Relative vs Absolute Antenna Calibrations:

How, when, and why do they differ?

A Comparison of Antenna Calibration Catalogs

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Purpose

Compare NGS relative catalog to the IGS catalog of absolute calibrations, and determine if/when/why the two catalogs are similar or different.

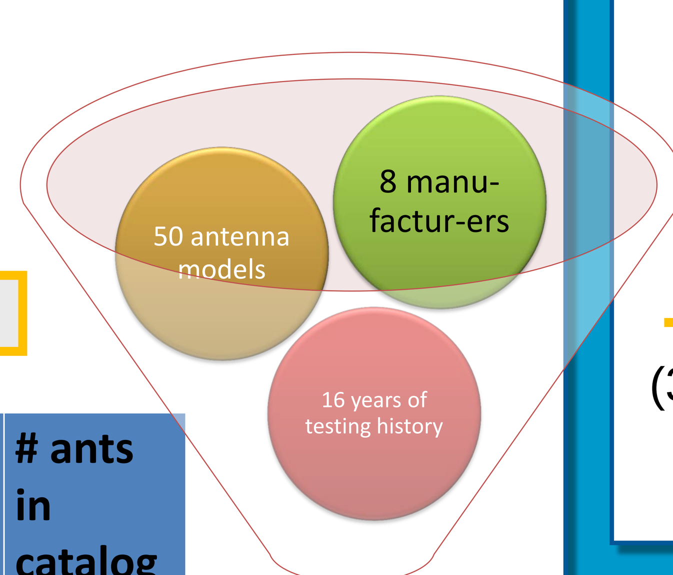
QUESTIONS WE WANT TO ANSWER

- when it is or is not valid to process a geodetic network using a combination of relative and absolute calibrations?
- if/when it is valid to combine the NGS and IGS catalogs?

Data

Calibration Catalogs

Purpose	File name / URL	Published version [download date]	# ants in catalog
NGS relative calibrations	ant_info.003 http://www.ngs.noaa.gov/ANTCAL/LoadFile?file=ant_info.003	13/09/20 [2013 Nov 11]	415
IGS absolute calibrations	igs08.atx http://igscb.jpl.nasa.gov/igscb/station/general/igs08.atx	week 1764 [2013 Nov 11]	255



76 *antennas in common*

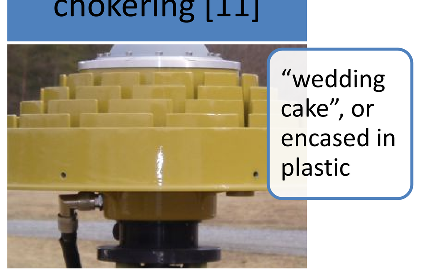
Antennas which are copies between catalogs were excluded from this study, but are included in the "total # receiving antennas".

Antenna Classification

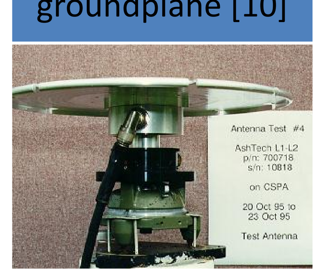
Number of antennas in group given in square brackets

Chokering [38]

Non-standard chokering [11]

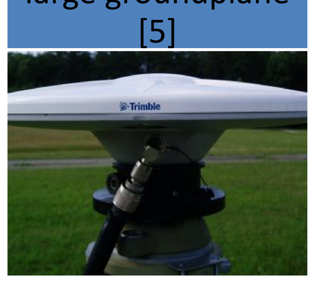


Patch with groundplane [10]



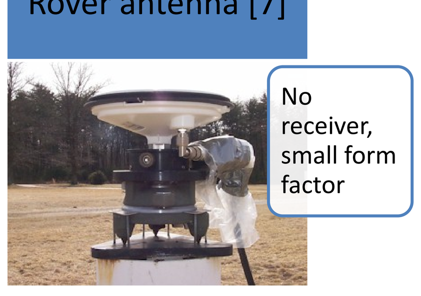
Patch without groundplane [1]

Geodetic with large groundplane [5]



Integrated receiver/antenna unit [4]

Rover antenna [7]

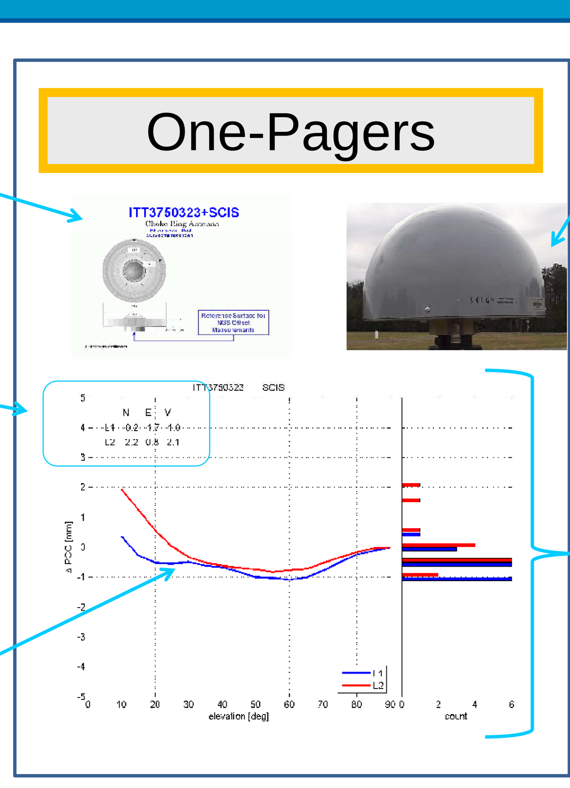


Antenna diagram

Difference in PCO *Aggregated to generate ΔPCO stats (right)*

Difference in PCC *(see 2b above)*

One-Pagers



Antenna photo

Sideways histogram of PCC differences: indicates number of ΔPCC points with that difference *Aggregated to generate ΔPCC stats (right)*

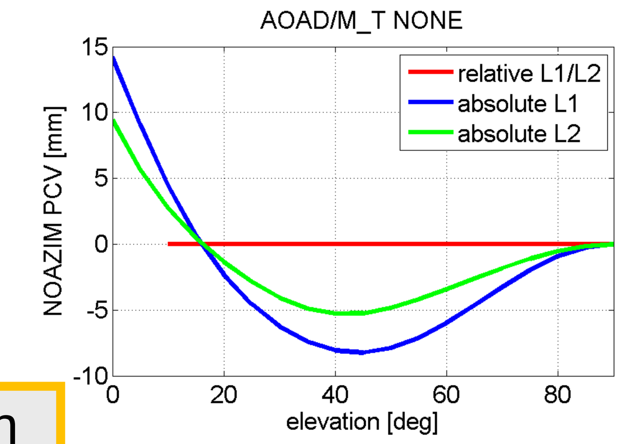
Data Transformation and Reduction

(1) Convert NGS relative to absolute

```
*L1*     N      E      U
Rabs  0.58 -0.37  91.85
Rrel  0.00  0.00 110.00
diff  0.58 -0.37 -18.15

*L2*     N      E      U
Rabs -0.08 -0.59 120.35
Rrel  0.00  0.00 128.00
diff -0.08 -0.59  -7.65
```

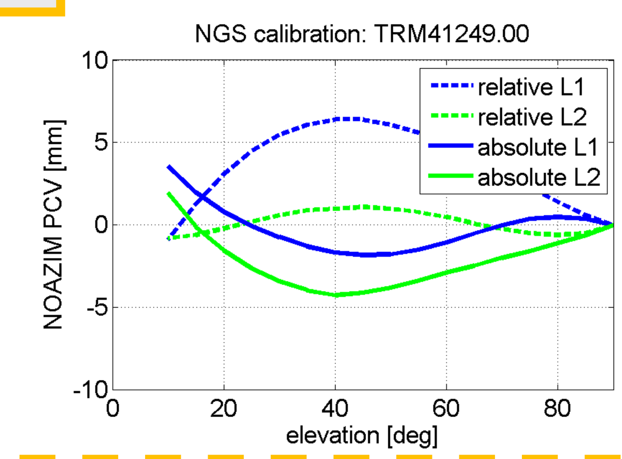
(1a) difference between relative and absolute calibrations (abs-rel) of *reference antenna* (AOAD/M_T NONE)



(1b) apply differenced reference antenna values to relative calibration for antenna of interest … this yields absolute calibration

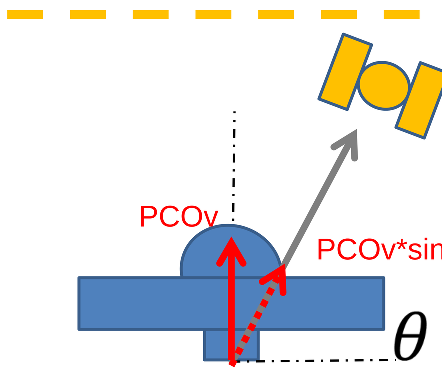
```
*L1*     N      E      U
rel   0.30   0.50  71.40
diff  0.58  -0.37 -18.15
abs   0.88   0.13  53.25

*L2*     N      E      U
rel  -0.40   0.10  68.20
diff -0.08  -0.59  -7.65
abs  -0.48  -0.49  60.55
```



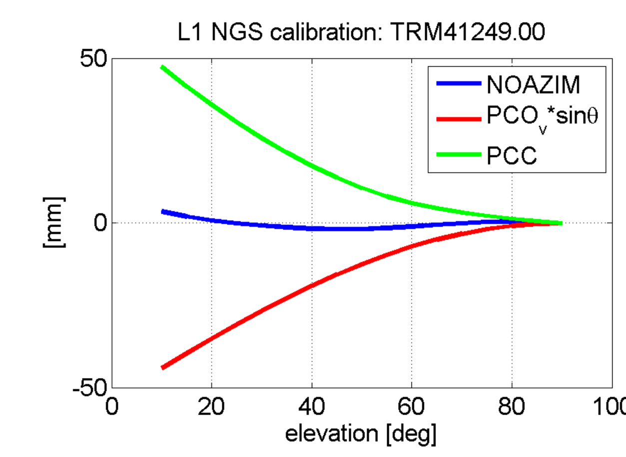
(2) Combine PCO and PCV = PCC *(phase center correction)*

(2a) add PCO projection: NGS relative calibrations depend only on elevation, so we account only for vertical PCO



$$PCC_{biased} = NOAZIM - PCO_v \sin\theta$$

(2b) remove arbitrary bias: use convention of zero bias at zenith (elevation = 90)



$$PCC = PCC_{biased} - PCC_{biased}(\theta = 90)$$

(3) Differences

Results below are IGS minus NGS (relative converted to absolute)

$$\Delta PCO = PCO_{IGS} - PCO_{NGS}$$

$$\Delta PCC = PCC_{IGS} - PCC_{NGS}$$

Conclusions

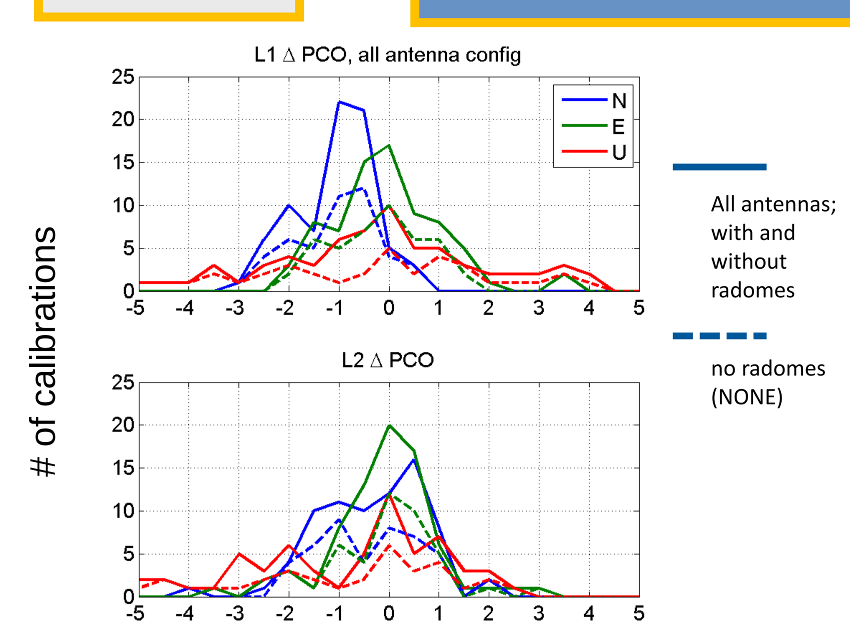
- ΔPCO
  - Reasonable agreement for horizontals (± 2 mm)
  - Large variation for verticals, but variation correlates with antenna type
- ΔPCC
  - Strong correlation with PCOv differences
    - Negative correlation on L1
    - Positive correlation on L2

Next Steps

- Attempt to correlate differences and patterns with software changes at NGS
- Reprocess older data with newest software, and analyze calibration differences (if any)

Results

Δ PCO



- Bias (constant difference)
  - -1 mm for L1 North, regardless of absence/presence of radome
  - Other components and frequencies are unbiased
- Histogram width
  - L2 North peak is 2x wider than other horizontal components
  - Wide peak for vertical
- Histogram tails
  - Horizontal PCO values are the same +/- 2 mm, except for few "outlier" differences
  - Large tails for verticals

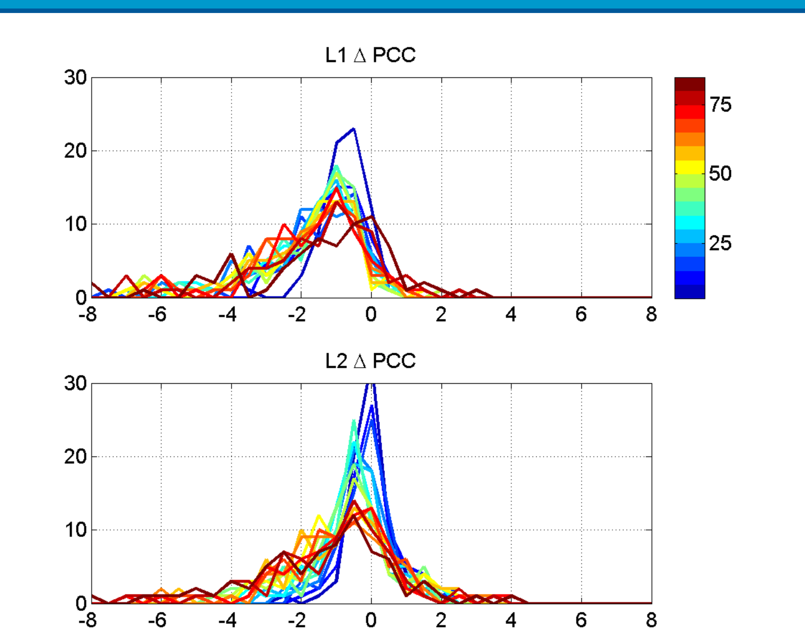
Δ PCC

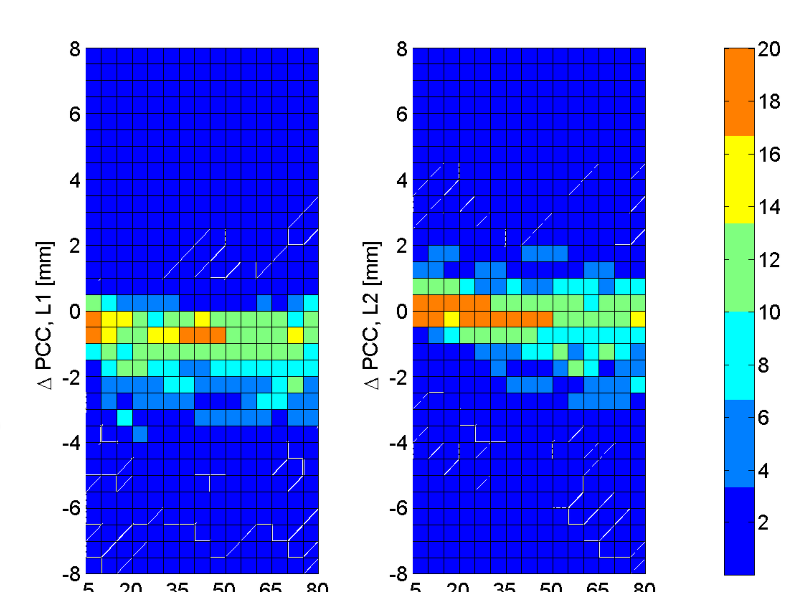
L1 ΔPCC

- Shows a -1 mm bias
- Strong tail to negative differences
- Distribution widens as zenith angle increases (wide distribution at lowest elevation angles)

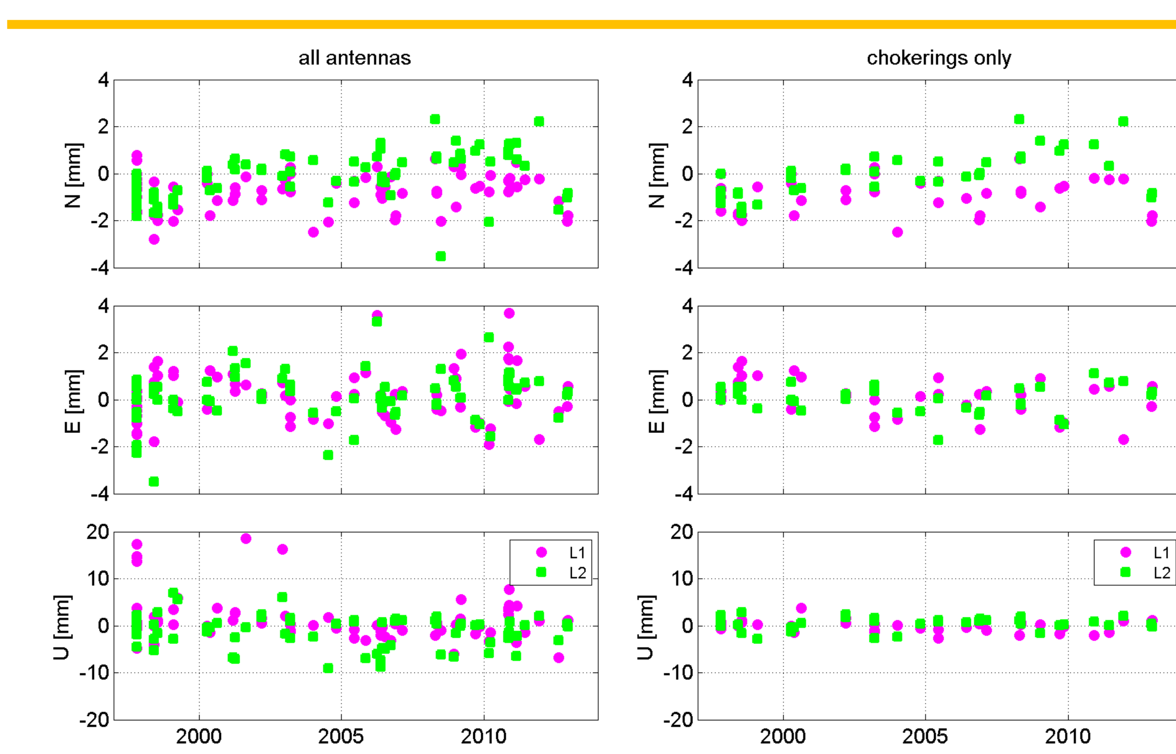
L2 Δ PCC

- Unbiased
- Distribution widens, tails to negative as zenith angle increases (near antenna horizon)

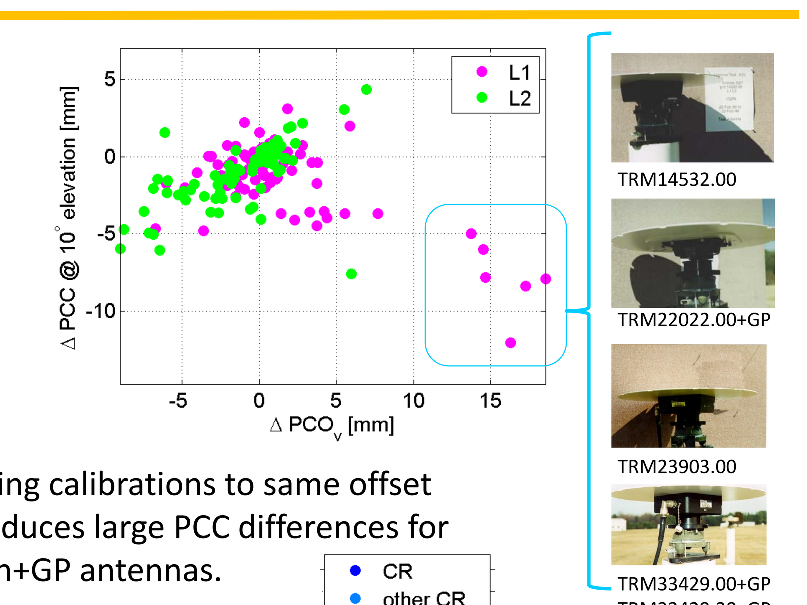




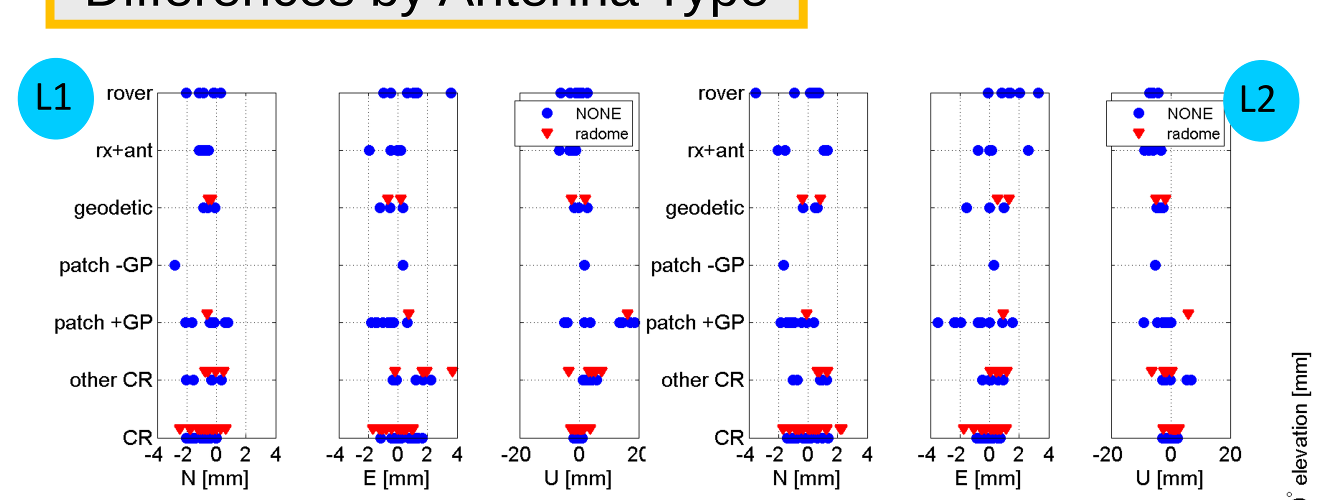
Patterns by Date of Calibration at NGS



- ΔPCO bias (constant difference)
  - L1 North bias consistent over 15-year history of NGS calibrations
  - Other components and frequencies are unbiased
- ΔPCO trends/groups with time
  - Possible trend in L2 North calibrations (explains the wide ΔPCO histogram shape (see above)); apparent trend could be offsets related to software versions



Differences by Antenna Type



- ΔPCO appear to be grouped by antenna type
- Presence/absence of radome does not affect grouping
- Strongest groupings appear in vertical component
- Chokering (CR) antennas have best vertical agreement with IGS (least spread, closest to zero ΔPCO)

Moving calibrations to same offset introduces large PCC differences for patch+GP antennas.