First activities of the IGS Antenna Working Group

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Comparison of ground- and space-based satellite antenna maps

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IGS Antenna Working Group members

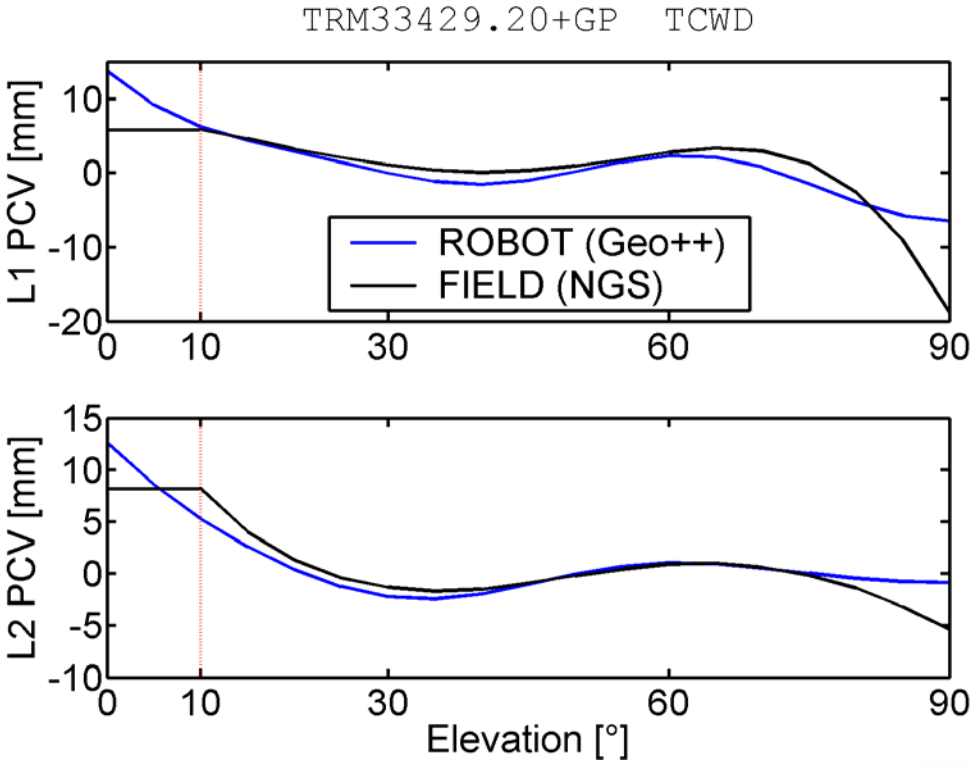
Relative field calibration	G. Mader
Absolute robot calibration	M. Schmitz, S. Schön
Absolute chamber calibration	M. Becker, P. Zeimetz
Satellite antenna corrections	R. Dach, S. Desai, G. Gendt, B. Haines, R. Schmid
IGS antenna files	R. Khachikyan, R. Schmid
IGS network, regional networks	C. Bruyninx (EPN), R. Khachikyan (CB), M. Piraszewski (NAREF), J. Ray (ACC), Reference Frame WG
Equipment testing	S. Fisher, M. Schmitz

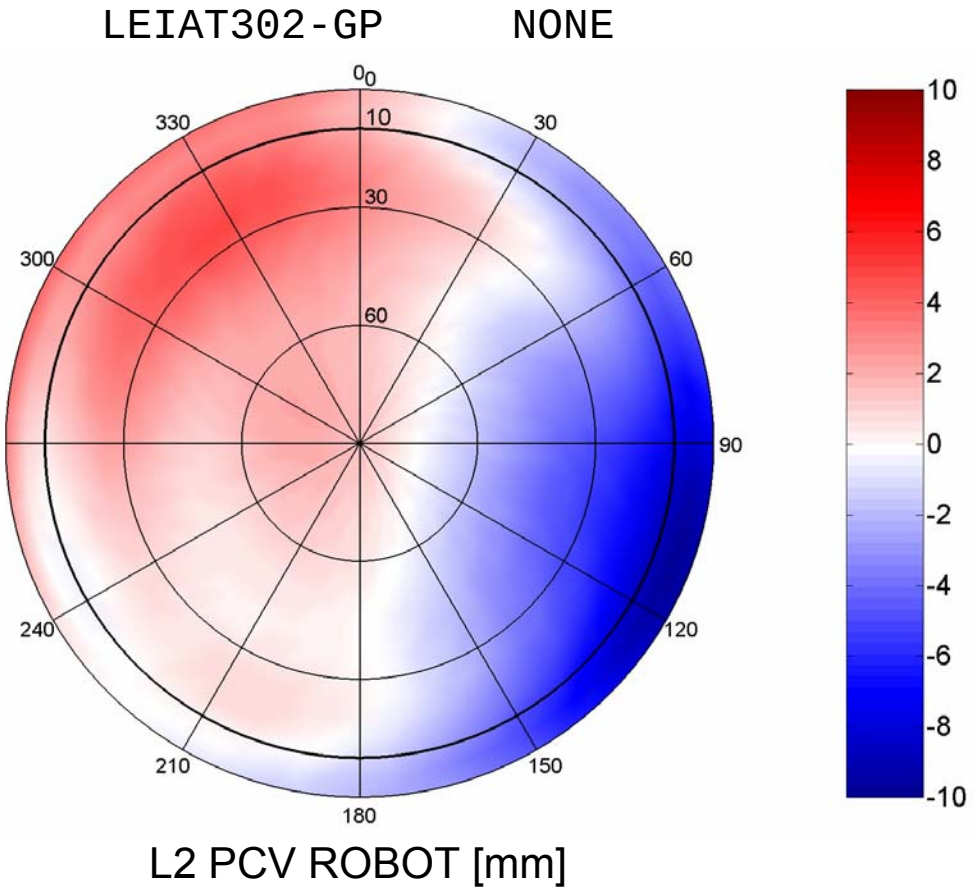
Should additional regional networks be considered?

Recent update of receiver antenna corrections

- Converted field calibration replaced by robot calibration for several EPN antenna types (igs05_1480.atx).
- Update only possible, as antenna types **not** in use!
- Still lots of antenna types with **converted field calibrations** and/or **uncalibrated radomes** within the IGS network.
- Current IGS reprocessing started without an update of the receiver antenna corrections.

Problems with converted field calibrations





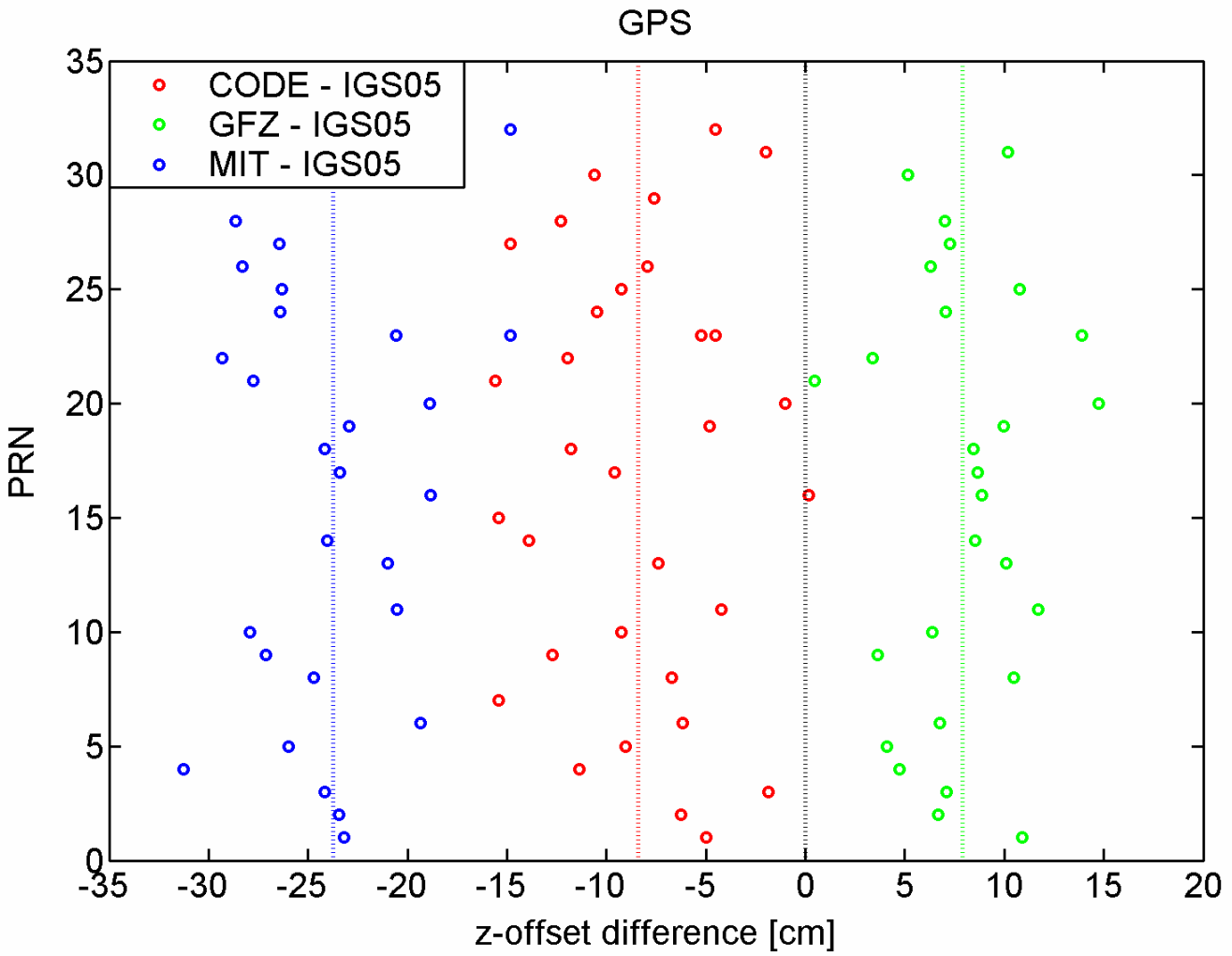
1. Uncertainties with high and low elevations

2. Missing azimuth-dependence

z-offsets for latest satellites

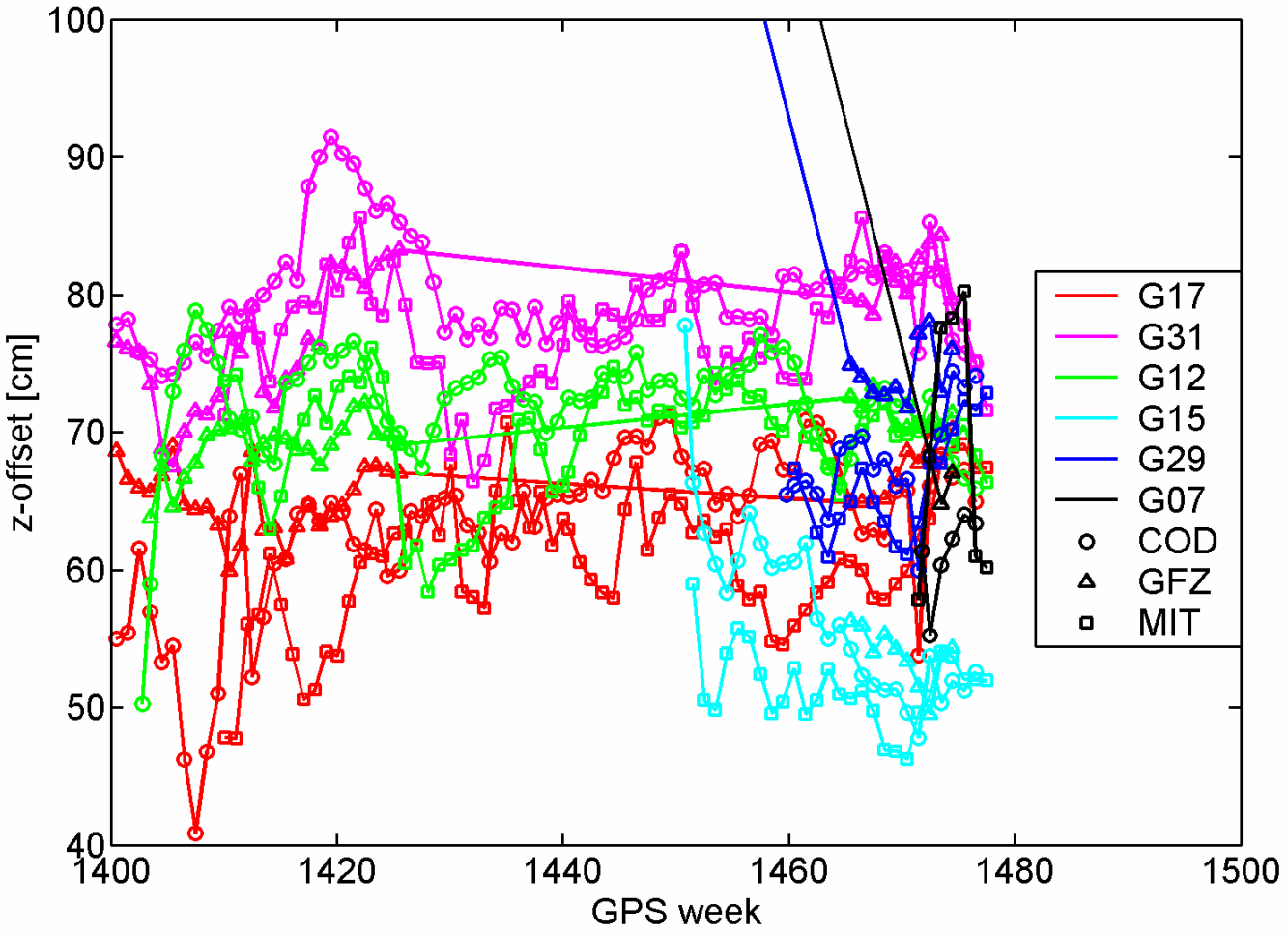
- For **newly launched satellites** block mean values are used, until satellite-specific z-offsets are available.
- At the moment 15 satellites are affected:
  6 GPS Block IIR-M: G07, G12, G15, (G17), G29, (G31)
  9 GLONASS-M: R09, R10, R11, R13, R14, R15, R17, R19, R20 (more than half of the GLONASS constellation)
- Weekly **SINEX** files of several ACs contain satellite antenna offset estimates: COD, GFZ, MIT, (EMR)
- Could the procedure to generate z-offsets for new satellites somehow be added to the routine IGS SINEX combination?

z-offsets estimated for all satellites



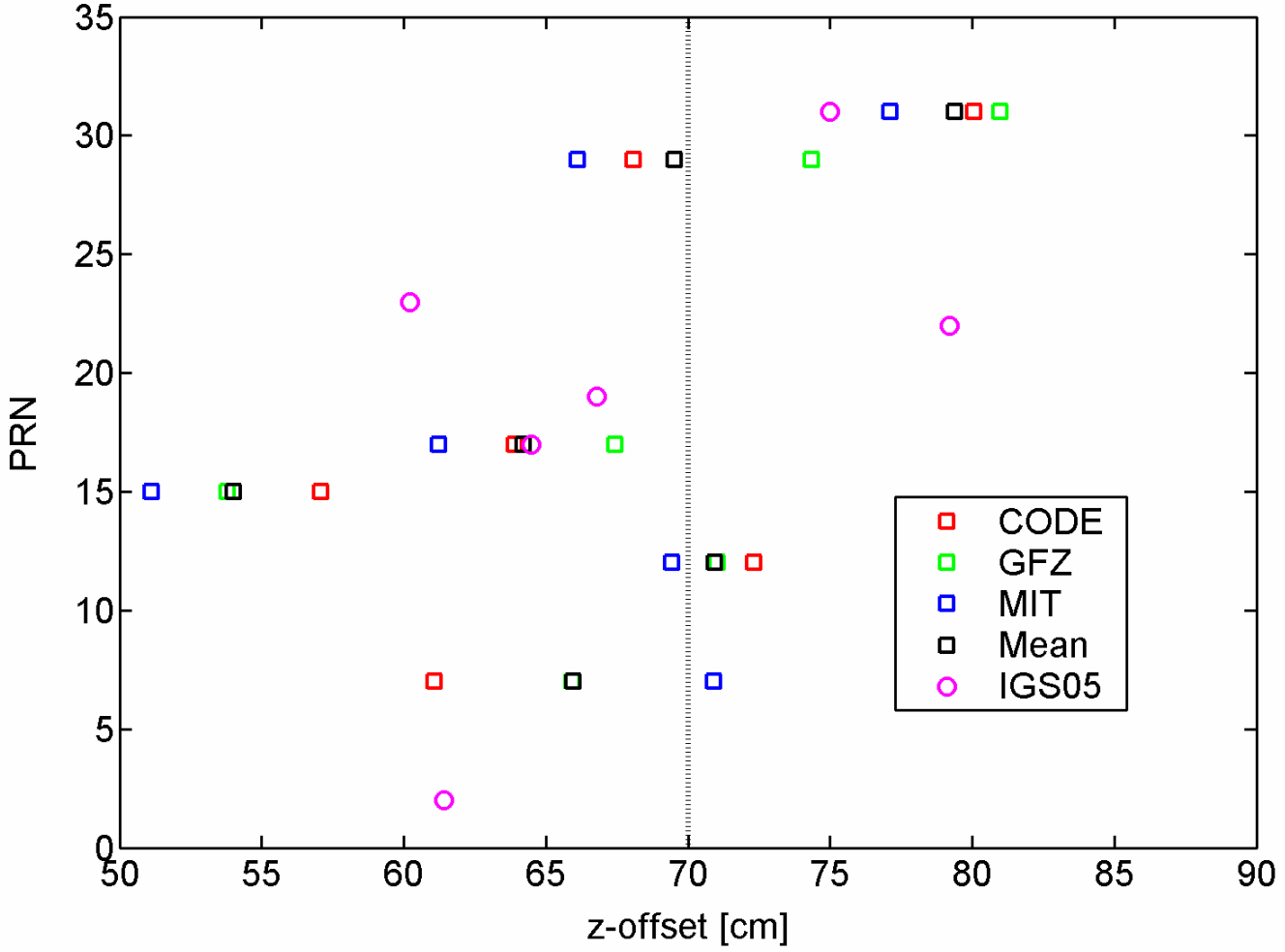
- large **biases** between individual ACs
- AC offsets would have to be trend-corrected to epoch 2000.0 (about +15 cm)

Known z-offsets fixed



- data of the early days of a satellite not usable
- GFZ with data gap
- scatter of about **±10 cm**
- good agreement on the proportion of the offsets to each other
- fewer problems with biases and trend-correction

Block IIR-B/M z-offsets



- excellent agreement with IGS05 for G17
- biggest inconsistencies for latest satellites (G29, G07)
- deviations of up to **15 cm** from block mean value

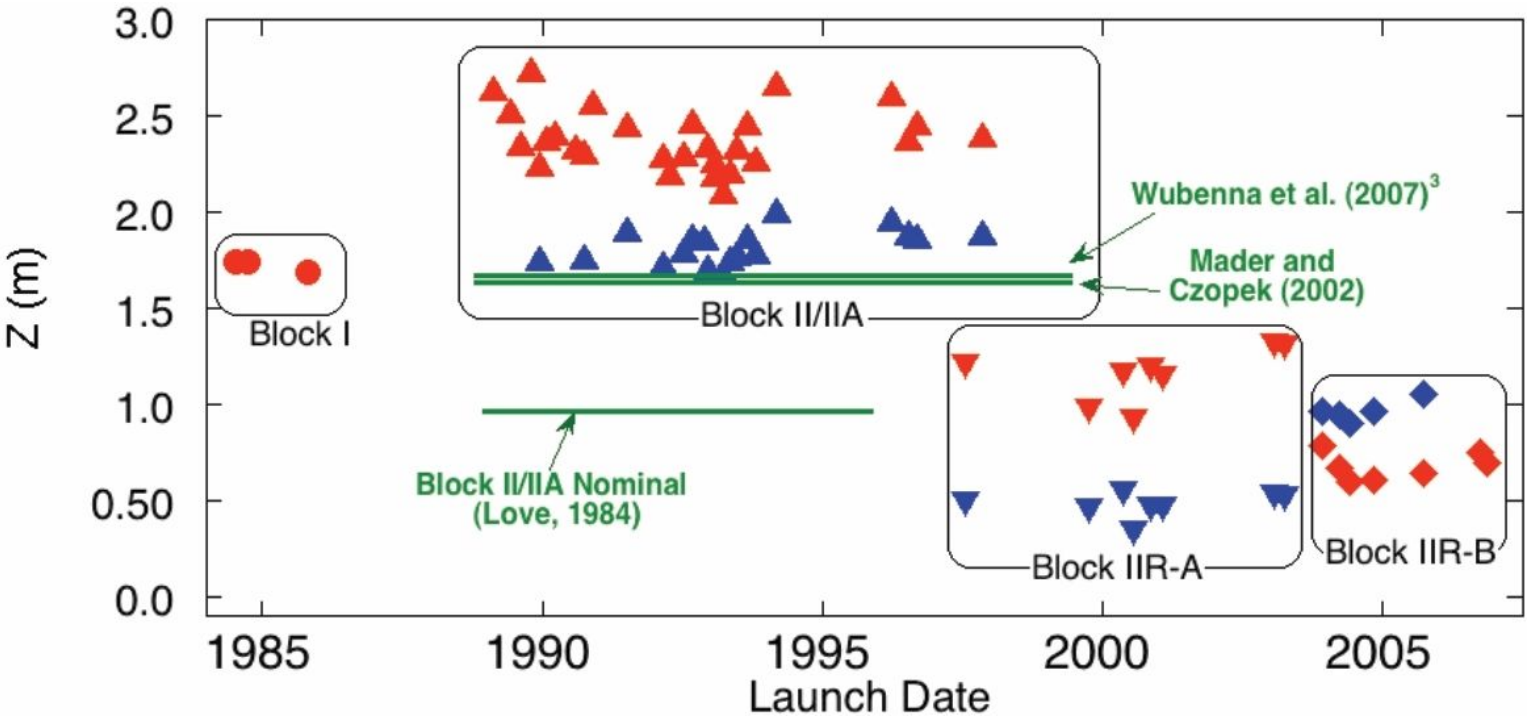
Major goals of the IGS Antenna WG

- maintenance of **IGS antenna files** and file formats; setting up of rules for the maintenance
- combination of ground- and space-based satellite antenna corrections (in view of **azimuth-dependence** and PCV values for **big nadir angles**)
- comparison of different receiver antenna calibration procedures; recommendations for antenna mounts
- **frequency-specific** phase center corrections (L1/L2 instead of LC, GLONASS, Galileo)
- contact point for antenna manufacturers and the user community

Ground- vs. space-based satellite antenna maps

	ground-based (IGS05)	**space-based** (JPL)
method	global solution including all relevant parameters	stacking of LEO (GRACE, Jason-1,...) tracking data residuals
scale	ITRF scale has to be fixed	orbit scale from dynamical POD constraint (GM)
troposphere	correlated with phase center corrections	troposphere-free
receiver antennas	deficiencies of individual calibrations might cancel out	dependence on the calibration of one single tracking antenna
azimuth-dep.	test results available	fully available
nadir angle	< 14.3°	< 15.4° (at GRACE altitude)
estimation possible for	all satellites (system operational, enough tracking stations)	all satellites active during LEO mission (Block I ?)
freq., signals	LC only	LC and PC (pseudorange)

Ground- vs. space-based z-offsets (I)

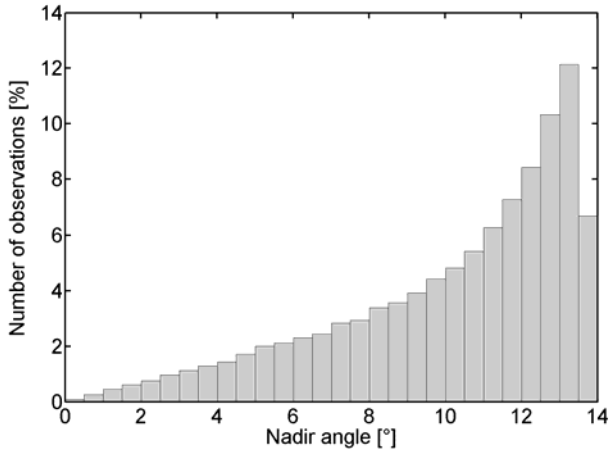


Haines et al. (2007):

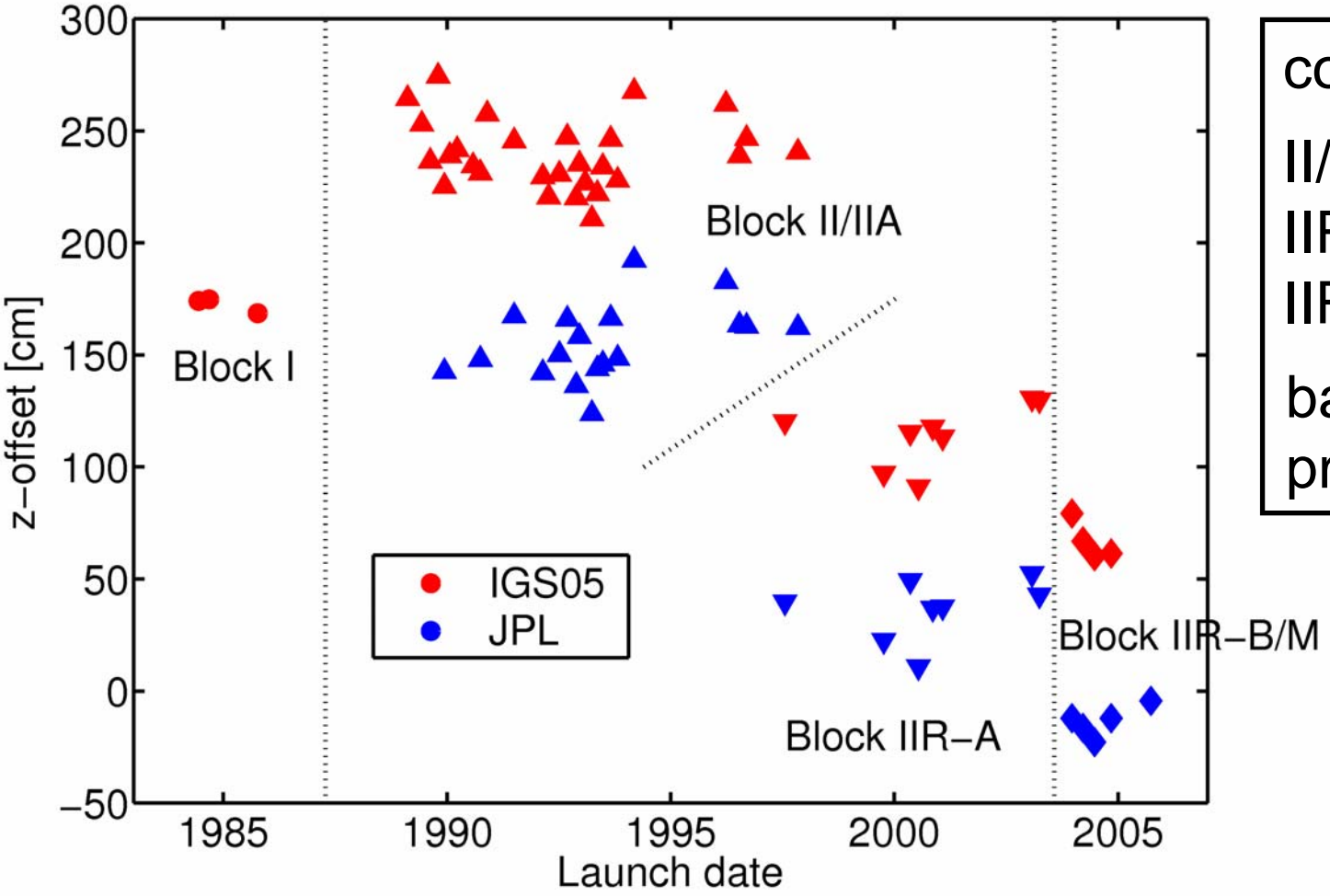
IGS05 ground-based z-offsets

JPL GRACE-based z-offsets

Separation of the phase center correction into PCV and PCO is arbitrary. PCV/PCO have to be consistent! Differing bias for Block IIR-B can be explained by special weighting.



Ground- vs. space-based z-offsets (II)

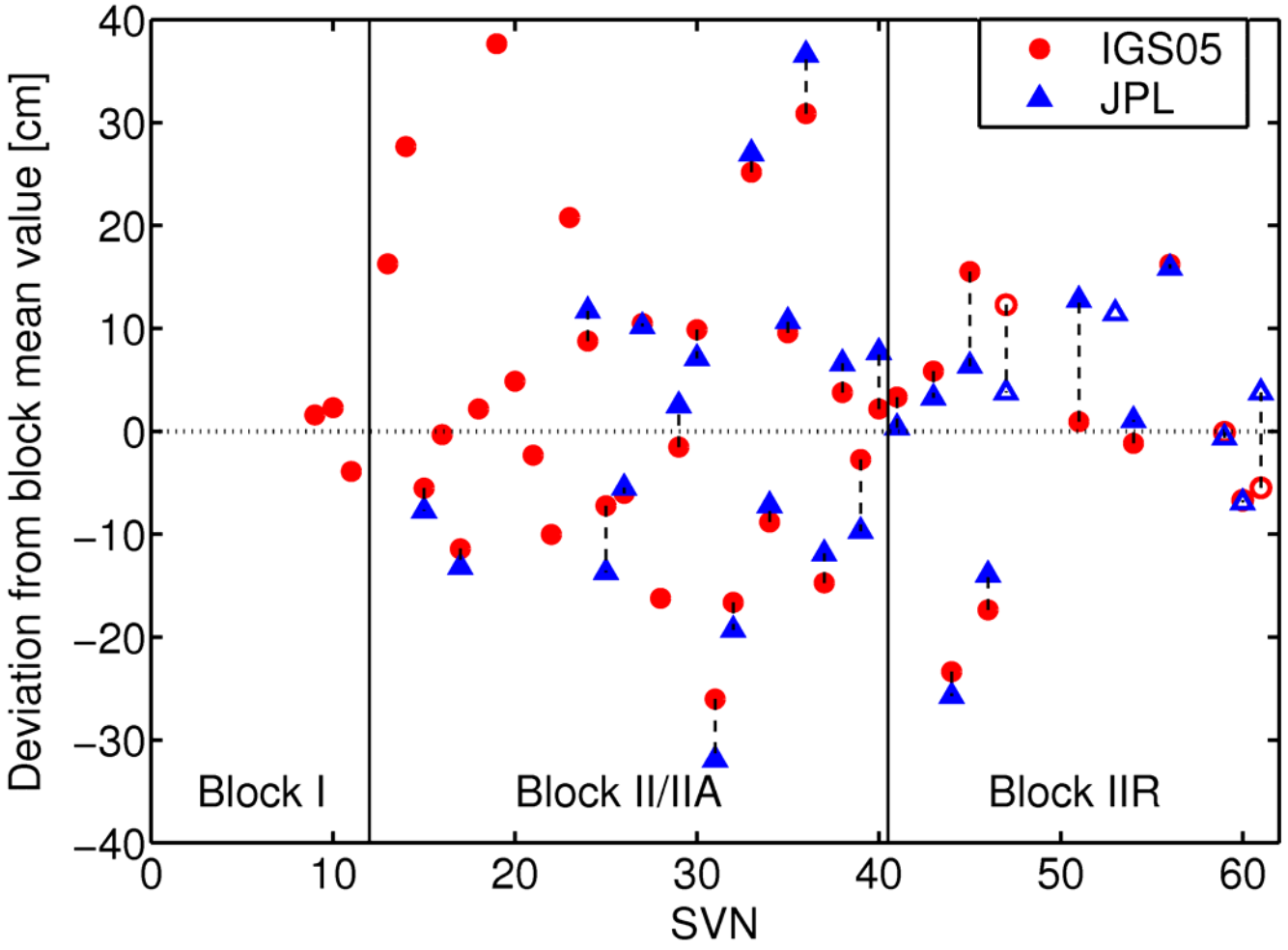


consistent **bias**:

II/IIA	81.0 cm
IIR-A	77.9 cm
IIR-B/M	82.8 cm

basically a **scale** problem (≈ **6 ppb**)

z-offsets compared to block mean value



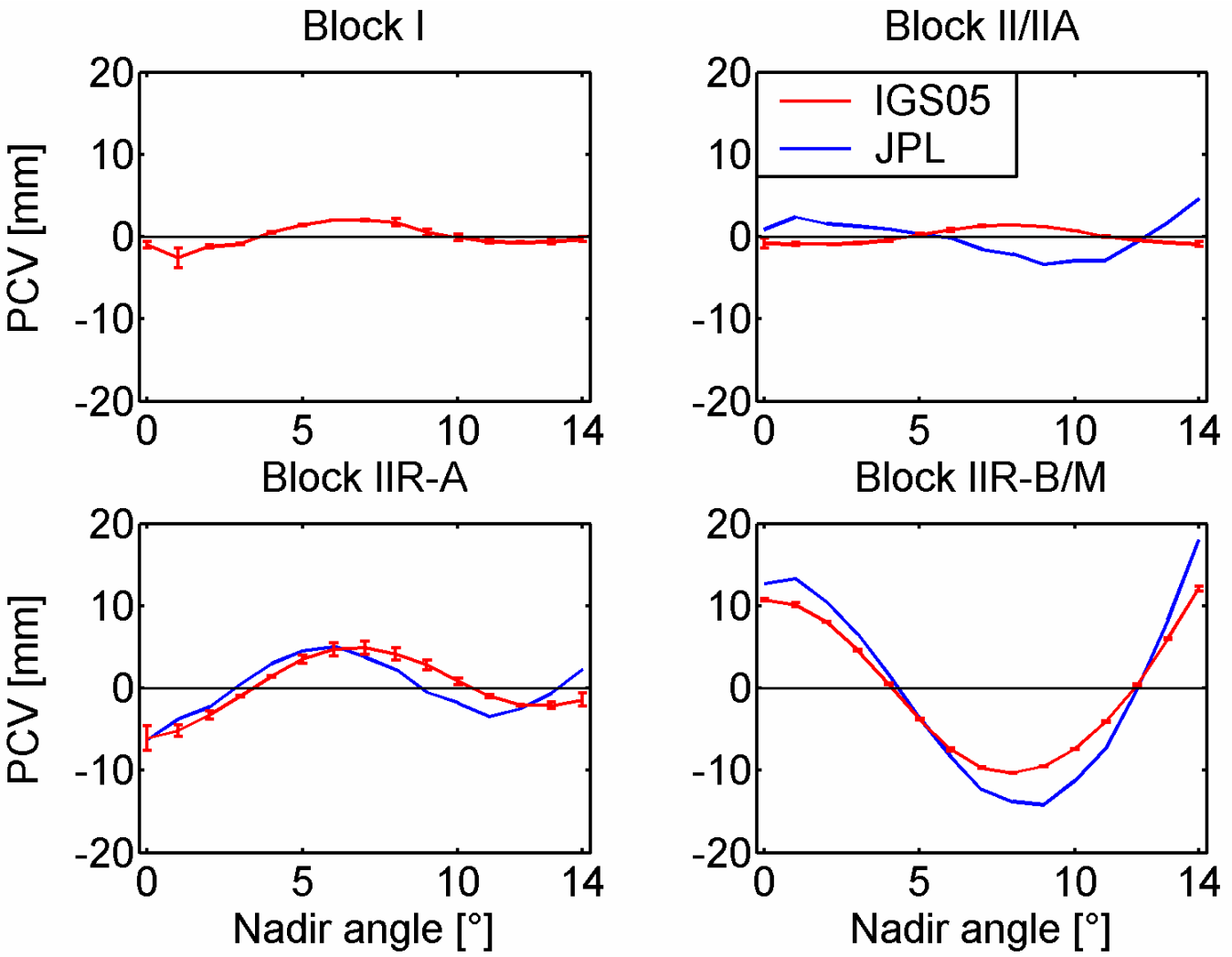
peak-to-peak:

II/IIA	**~ 70 cm**
IIR-A	~ 40 cm
IIR-B/M	~ 20 cm

mean difference:

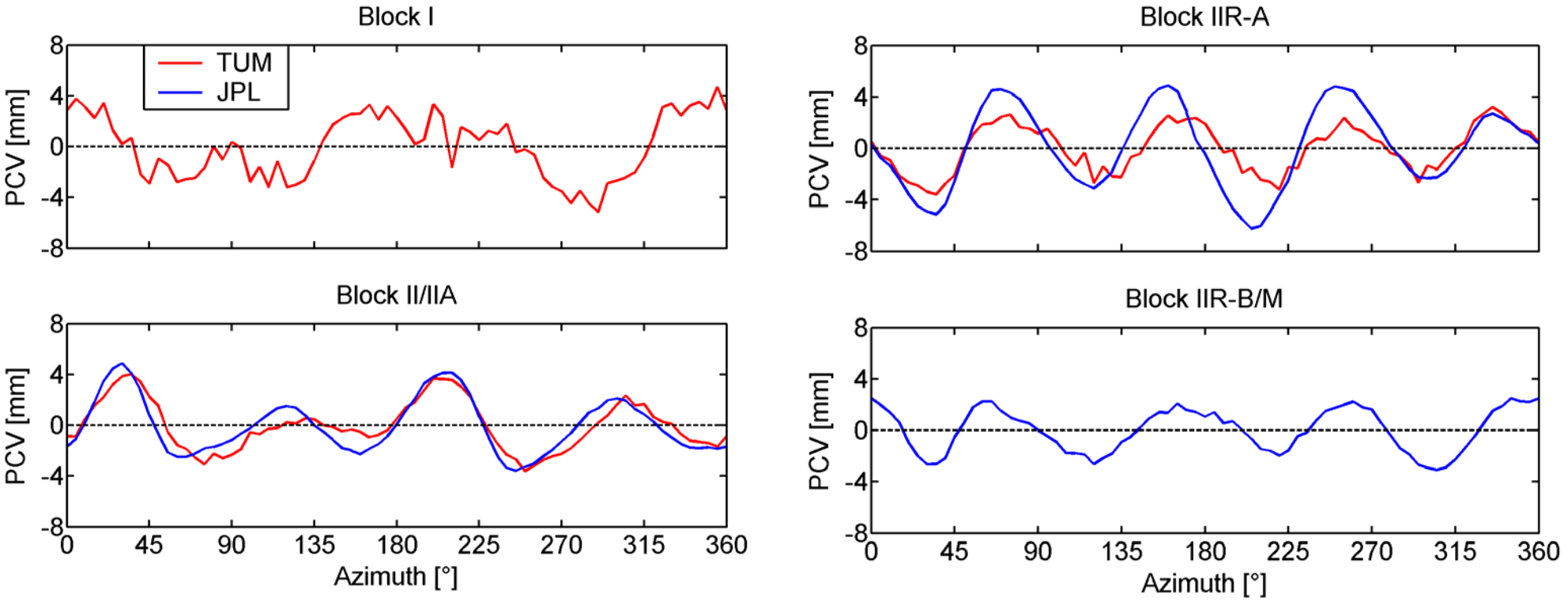
II/IIA	**3.2 cm**
IIR-A	4.4 cm
IIR-B/M	4.6 cm

Nadir-dependent PCVs

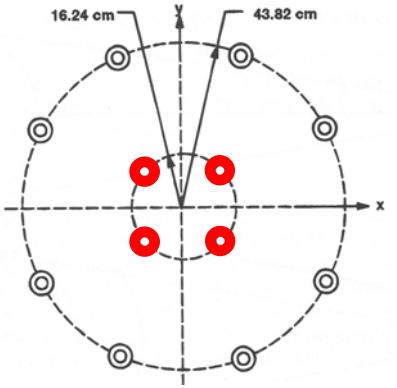


- error bars show difference between GFZ and TUM
- good agreement for Block IIR
- **systematic difference**

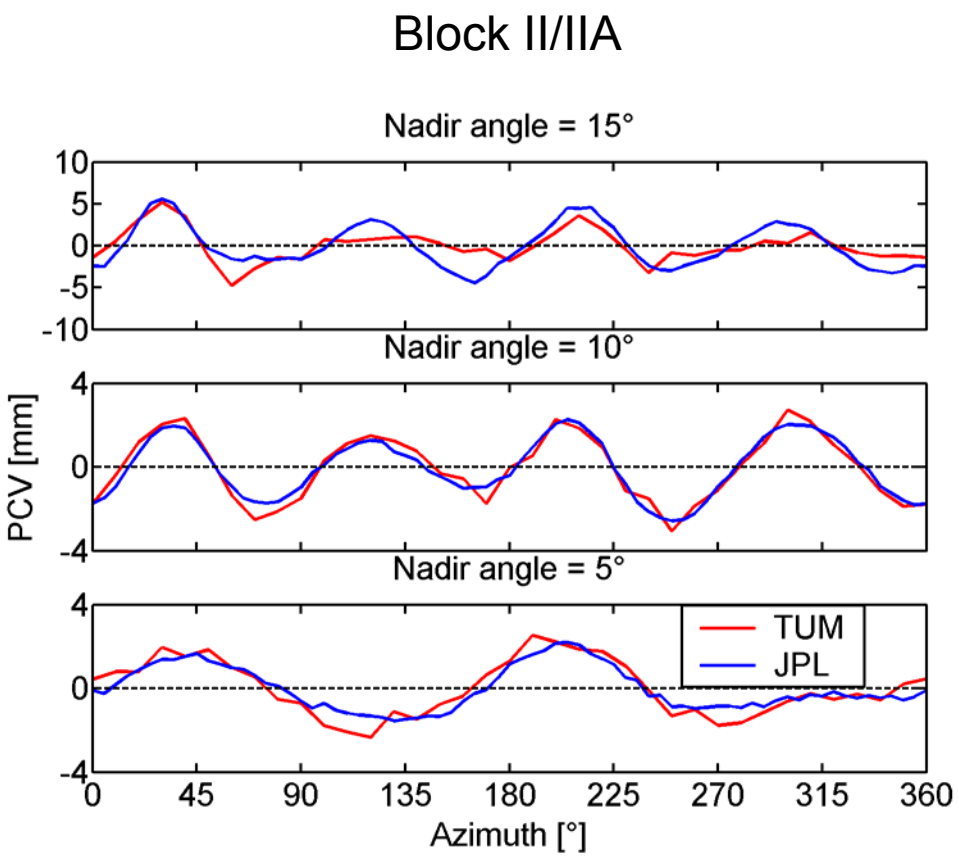
Azimuth-dependent PCVs (nadir angle = 14°)

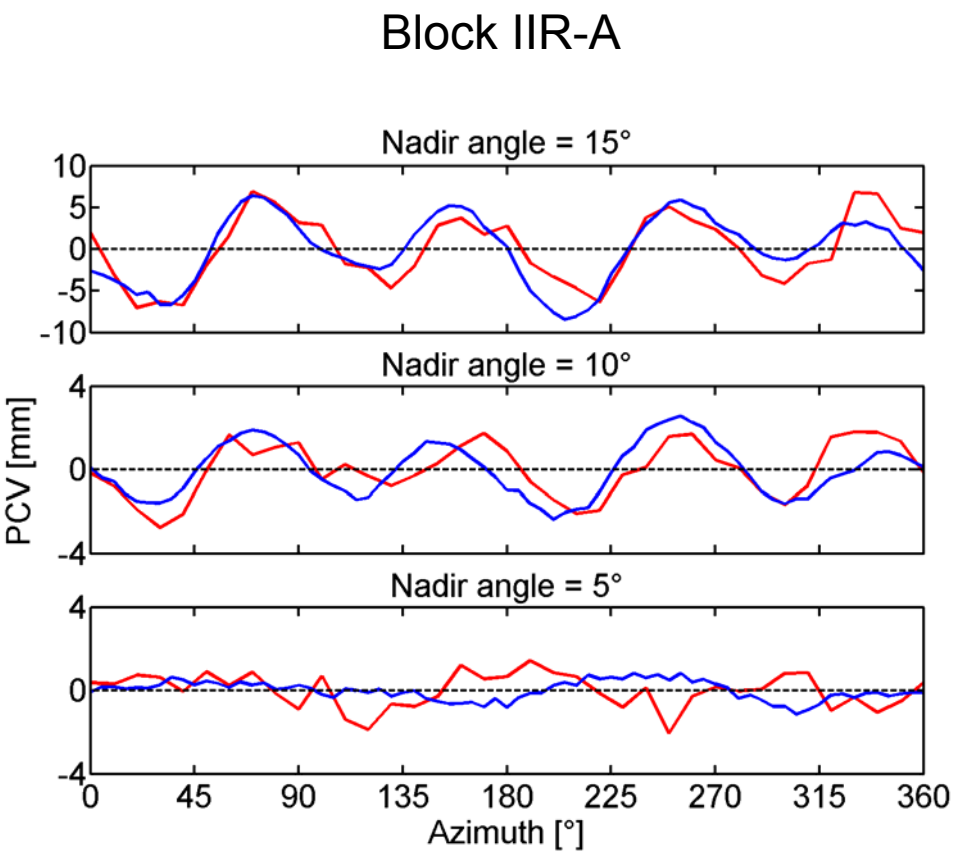


- TUM results based on a few days of data only (Schmid et al., 2005)
- JPL values shifted by 90° in azimuth direction
- different resolution in nadir: 14° (TUM), 1° (JPL)



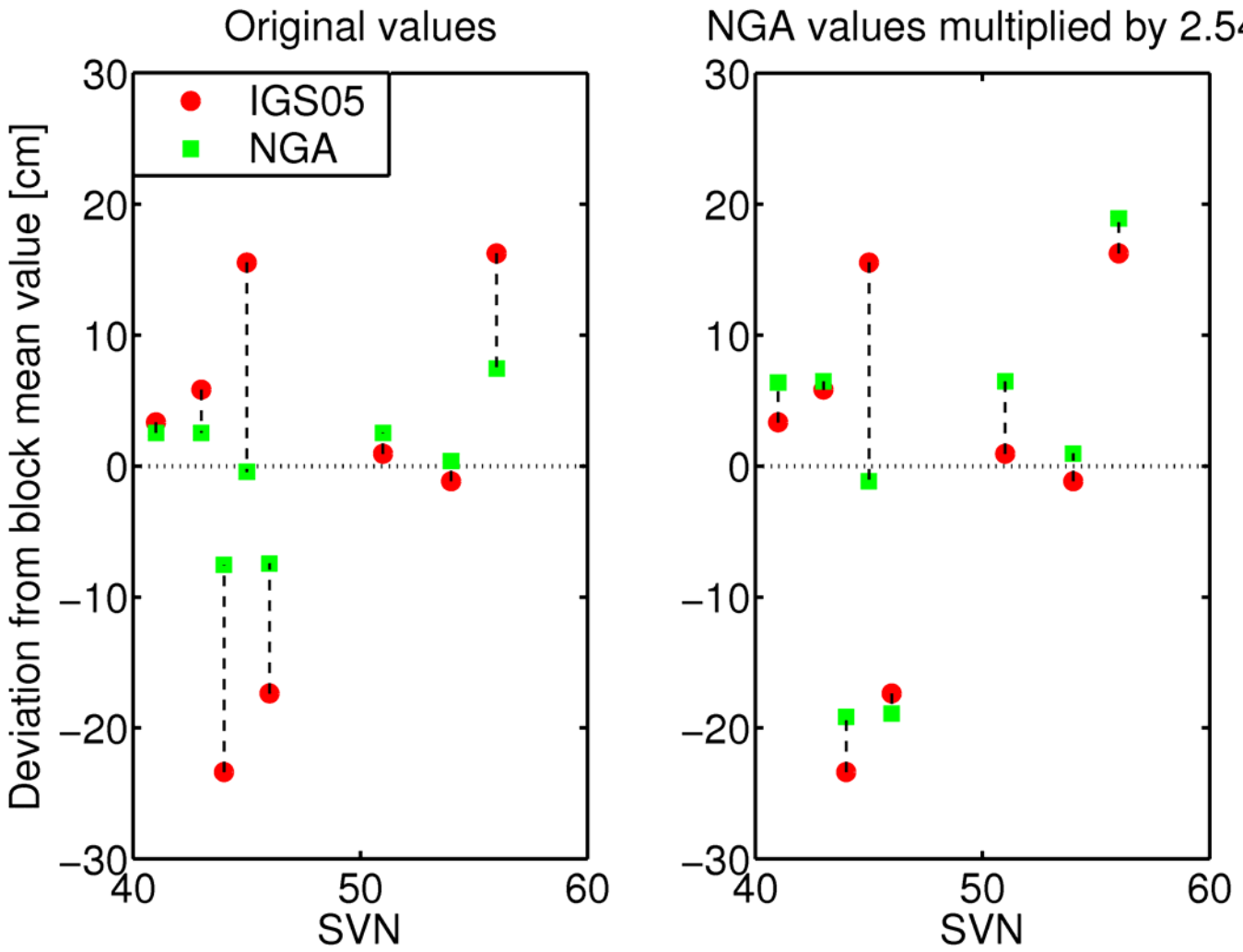
Azimuth-dependent PCVs (different nadir angles)





- different resolution in nadir: 5° (TUM), 1° (JPL)
- nearly perfect agreement in amplitude and phase

IGS05 vs. NGA z-offsets



- origin of NGA values not clear
- better agreement after scaling NGA values (1 Inch = 2.54 cm)

Conclusions

- Replacement of **converted field calibrations** essential for highest precision.
- Update of **z-offsets for latest satellites** pending; routine procedure should be installed.
- Partially excellent agreement between IGS05 and JPL phase center corrections.
- **Scale difference** of about 6 ppb has to be analyzed.
- **Azimuth-dependent** satellite antenna PCVs should be considered.
- Contact to the providers of the NGA values would be worthwhile.


Thanks for
your attention!
Photo: Enrique Cabral, UNAM