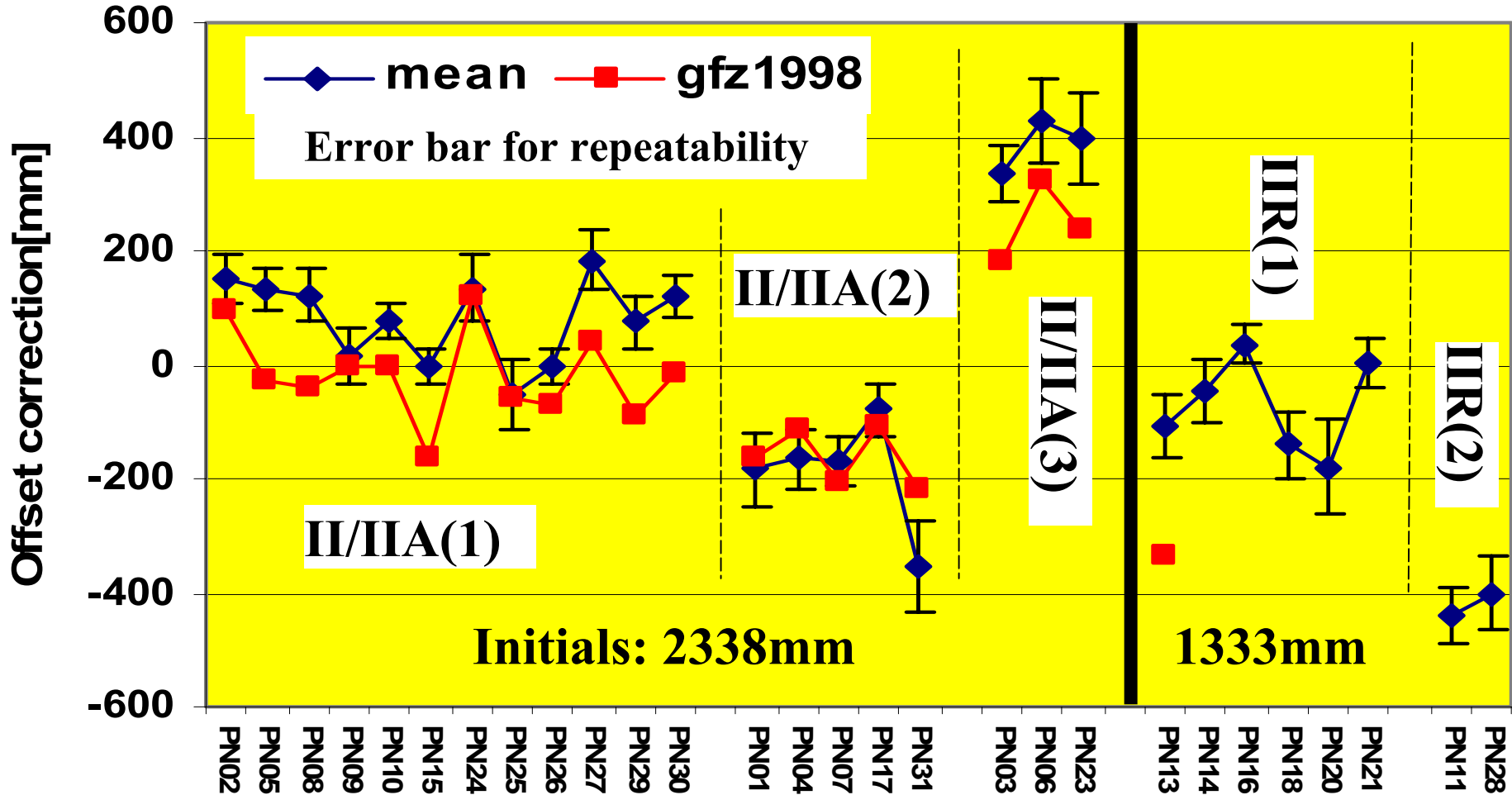


Mean RAW PCV for all satellites. Clear difference between Block II/IIA and IIR. Significant differences among satellites with the same block type.

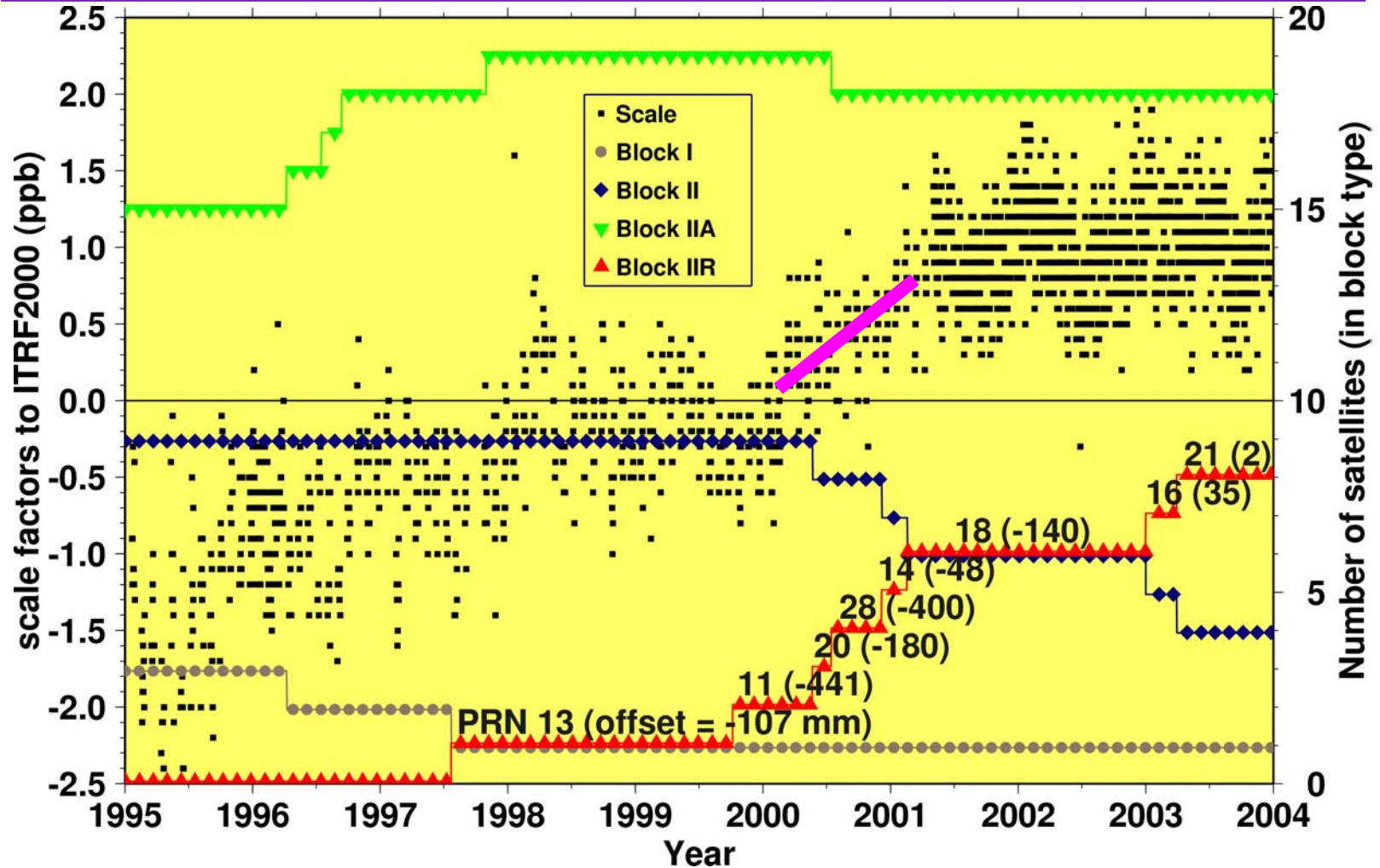


Group	Offset
II-1	67.2
II-2	-219.2
II-3	386.7
IIR-1	-73.1
IIR-2	-420.7

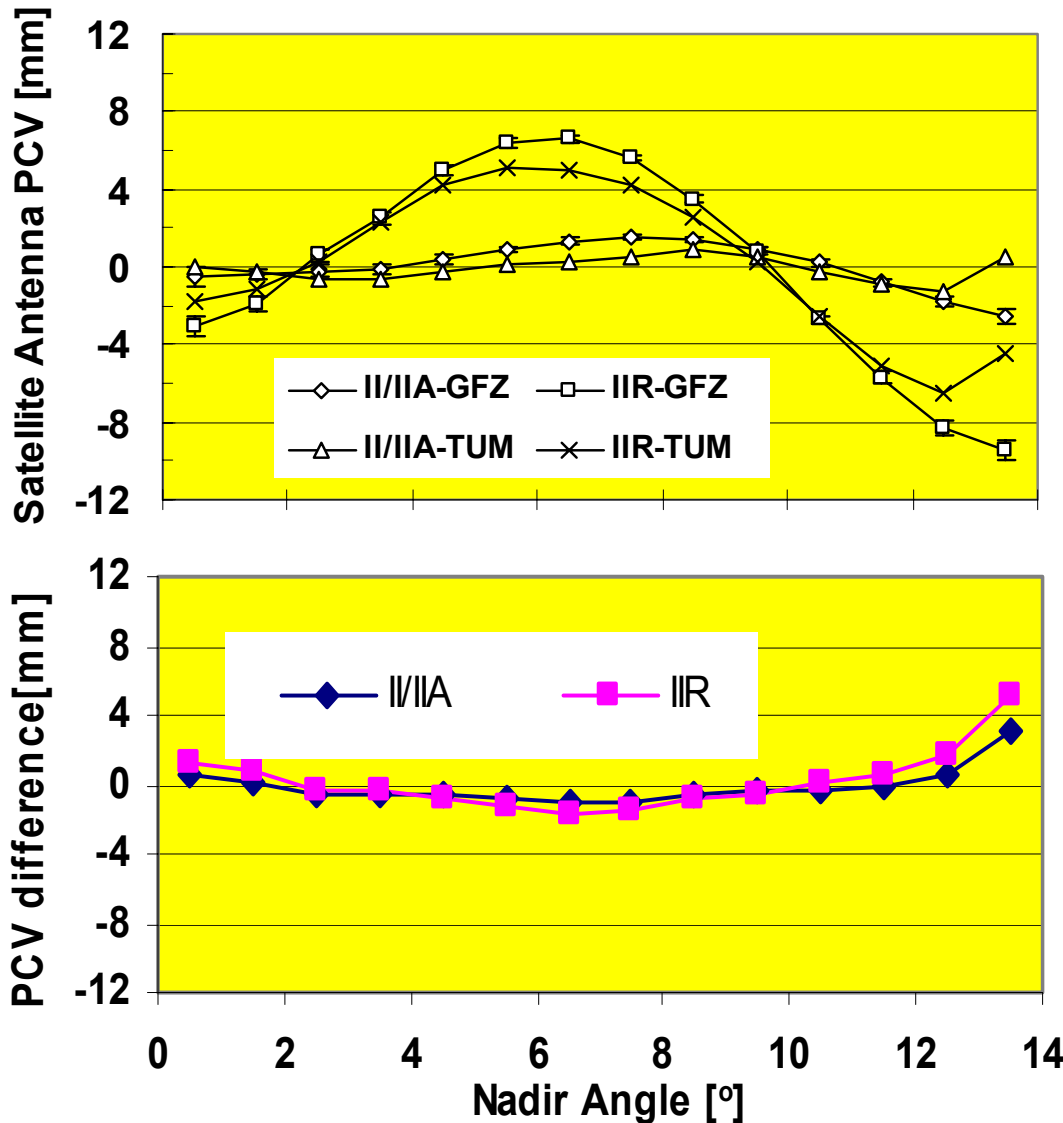
- *Similar PCVs for satellites belonging to the same group*
- *Small differences among groups for the same block types*



- Reasonable offsets compared to GFZ results from 1998
- Maximum offset difference reaches 0.8m in II/IIA, 0.5m in IIR
- Offset can be estimated with precision of cm-level



➤ *Scale change 2000-2001 is caused by IIR offset errors*

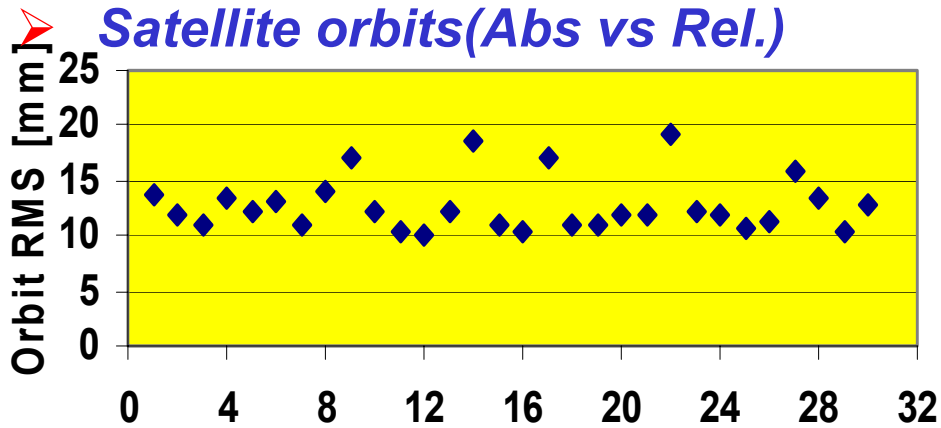


	II/IIA	IIR
MeanOffset	119.8	220.8

Difference between GFZ and TUM

	All points		No Last point	
	II/IIA	IIR	II/IIA	IIR
Mean	-0.1	0.2	-0.4	-0.2
STD	1.1	3.0	0.3	1.1

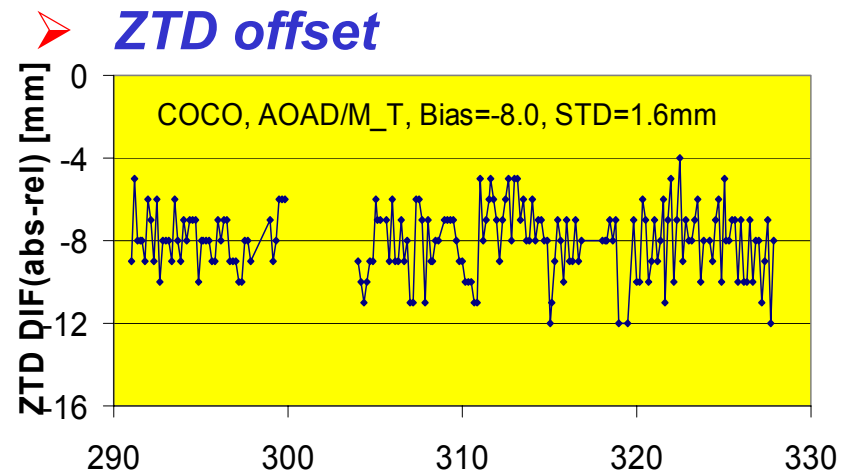
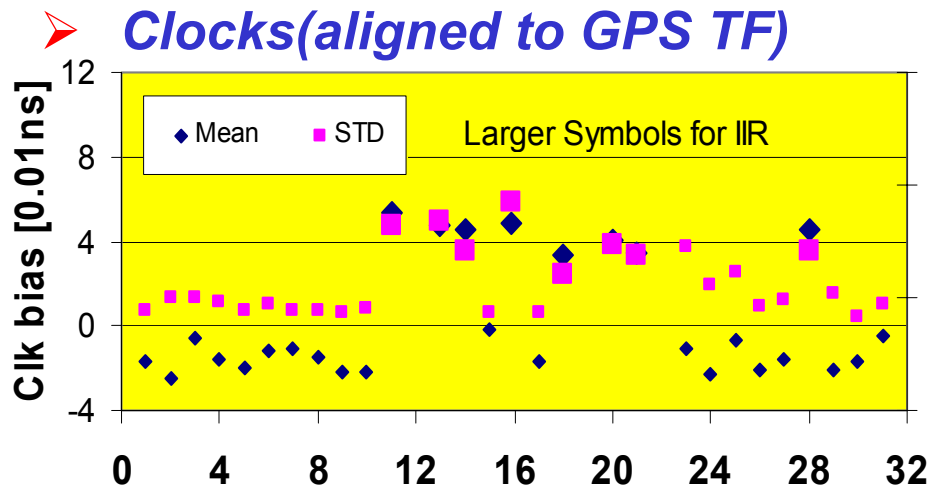
- *Using the same converting method, PCVs agree with TUM within 1 mm.*
- *Differences in offsets come from: change of satellite constellation, RF realization*



➤ **Station coordinates**

Shift&scale to IGS00 (mm, ppb)

	dx	dy	dz	Scale
A PCV	2.0	0.2	1.5	-1.1
R PCV	0.5	1.1	-2.0	1.0
GFZ_A	1.2	-0.2	-0.4	0.1



➤ **Station clocks 1.31m +/-0.03m, 2 cm offset diff. in sat. clocks**

➤ **-1 ppb scale with TUM offset, 0.1 with GFZ's**

➤ **-7.0mm +/-1.9mm ZTD offset may reduce bias btw GPS and RS**

Estimation

- *PCV and offset can be estimated with an accuracy for few mm observation modeling*
- *PCV for groups/block types and individual offset for each satellite should be used.*
- *The estimated PCV is dependent on the fixed receiver PCVs and reference frame.*

Influence on Products

- *Small difference in satellite orbits,*
- *1.31m offset in clocks*
- *-1 ppb scale offset to IGS00 due to difference in offsets*
- *-7 mm bias in ZTD, will correct the bias between GPS and RS*

$$obs = \rho + pcv(\phi) - r_0 \cos \phi$$

PCV and Offset are correlated

$$[pcv(\phi), r_0] = [pcv(\phi) - r_0 \cos \phi, 0]$$

Sat. PCV and Rec. PCV are correlated

$$\sin(\phi) = R / r \sin(z)$$

Scale and Offset

$$\Delta scale = -7.8 \Delta r, \text{ unit in ppb and m}$$

PCV and clock

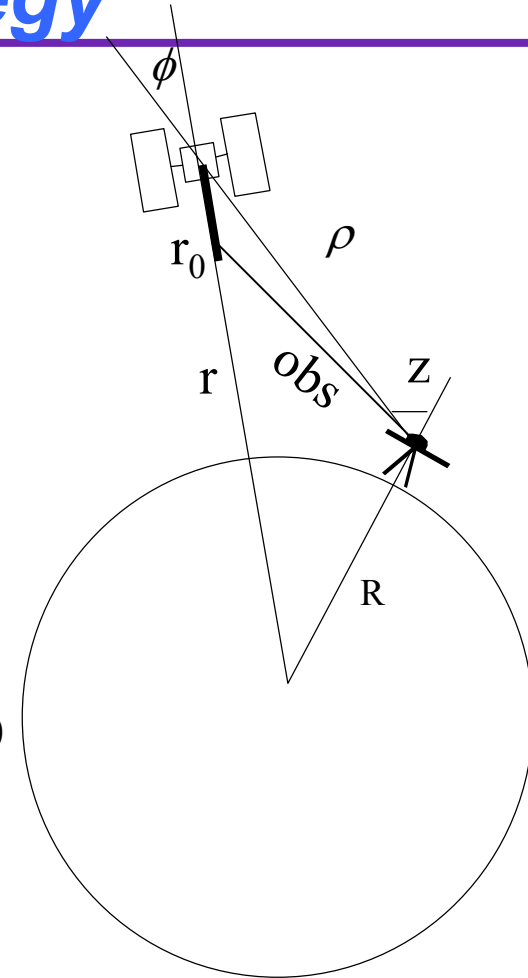
$$pcv(\phi) - r_0 \cos \phi = pcv(\phi) + r_0 (1 - \cos \phi) + r_0$$

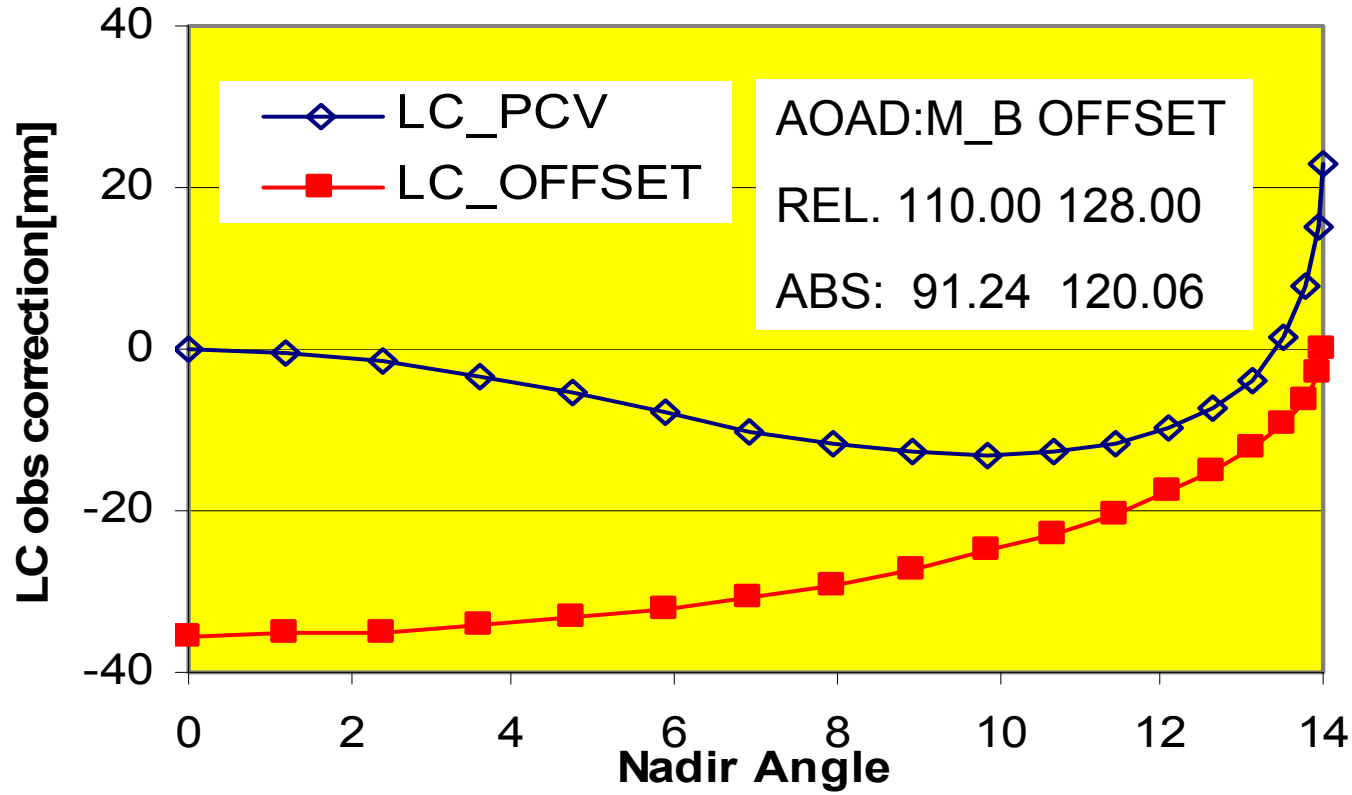
Separate PCV and offset by

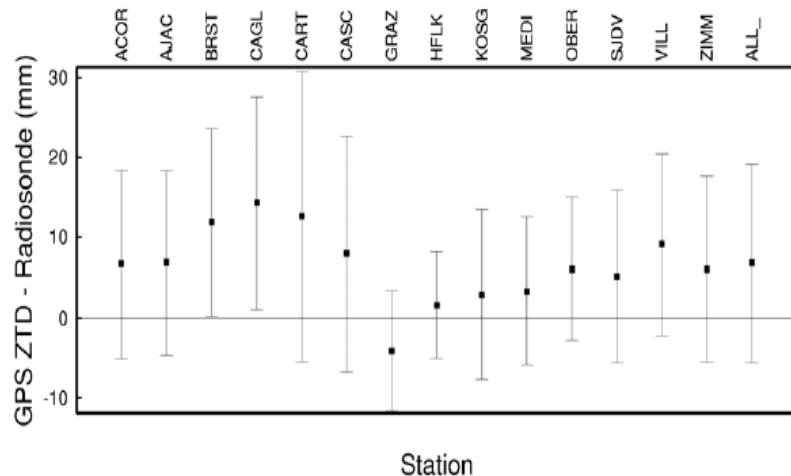
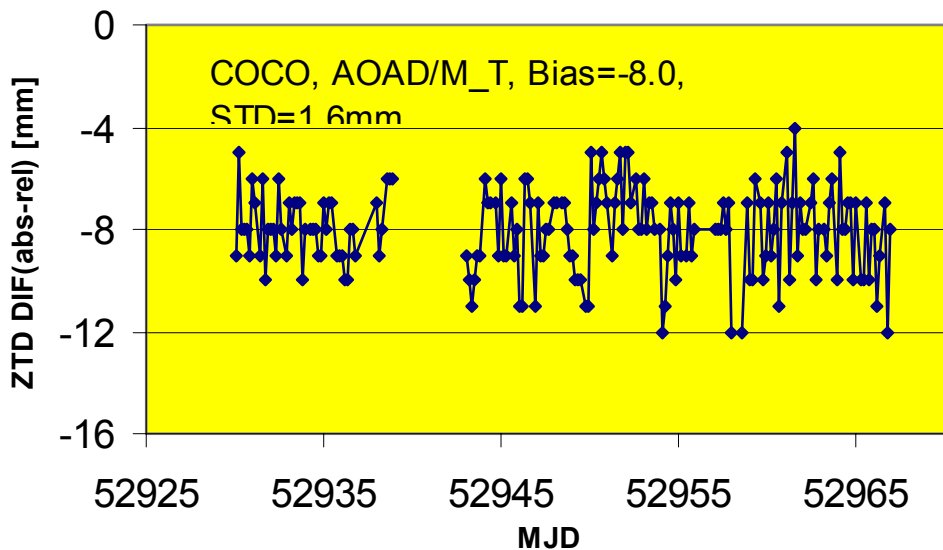
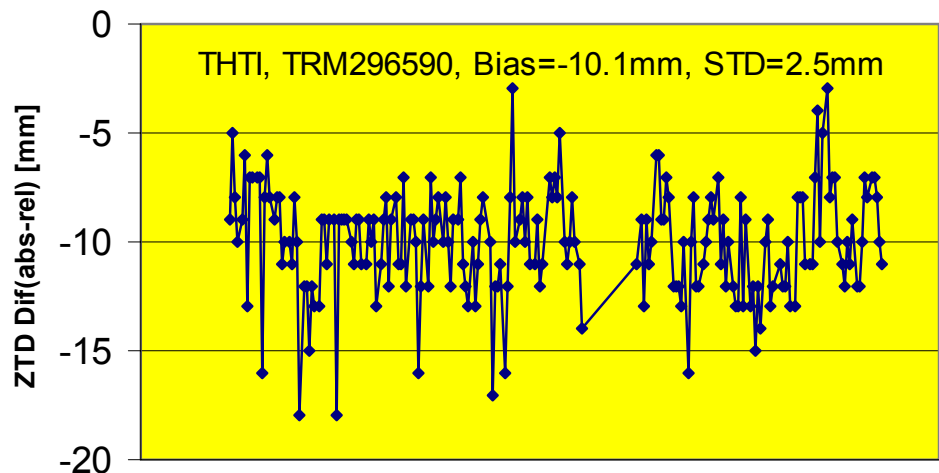
$$pcv_i(\phi_j) = x_i(\phi_j) - \Delta r_i (1 - \cos(\phi_j))$$

where offset is derived by LSQ fit

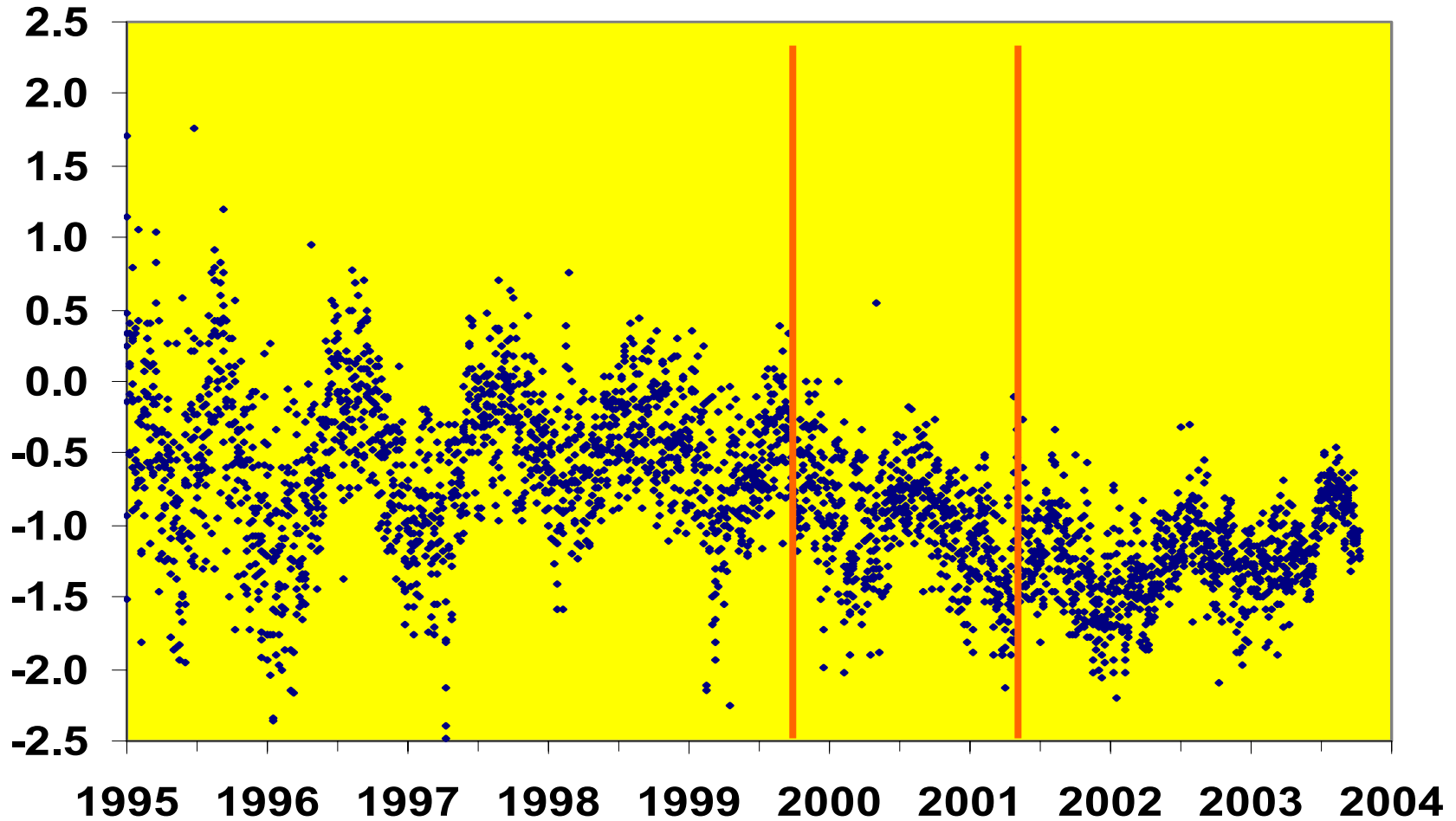
$$\sum_j [x_i(\phi_j) - a_i - \Delta r_i (1 - \cos(\phi_j))]^2 = \min$$







- *Mean and std: -7.0 +/-1.9*
- *Reduces the bias between GPS and Radiosondes*



Scale from GPS to ITRF2000, from <http://sideshow.jpl.nasa.gov/mbh/series.html>

Michael Heflin, Donald Argus, David Jefferson, Frank Webb, James Zumberge,
Comparison of GPS-defined global reference frame with ITRF 2000, GPS
solution(2002) 6:72-75