National Geodetic Survey Absolute Antenna Calibrations

CORS User Forum

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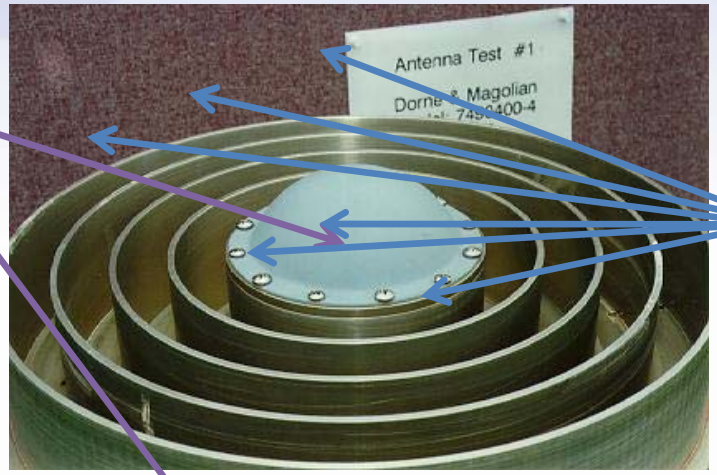
NGS Geosciences Research Division

Outline

- Absolute antenna calibrations
  - What are they?
  - How are they different from relative calibrations?
  - What do they look like?
  - What impact do they have on positions?
- NGS Calibration Services
  - How do I get my antenna calibrated?
  - Where are the values published?

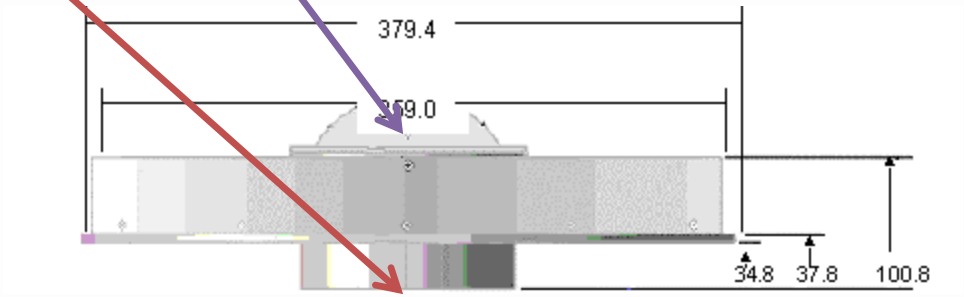
Where do I receive the signal?

Antenna element



Nonphysical and inconstant point floating in space

Antenna reference point (ARP)



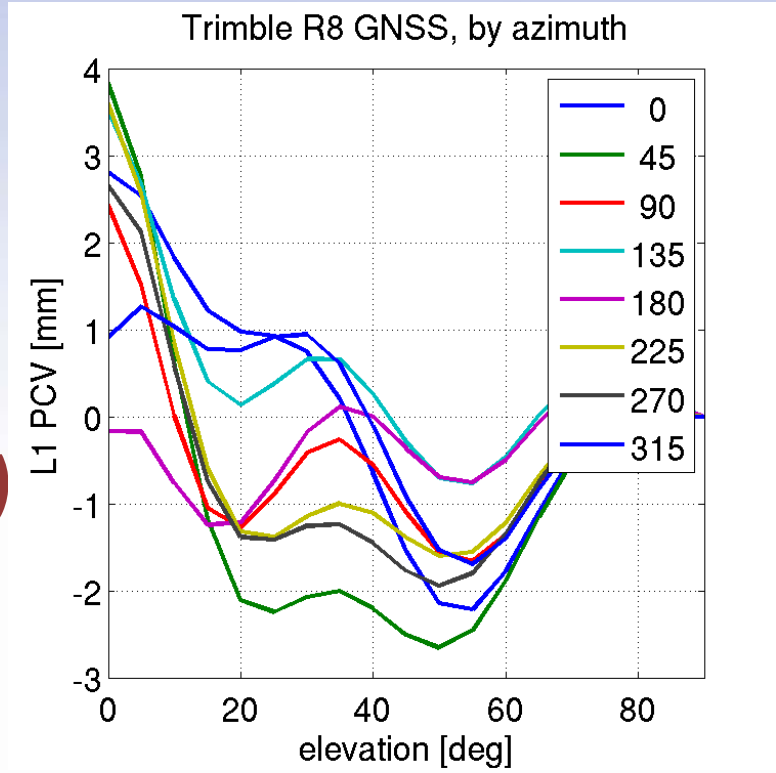
What is GNSS Antenna Calibration?

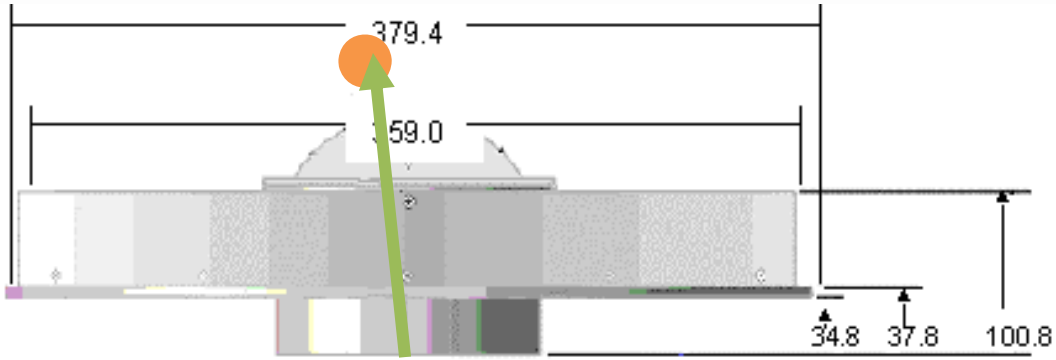
Create a "map" of antenna characteristics

- Mean point being positioned (**PC0**)
- Spatial variations (**PCV**)

PCV *(el)*

PCV *(az,el)*





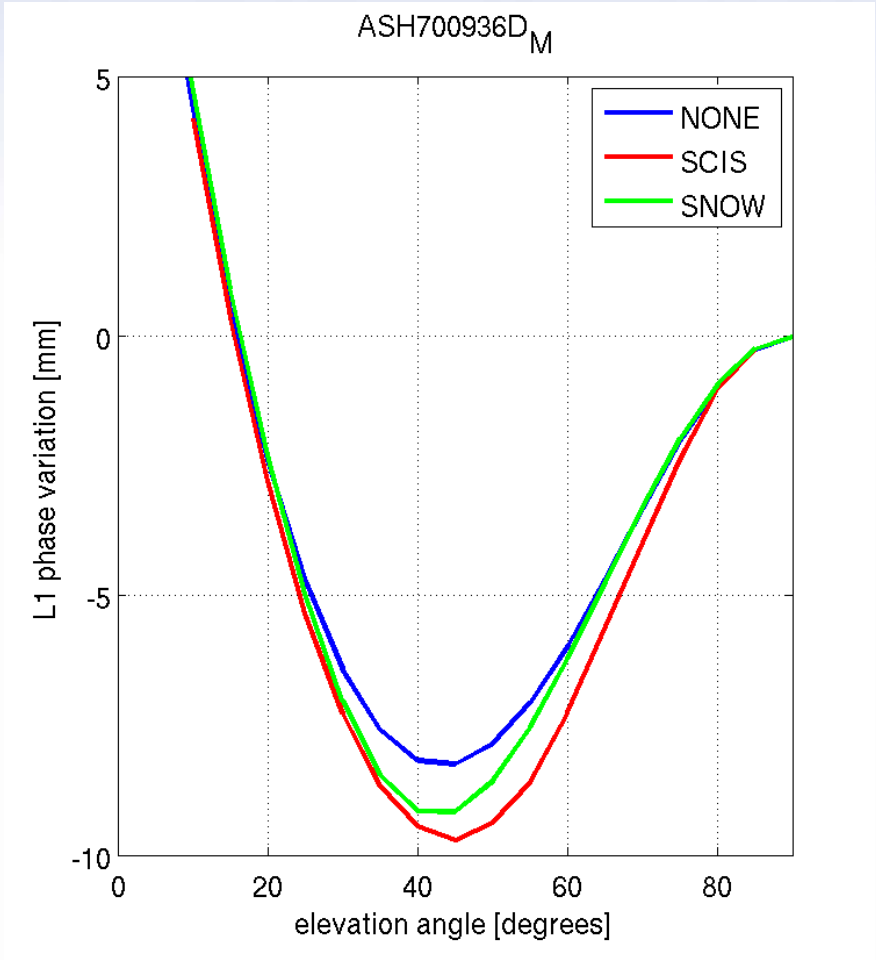
PC0 *[ENU]*

Equipment and Environment Effects on PCV

Ashtech chokering (700936D_M)

with SCIS radome

with SNOW radome



What Is The Effect of PC0/PCV?

Antenna element introduces elevation- (and azimuth-) dependent advance/delay to the carrier phase observation = PC0 + PCV

- Effect on heights (wrt elevation cutoff)
- Alias into troposphere estimate
- <= 10cm height errors on mixed-antenna baselines

Mixed-antenna and longer baselines demand good antenna calibrations

Published values are idealized (environment-free)

Relative vs. Absolute

Short baseline, differential solution

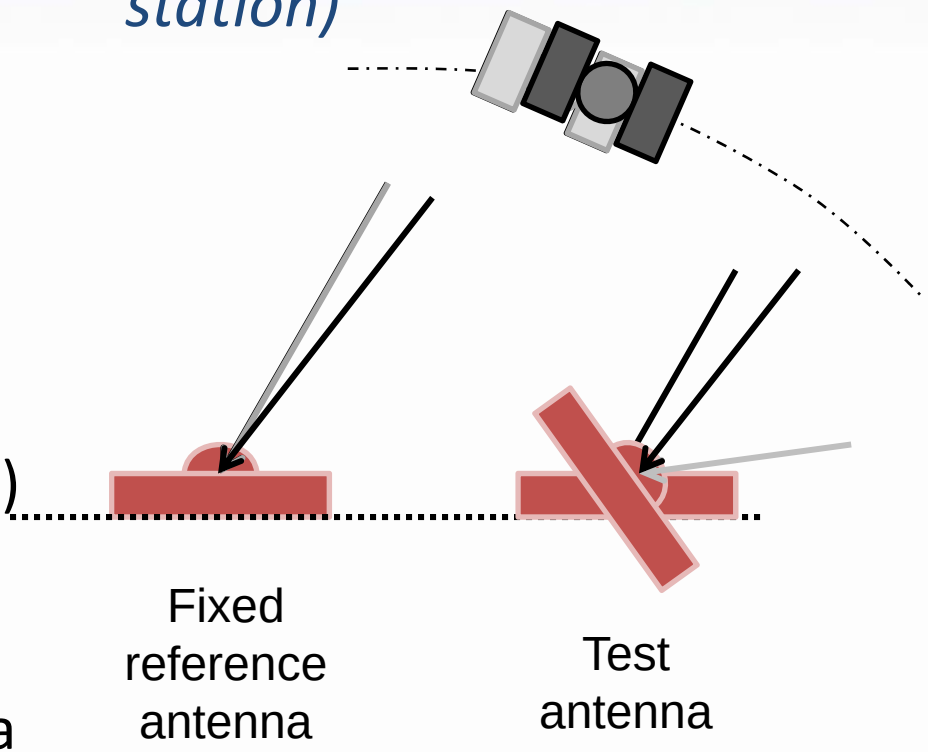
Relative:

- 2 fixed antennas
- Can only determine PCV/PC0 *relative to reference antenna*

Absolute:

- 1 fixed (ref), 1 moving (test) antenna
- Observable combination removes reference antenna effects

IGS switch to absolute created ~ 1 ppb scale change (on average, 0.5 cm per station)

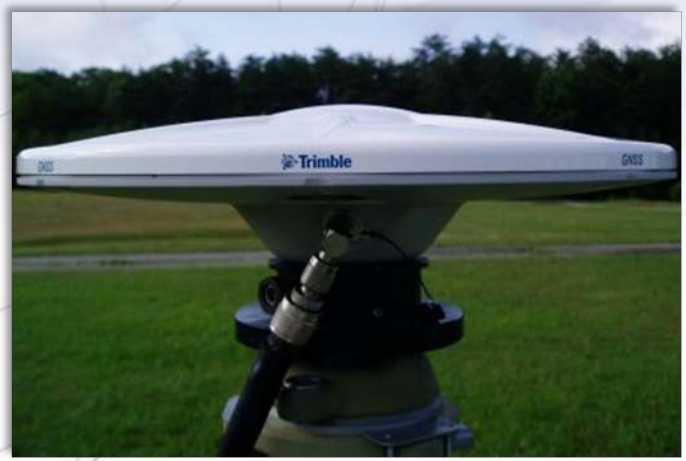


NGS Absolute Calibrations Motivations and Goals

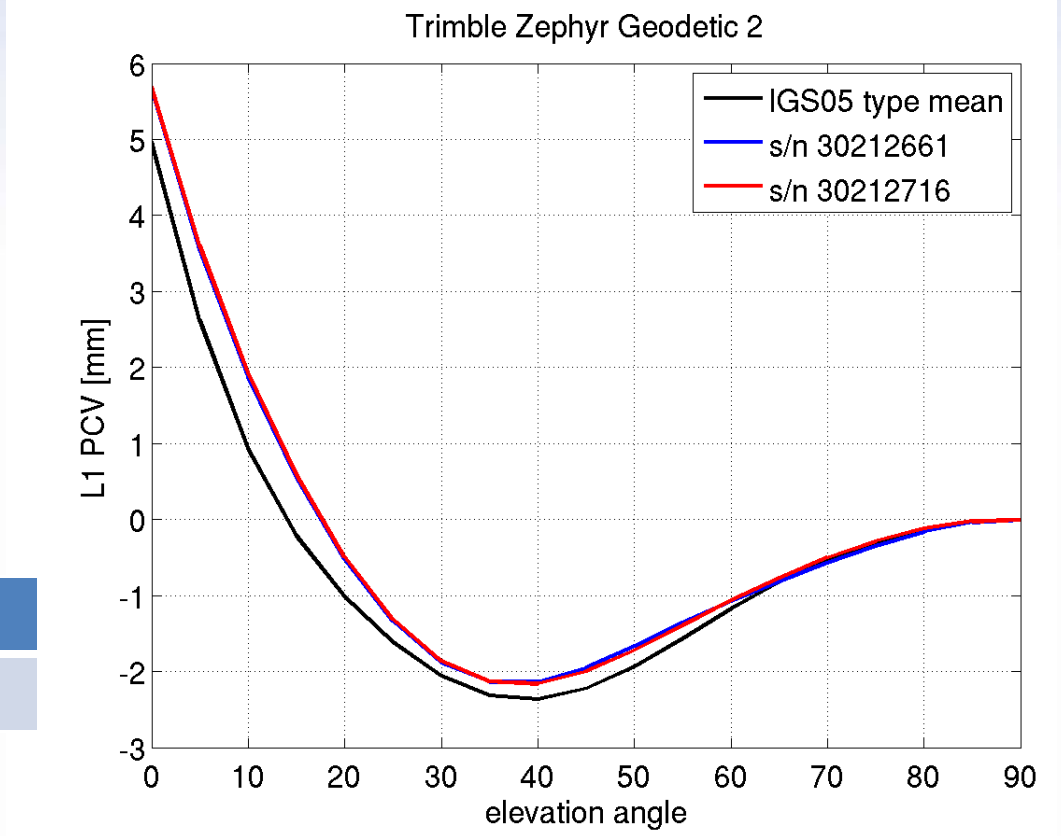
Serve high precision needs of U.S. surveying and geodesy communities

- Simultaneous multi-freq, multi-GNSS calibrations
- Absolute (phase out relative)
- 2-D (elevation, azimuth) phase center patterns
- Free calibration service
- Calibration values publicly distributed via Internet

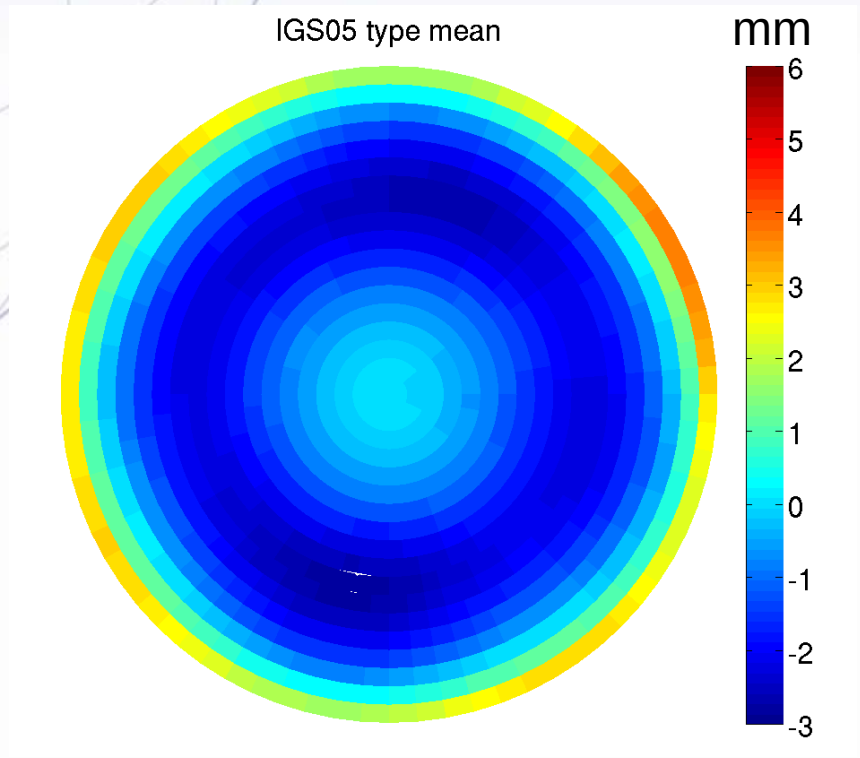
Trimble Zephyr Geodetic 2 (TRM55971.00)

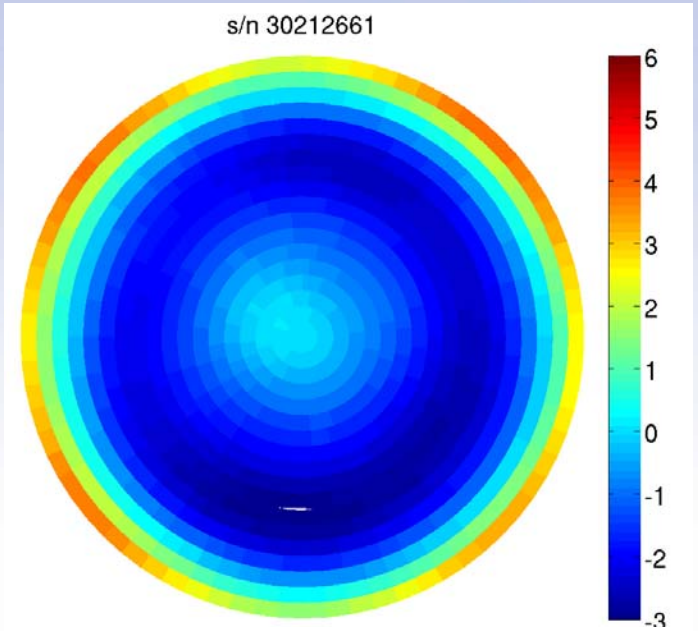


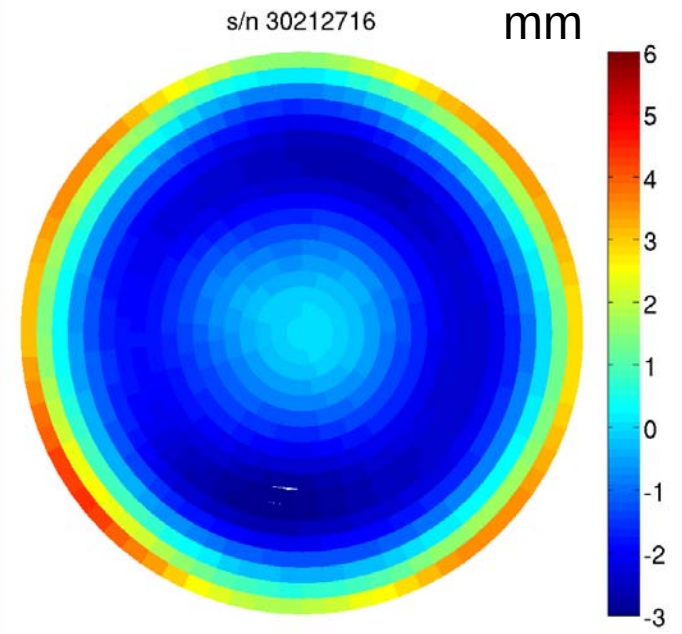
(mm)	North	East	Up
IGS05	1.07	-0.19	67.17



TRM55971.00 phase center pattern

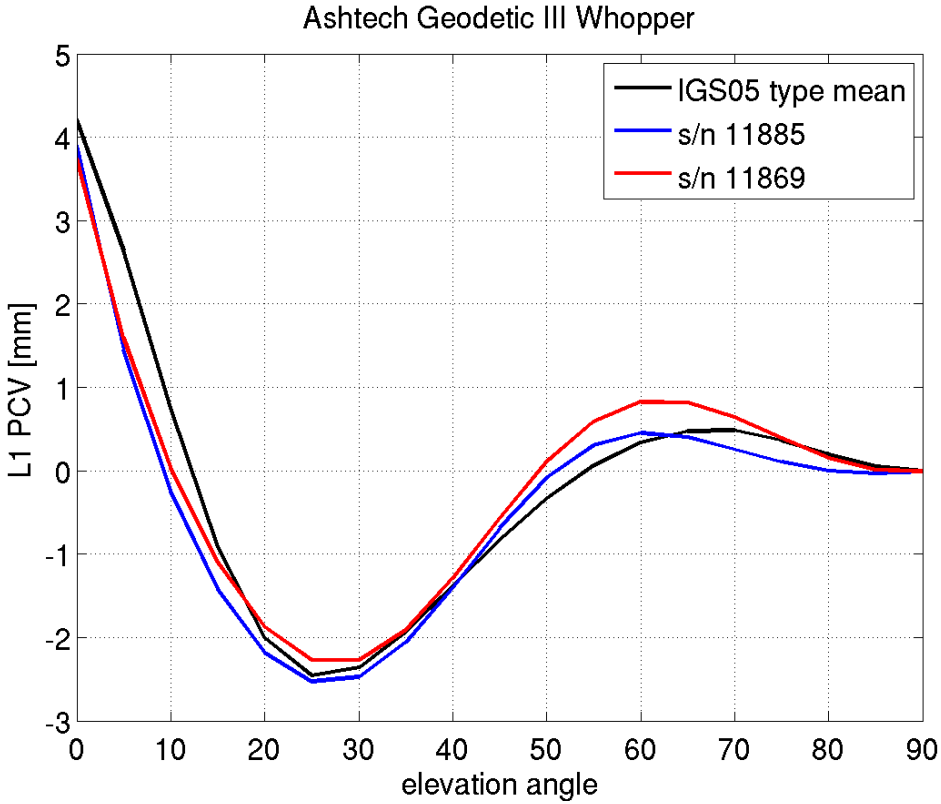




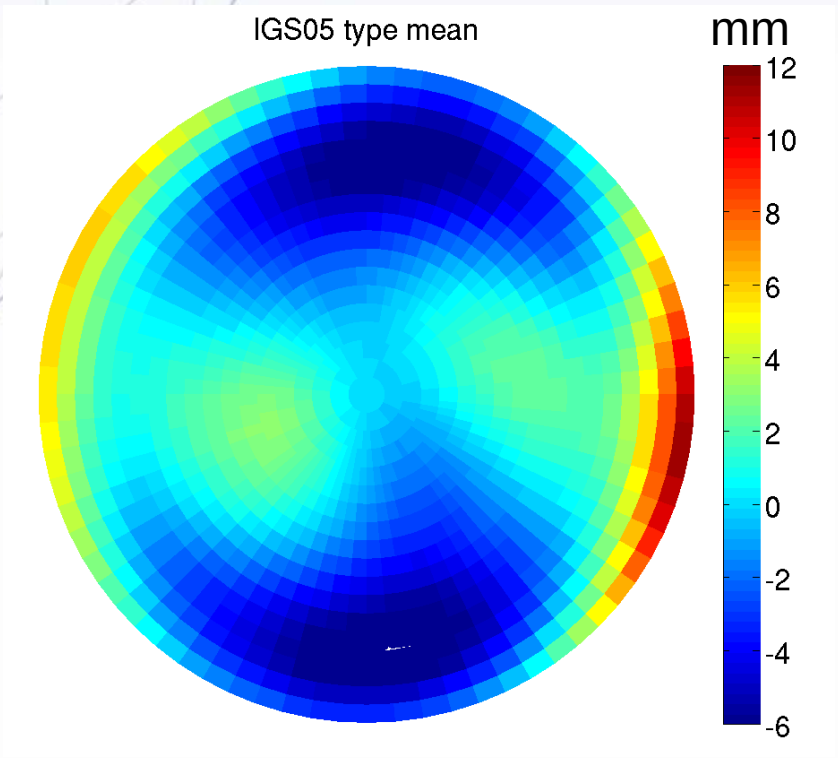


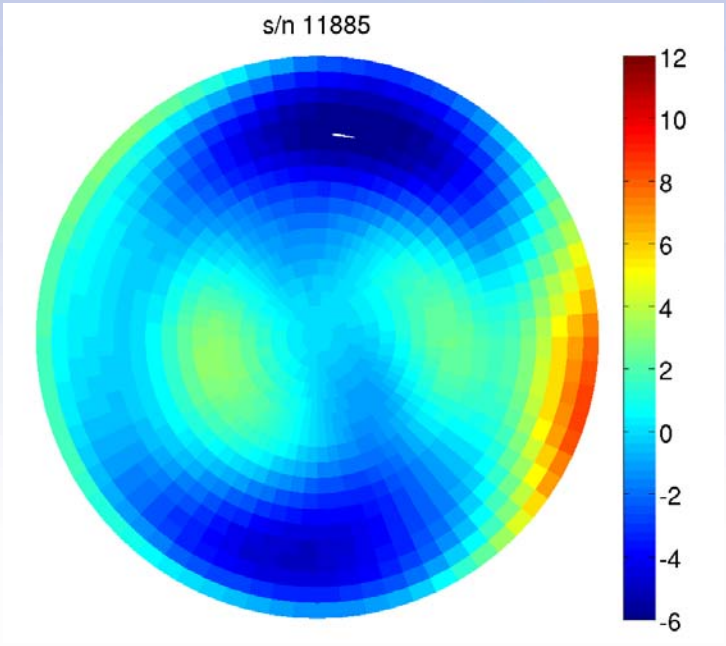
Ashtech Geodetic III 'Whopper' (ASH700718B)

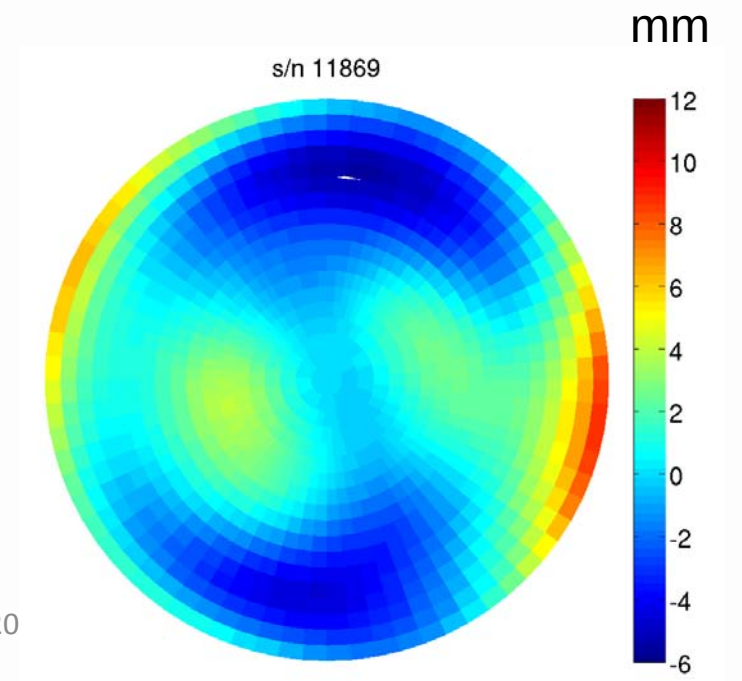
(mm)	North	East	Up
IGS05	-1.67	-0.47	69.48

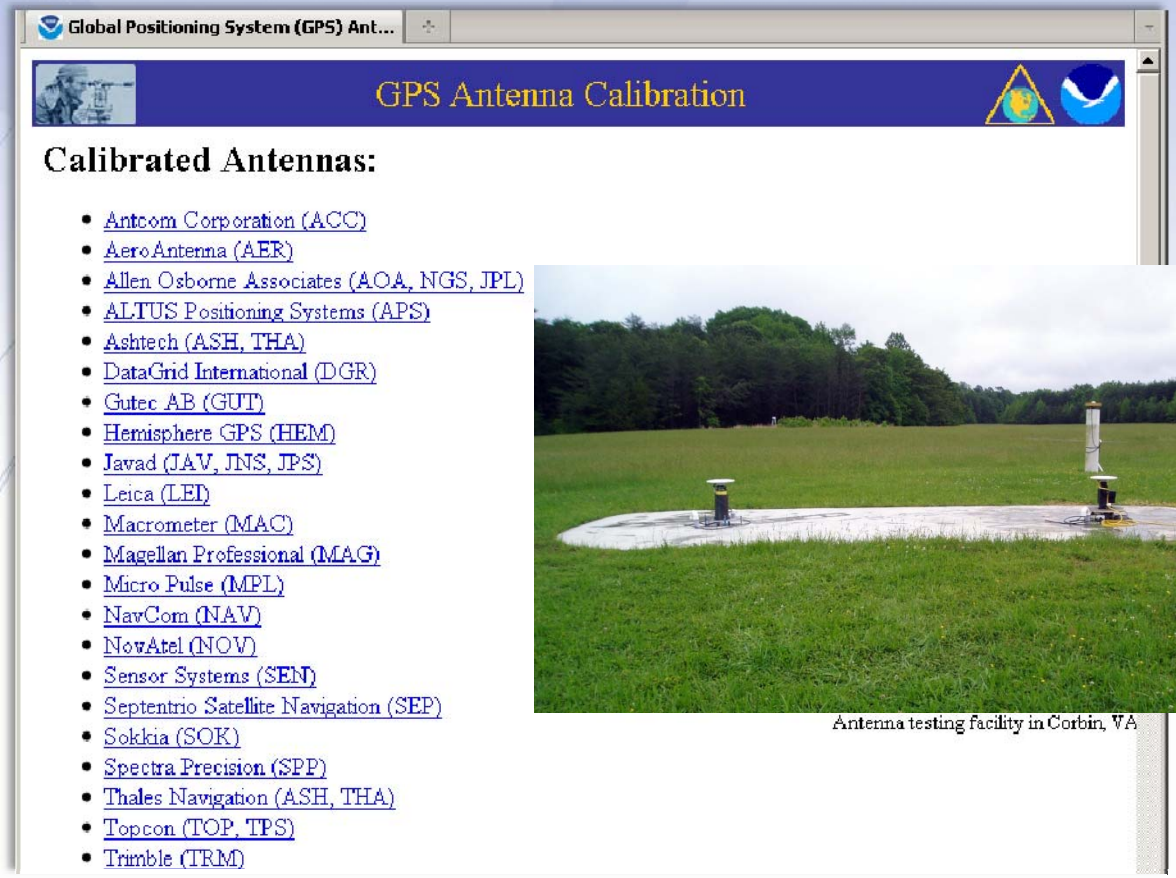


ASH700718B phase center pattern





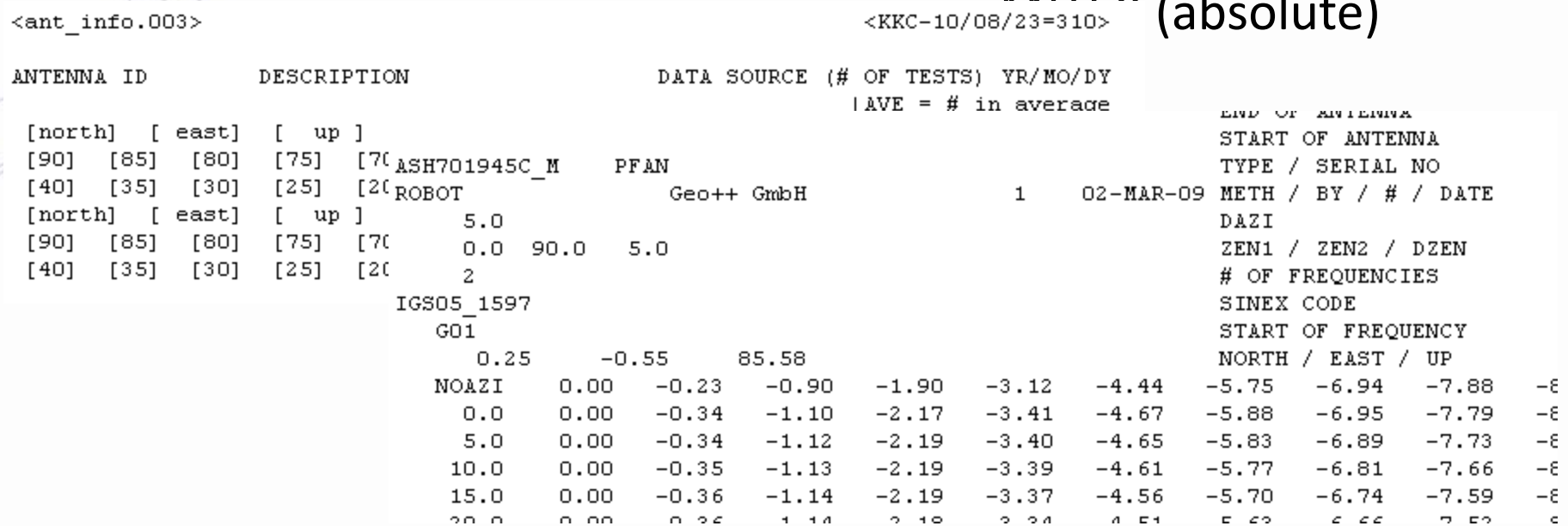




NGS Calibration Services

PC0/PCV Distribution

- Freely available
- Distribution via website: http://www.ngs.noaa.gov/ANTCAL
- Data formats for different software:
  - NGS format (relative and absolute)
  - ANTEX (absolute)



```
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ANTENNA ID          DESCRIPTION                 DATA SOURCE (# OF TESTS) YR/MO/DY
                                                                |AVE = # in average
 [north]   [ east]   [  up ]                                                    END OF ANTENNA
 [90]   [85]   [80]   [75]   [7(ASH701945C_M    PFAN                                        START OF ANTENNA
 [40]   [35]   [30]   [25]   [2(ROBOT                Geo++ GmbH              1    02-MAR-09 TYPE / SERIAL NO
 [north]   [ east]   [  up ]        5.0                                                    METH / BY / # / DATE
 [90]   [85]   [80]   [75]   [7(   0.0  90.0   5.0                                        DAZI
 [40]   [35]   [30]   [25]   [2(   2                                                      ZEN1 / ZEN2 / DZEN
                                                                                        # OF FREQUENCIES
                              IGS05_1597                                                SINEX CODE
                                 G01                                                    START OF FREQUENCY
                                    0.25      -0.55      85.58                          NORTH / EAST / UP
                                 NOAZI    0.00   -0.23   -0.90   -1.90   -3.12   -4.44   -5.75   -6.94   -7.88   -8
                                   0.0    0.00   -0.34   -1.10   -2.17   -3.41   -4.67   -5.88   -6.95   -7.79   -8
                                   5.0    0.00   -0.34   -1.12   -2.19   -3.40   -4.65   -5.83   -6.89   -7.73   -8
                                  10.0    0.00   -0.35   -1.13   -2.19   -3.39   -4.61   -5.77   -6.81   -7.66   -8
                                  15.0    0.00   -0.36   -1.14   -2.19   -3.37   -4.56   -5.70   -6.74   -7.59   -8
```
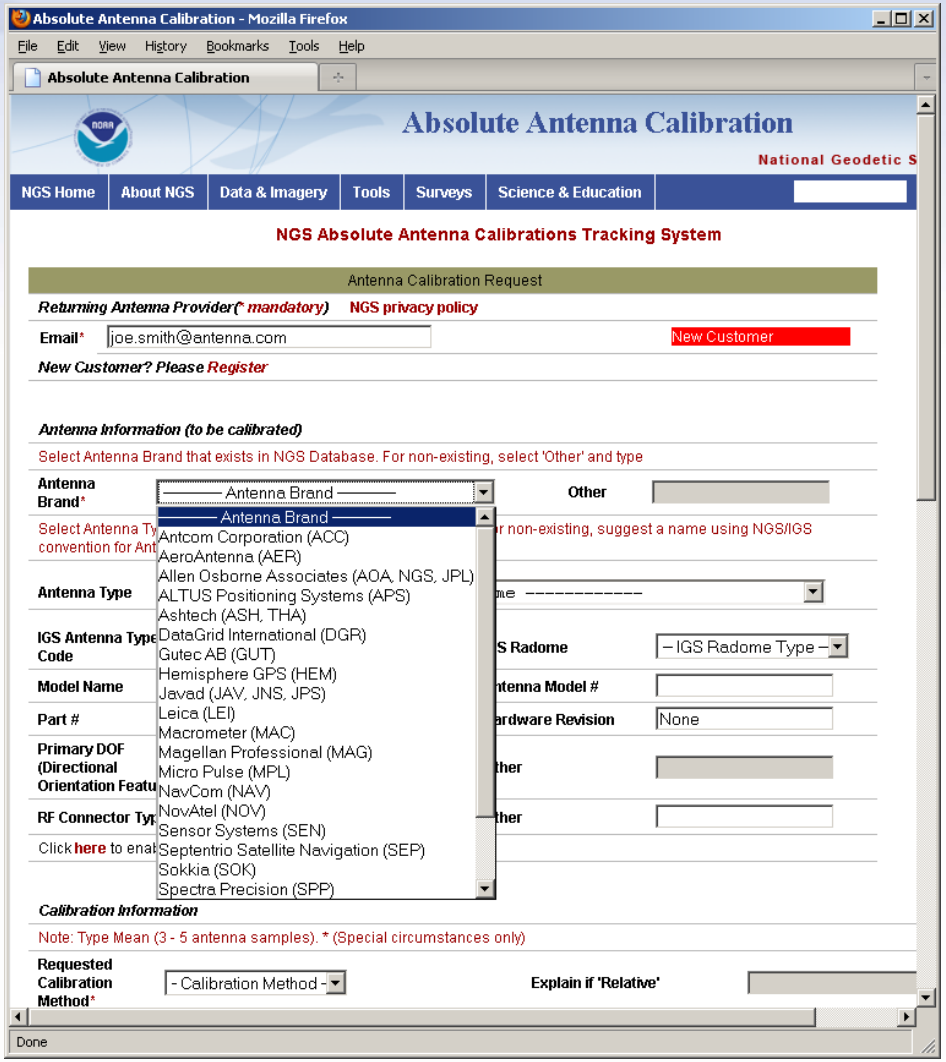

NGS Calibration Services

- Formal policy document
  - Calibration process and stages
  - Eligibility for calibration
  - Rights and responsibilities
- Request calibration via web form
- Tracking system with automated customer notification emails

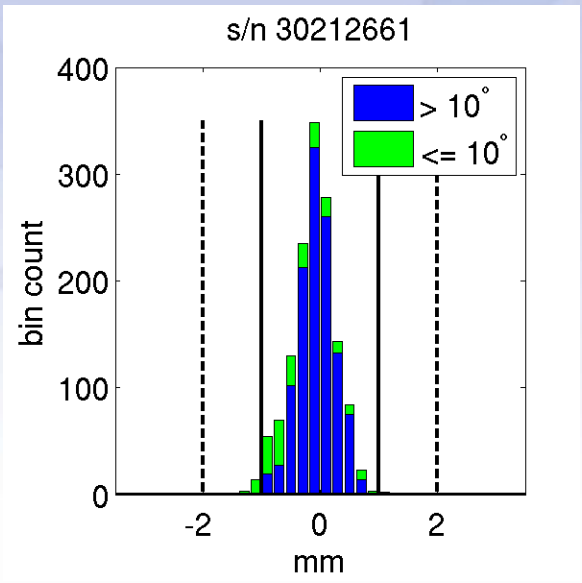


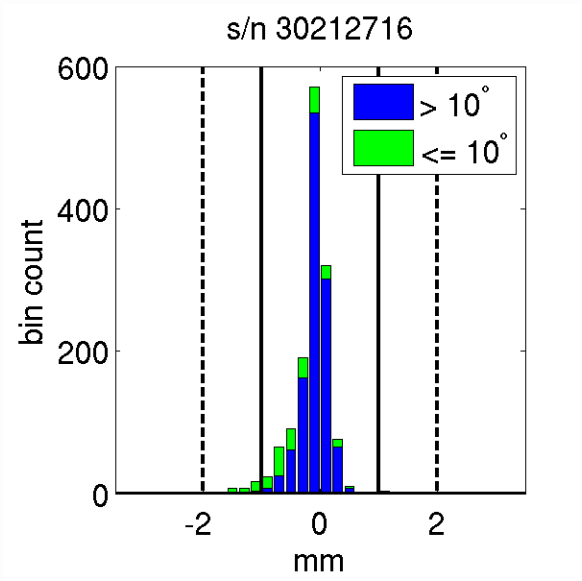
For more information…

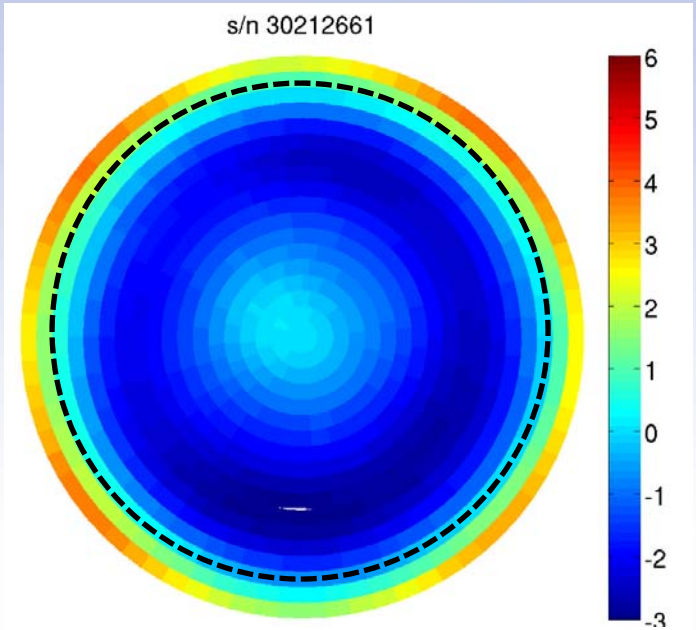
- Website: http://www.ngs.noaa.gov/ANTCAL
- Email NGS Calibrations staff at NGS.AbsAntCal@noaa.gov

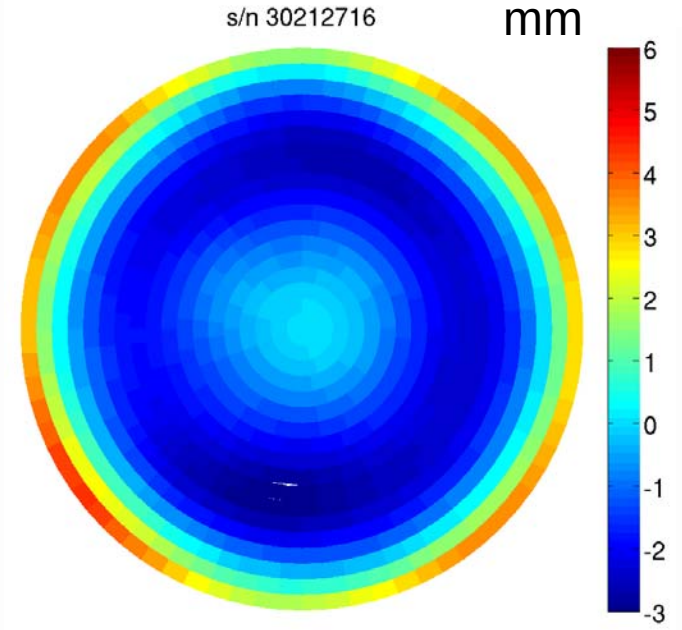
Thank you for your attention!

Deviation from IGS type mean



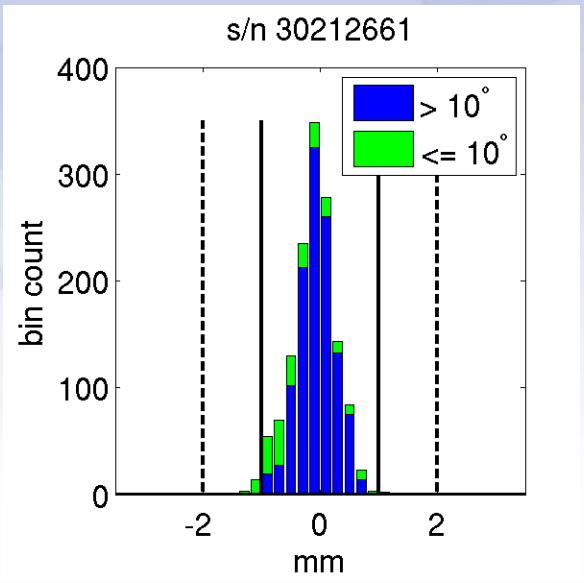


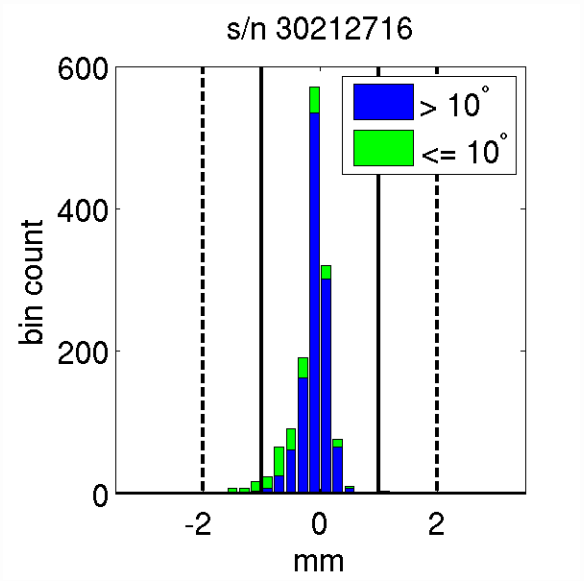


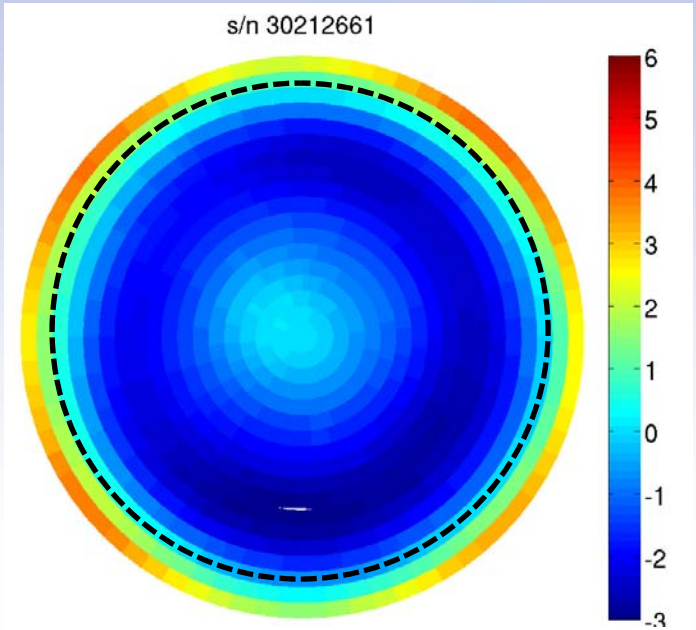


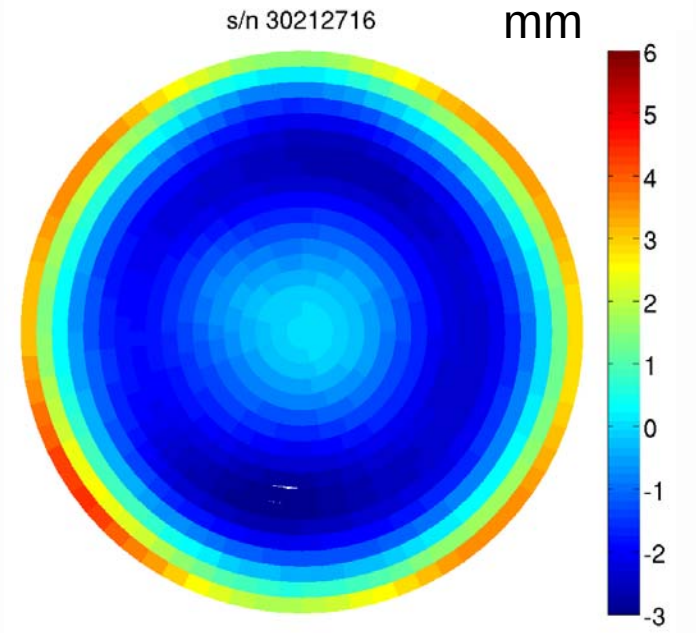
mm

Deviation from IGS type mean

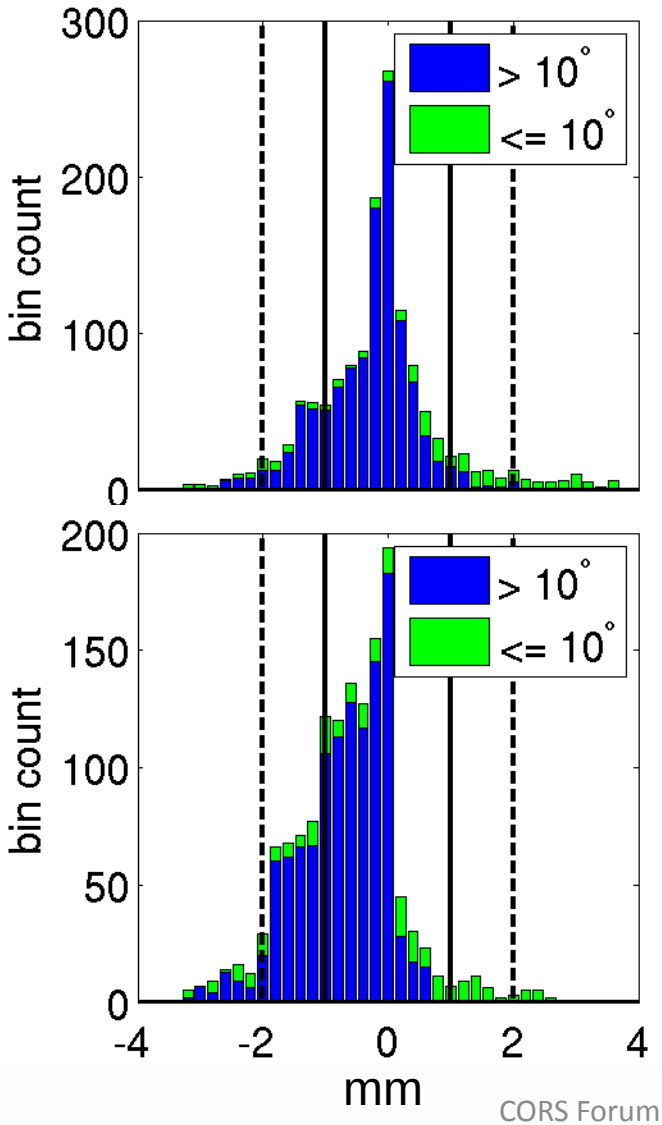


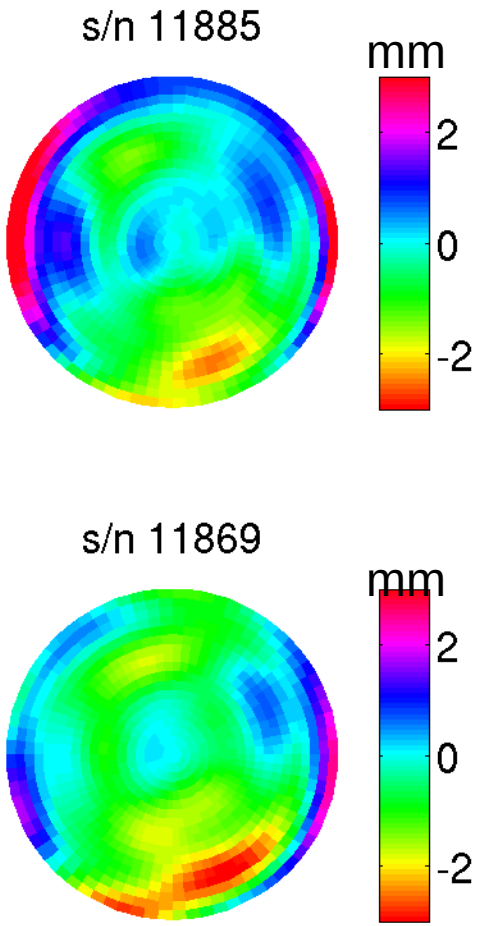






Deviation from IGS type mean





Calibration Setup

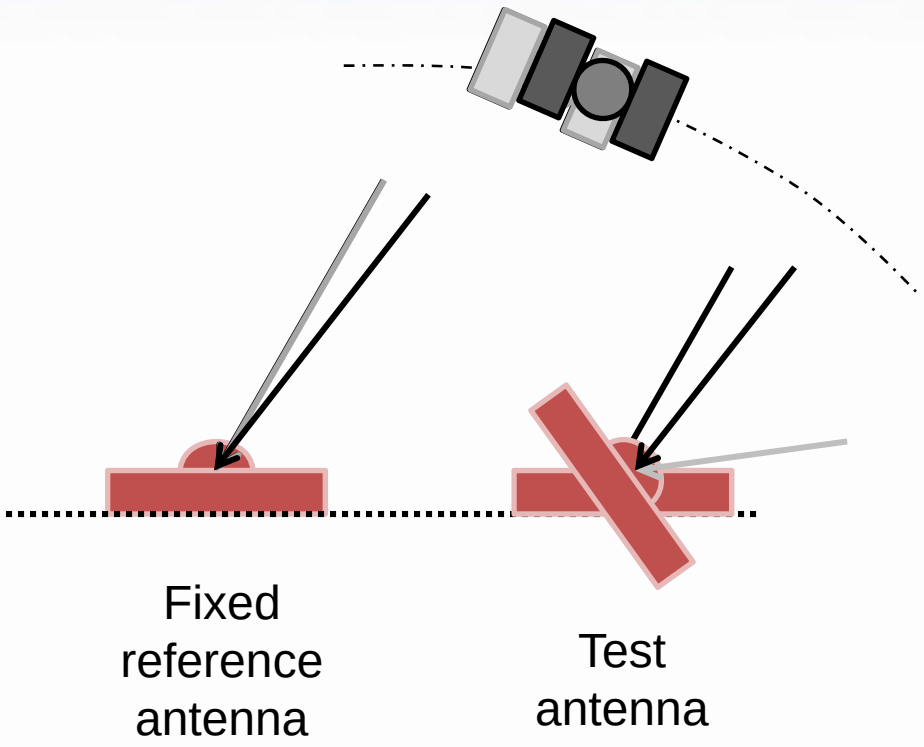
- *Single differences*
- Short baseline (5 m)
- Simplified multipath environment
- Common clock (heading receiver)

- Remaining factors = phase centers (ref, test), differential multipath, hardware bias

Time Difference of Single Differences

Closely spaced time pairs + robot motion =

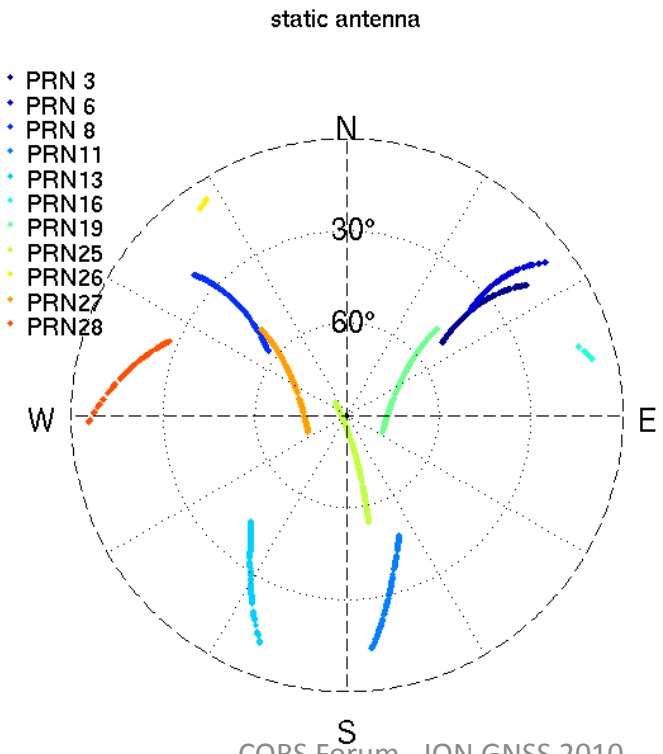
- PC0/PCV at reference antenna removed
- slowly varying biases (differential MP, hardware bias) minimized

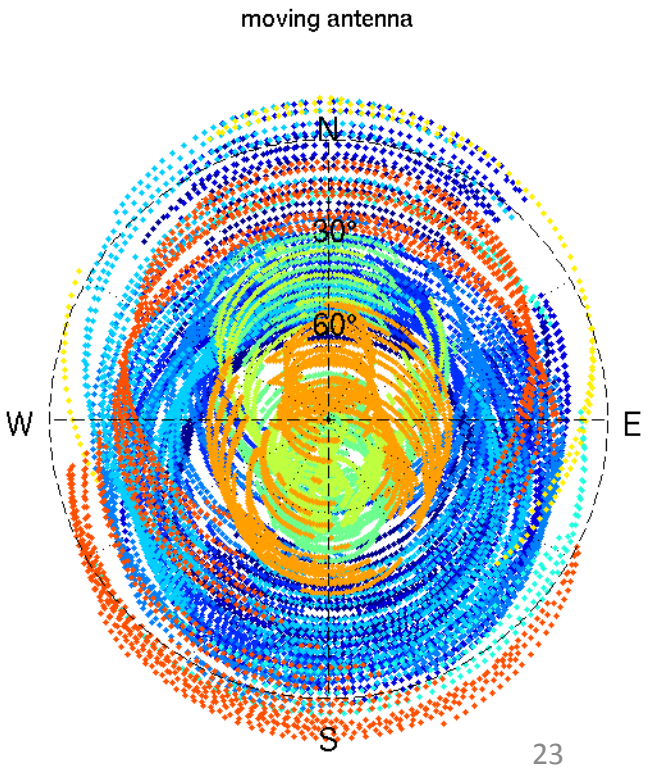


Why Robot?

- Introduce angle changes for TDSD

- Better spatial coverage





Modelled Factors

- *A priori* position
- Frame rotation(s) between robot and local frame
- Rotation arm length
- Phase windup (antenna motion)