PCV Issues!!!

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Issues?

Two approaches for estimating PCV of GPS sats from tracking data

- Robot-based/ground-based/ITRF-fixed (GFZ/TUM/IGS)
- GRACE-based/space-based (JPL)
- The resulting PCVs are clearly different
- No compelling evidence yet to suggest which one is superior

Key differences (are they meaningful?):

- Significant bias in Z-offset/scale
- Drift
- Elevation angle span

Other PCV issues:

- PCV extrapolation for LEOs
- The relationship between PCVs and offset values

Related issues:

- Ties with other techniques require PCVs
- How to maintain PCVs with the evolving GNSS/ITRF

GPS Nadir (+Z) Phase Center Offsets
GRACE- Vs. Ground-based (IGS) Solutions

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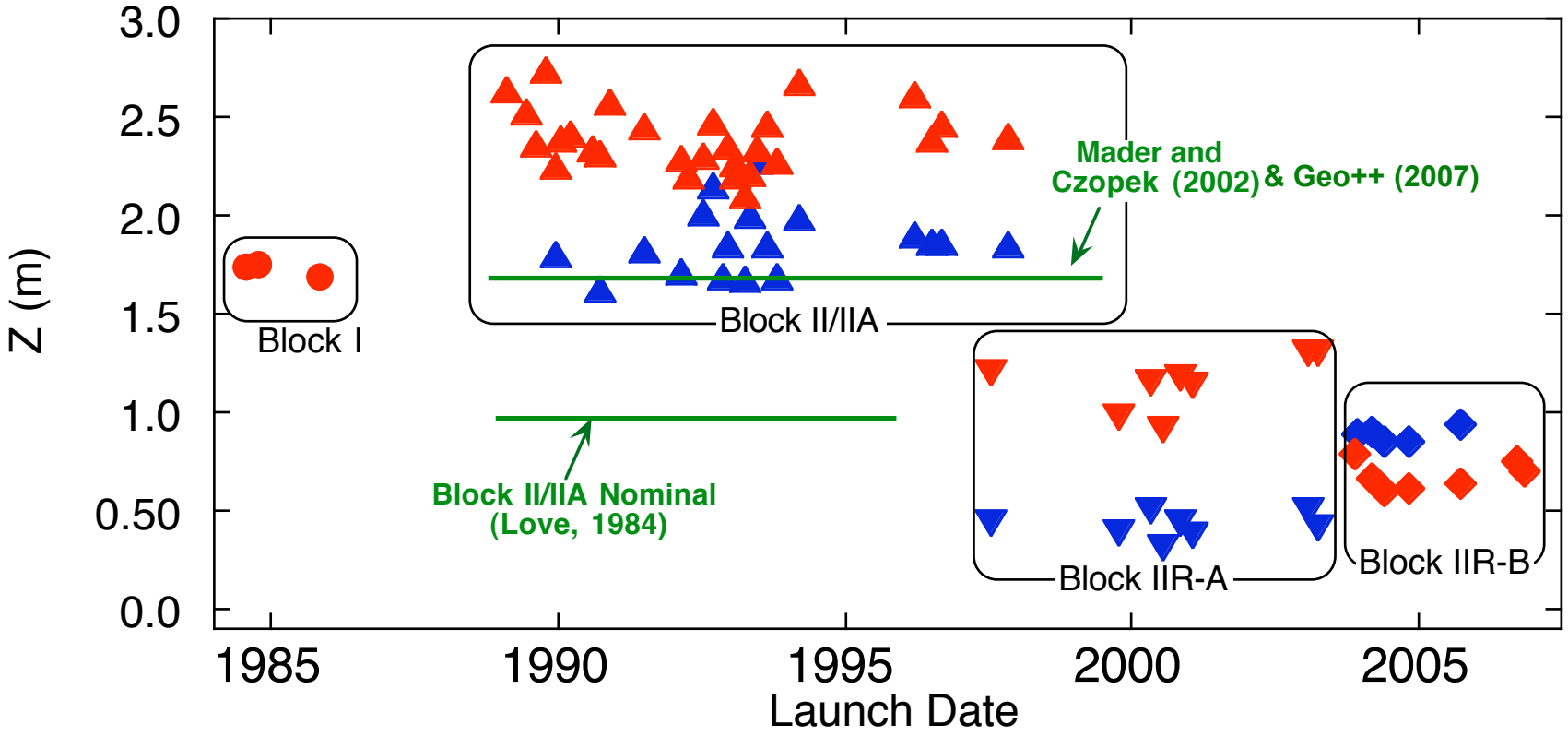


▲ GRACE[1] Block II/IIA:	+1.87 ± 0.17 m	● Ground[2] Block I:	+1.73 ± 0.03 m
▼ GRACE[1] Block IIR-A:	+0.42 ± 0.06 m	▲ Ground[2] Block II/IIA:	+2.40 ± 0.16 m
◆ GRACE[1] Block II/IIA:	+0.89 ± 0.04 m	▼ Ground[2] Block IIR-A:	+1.14 ± 0.14 m
		◆ Ground[2] Block IIR-B:	+0.68 ± 0.07 m

1 From equi-area fitting of map to A – Bcos ϕ, where ϕ is the off- nadir angle and B is the phase-center offset in the Z direction.

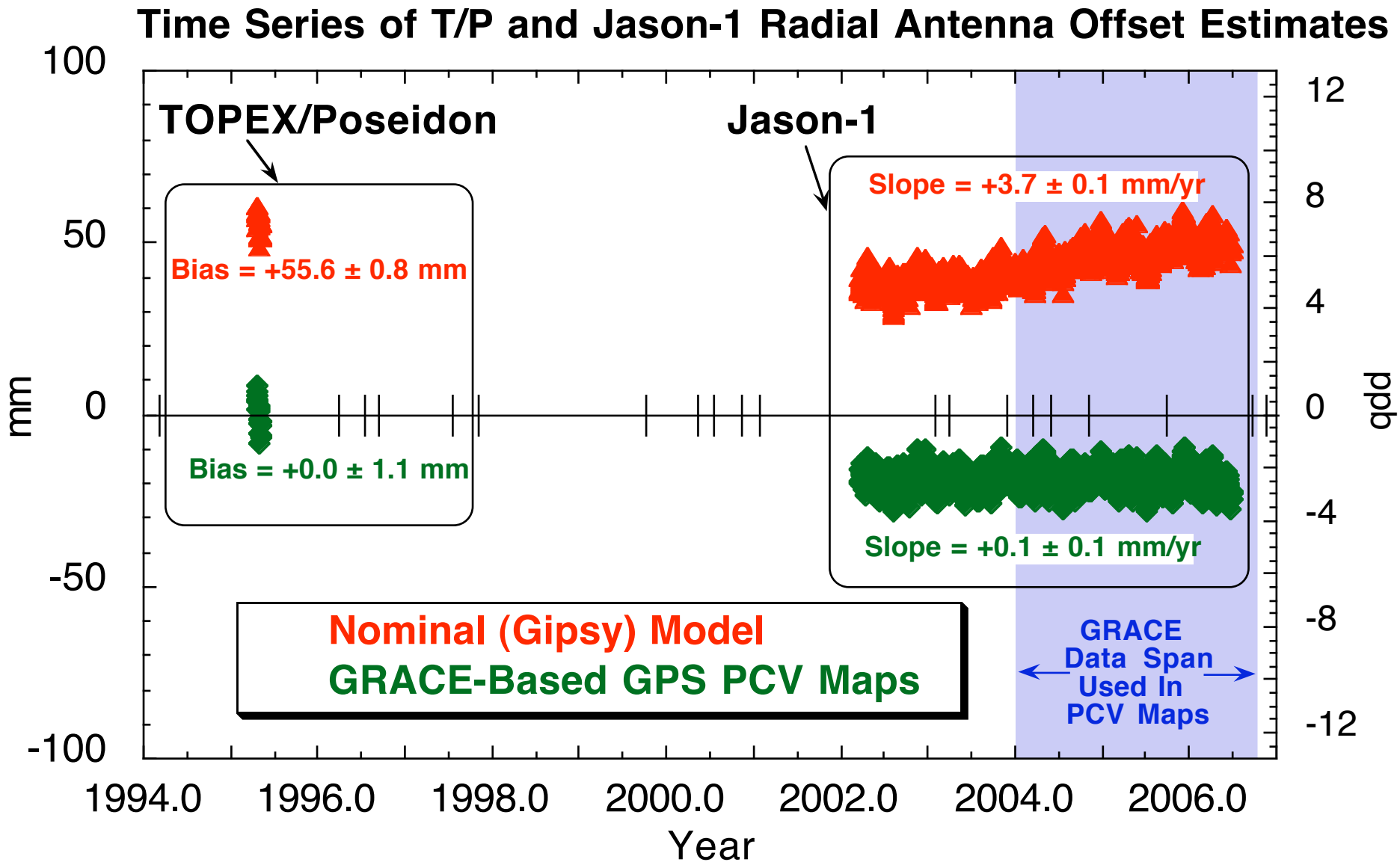
2 TUM/GFZ Ground Network Solution (igs05_1402.atx; e.g., Schmid and Gendt, 2005)

Biases in Derived Offsets

Biases in the Z-offset of GPS sats induce scale difference in ground positions (and vice versa)

- Bias in the vertical position of ground sites (between JPL and ITRF/IGS approaches) could be attributed to 'typical' multipath
- Biases observed with the GRACE-based PCVs are consistent with different levels of multipath
  - **0 cm Topex Z-offset (used to be 5 cm w/o PCVs)**
  - **2 cm Jason Z-offset**
  - **3.6 cm Ground Z-offset (scale)**
- As long as ground PCVs and sat PCVs are consistent, is there a problem?
  - **Possibly meaningful trop bias (easy to verify; may be a discriminator)**
  - **What happens when the ground environment changes?**
  - **Distortions are introduced in site positions due to (weak) dependence on elevation angle cutoff**

T/P Radial Antenna Offset Explained



Drifts

- **No discernable scale drift using the GRACE-based PCV approach**

- **Maps that depend on ITRF00/IGS00 are likely to contain scale drift**
  - With appropriate elevation angle confinement of IGS sat PCVs we see no drift in Jason's offset
  - Are there residual drifts in ITRF05?
  - Will the changing configuration of the ground sites introduce a drift (due to change in multipath environment) ?

GPS Transmitter PCV Maps Explain Anomalous Estimated Radial Antenna Offsets for Jason-1

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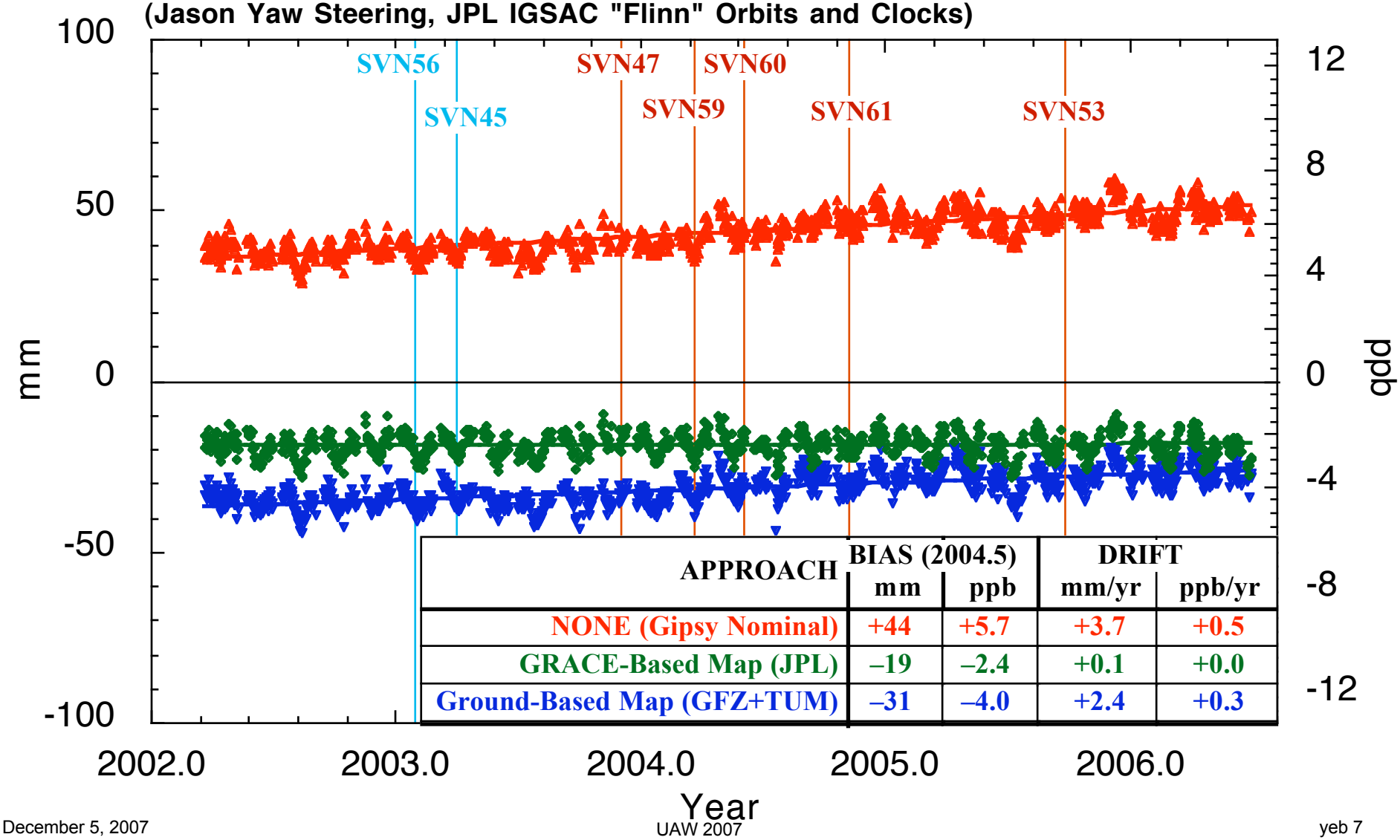
Time Series of Jason-1 Radial Antenna Offset Estimates

(Jason Yaw Steering, JPL IGSAC "Flinn" Orbits and Clocks)



APPROACH	BIAS (2004.5) mm	BIAS (2004.5) ppb	DRIFT mm/yr	DRIFT ppb/yr
NONE (Gipsy Nominal)	+44	+5.7	+3.7	+0.5
GRACE-Based Map (JPL)	–19	–2.4	+0.1	+0.0
Ground-Based Map (GFZ+TUM)	–31	–4.0	+2.4	+0.3

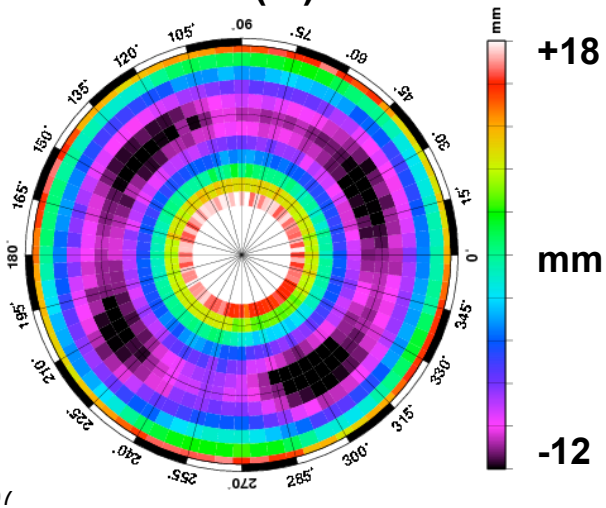
PCV and offsets

There is no 'correct' way to derive offsets (eg, z offset) from PCV maps

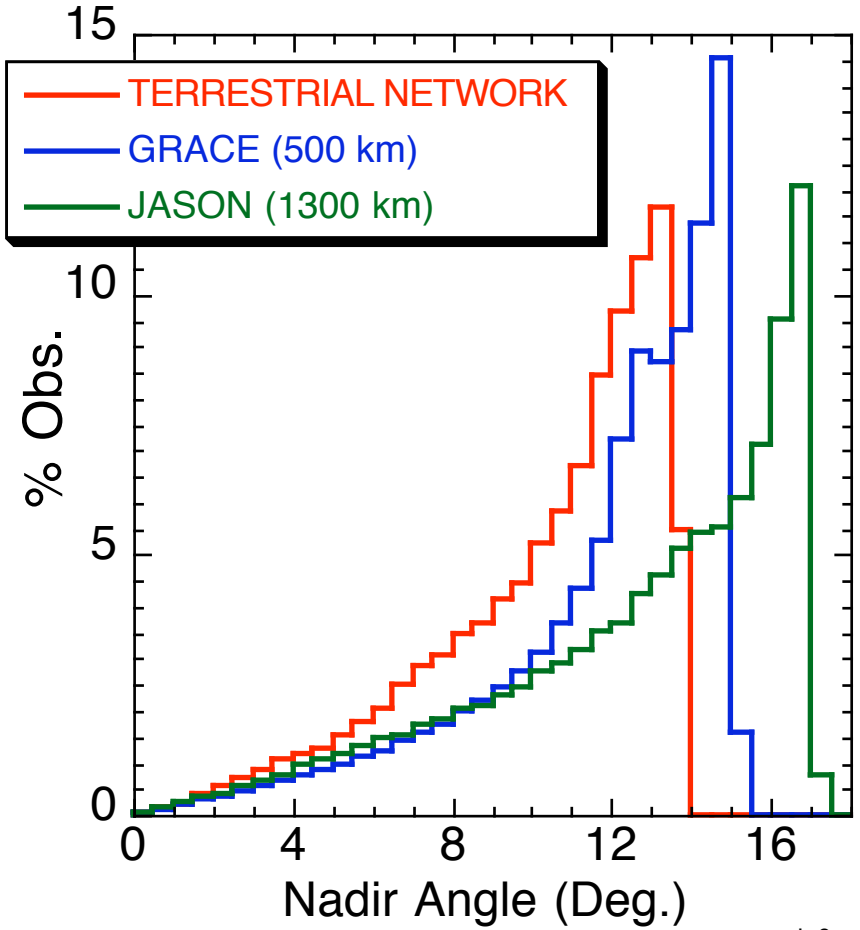
Value depend on elevation angle range, data weight

- The PCV itself depend on range of elevation angles observed
- Block IIR-B maps do not look dominated by z-offset, and are particularly sensitive to the derivation method and elevation cutoff
- How to apply maps at LEOs?
- Should we only specify PCV?

Block IIR-B(M) PCV



Sampling of GPS Transmitter Beam Pattern



PCV and Collocation Ties

Assuming local multipath is a significant factor in GPS, and could vary in time, local survey techniques to establish collocation ties are highly suspect (ignoring the challenges of precision survey techniques)

How to tie the *phase centers* of the collocated techniques?

Geodetic Reference Antenna in Space (GRASP)

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The GRACE approach has a number of weaknesses at present:

- The GRACE GPS antenna was not precisely calibrated on the ground
- The satellite orbit is very low, susceptible to dynamic mismodeling
- The SLR/GPS baseline onboard is not known at the mm level
- Cannot use the spacecraft to collocate other techniques: DORIS, VLBI

These shortcomings could be addressed with a dedicated mission: GRASP, which is currently being pursued by NASA/JPL

- Collocate all the techniques on one spacecraft to sub-mm
- Calibrate all sensors to sub-mm
- Design spacecraft and orbit to facilitate sub-mm POD

An ideal platform with which to assess cross-technique combination/unification