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.

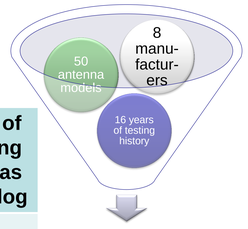
QUESTIONS WE WANT TO ANSWER

- 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]	Total # of receiving antennas 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

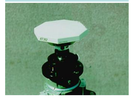
Number of antennas in group given in square brackets

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]

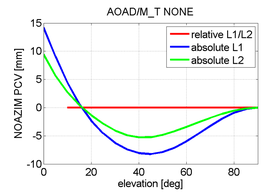
Method

Data Transformation and Reduction

(1) Convert NGS relative to absolute

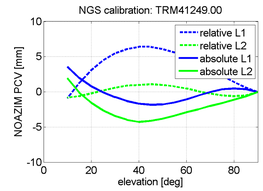
(1a) difference between relative and absolute calibrations (abs-rel) of *reference antenna* (AOAD/M_T NONE)

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



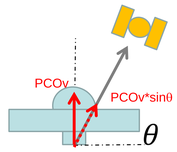
(1b) apply differenced reference antenna values to relative calibration for antenna of interest … this yields absolute calibration

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

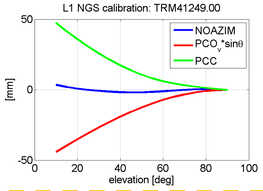


(2) Combine PCO and PCV = PCC *(phase center correction)*

(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 at right are IGS minus NGS (relative converted to absolute)

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

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

One-Pagers

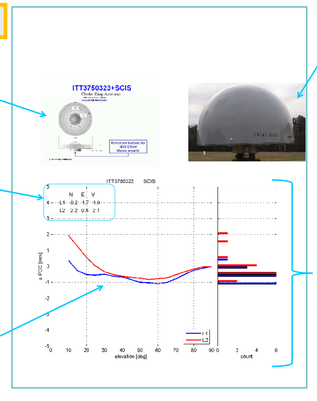
Antenna diagram

Antenna photo

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

Difference in PCC *(see 2b above)*

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



References & Acknowledgements

Please see our website at http://www.ngs.noaa.gov/ANTCAL for more information.

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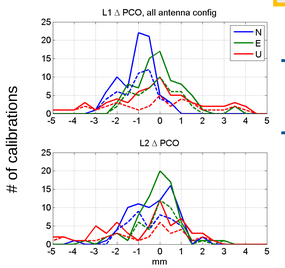
Results

Δ PCO

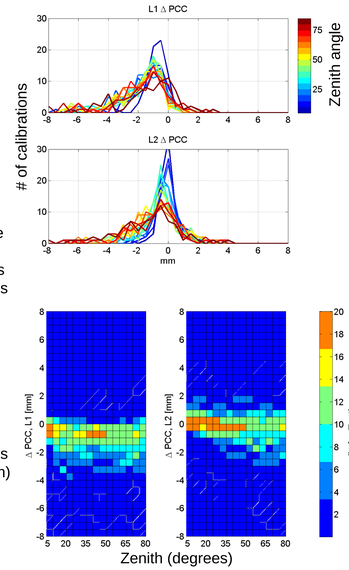


All antennas; with and without radomes

no radomes (NONE)

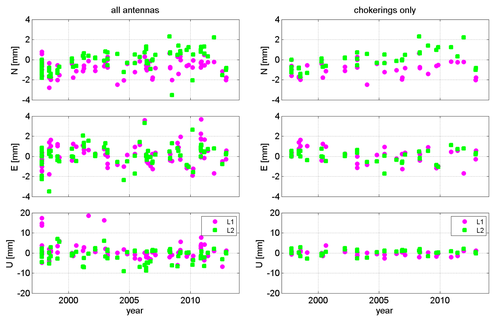
- Bias (constant difference)
  - -1 mm for L1 North, regardless of absence/presence of radome
  - Other components and frequencies are unbiased
- Histogram width
  - L2 North peak is 2x wider than other horizontal components
  - Wide peak for vertical
- Histogram tails
  - Horizontal PCO values are the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

Δ PCC



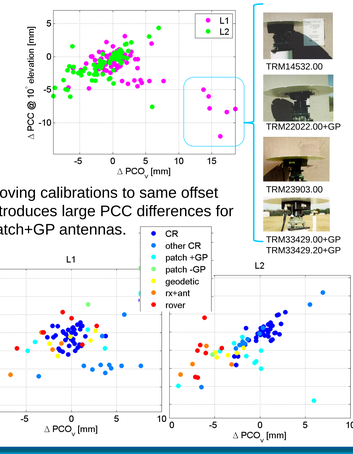
L1 ΔPCC
- Shows a -1 mm bias
- Strong tail to negative differences
- Distribution widens as zenith angle increases (wide distribution at lowest elevation angles)

L2 Δ PCC
- Unbiased
- Distribution widens, tails to negative as zenith angle increases (near antenna horizon)



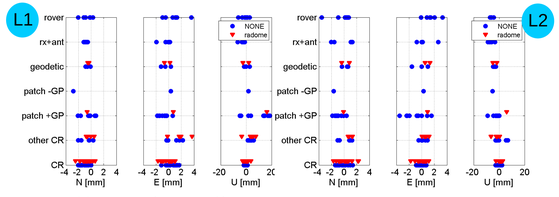
Patterns by Date of Calibration at NGS

- 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



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

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)

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)