Wuhan University

CENTER NSS

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Field Absolute Calibration of the GPS/BDS Receiver Antenna at Wuhan University: *Preliminary Results*

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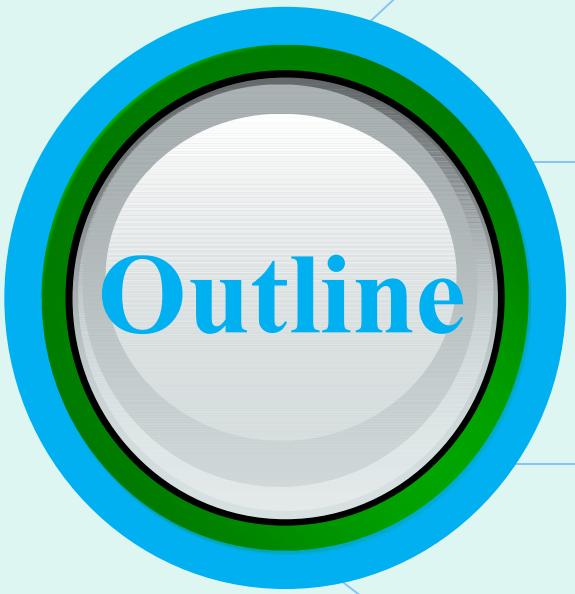
Content



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1 Introduction

1 Introduction

Great demands for GNSS high accuracy applications:

- High accuracy terrestrial coordinate frame maintaining
- Continuously Operating Reference Stations (CORS)
- Precise Point Positioning (PPP)
- High accuracy level aircraft mission (Navistar, LEO)

To achieve high level accuracy, measurement and instrument biases at the cm to mm level must be understood.

One important bias is antenna phase center (APC)

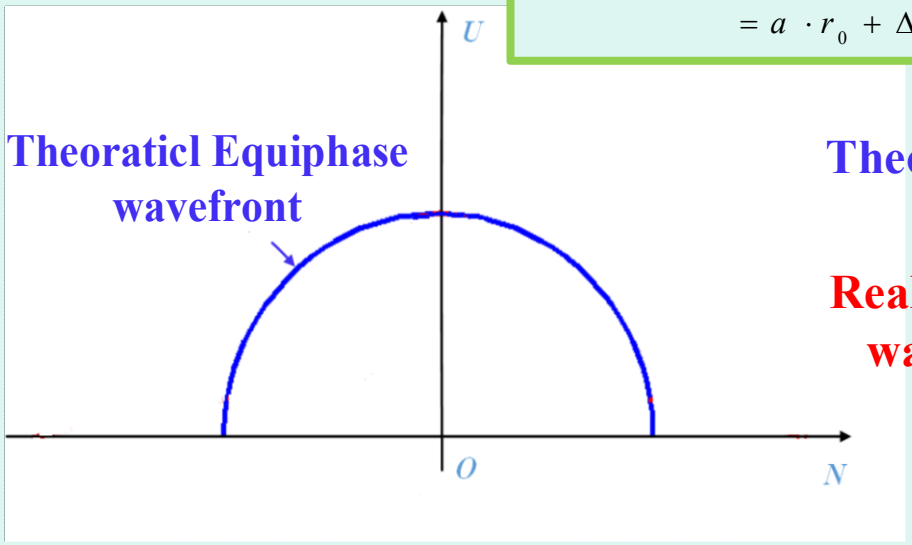
1 Introduction

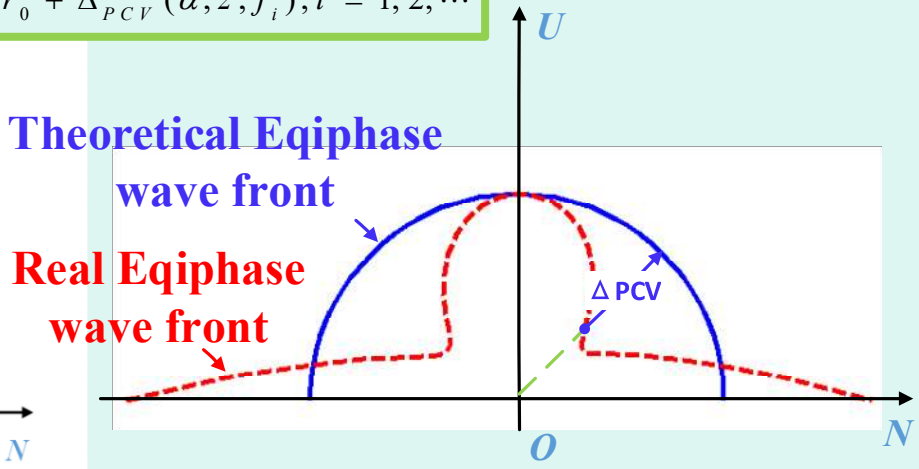
In theory, the equiphase wave-front from a transmitting antenna should be perfectly spherical.

However, in reality, APC is not a single point, but depends on azimuth & elevation of each frequency signal reception.

APC is described by PCO – Phase Center Offset and PCV – Phase Center Variation

$$\Delta\Phi(\alpha,z) = \Delta_{PCO} + \Delta_{PCV} = a \cdot r_0 + \Delta_{PCV}(\alpha,z,f_i), i = 1,2,\cdots$$





1 Introduction

- **Relative PCV Calibration (Adopted by IGS in 1996)**

It is reasonable for not too long baselines GNSS App.

Disadvantages:

① Unsuitable - long distance baseline observations

② Unavailable - PCV with both azimuth and elevation

③ Unavoidable - site-dependent effects

- **Absolute PCV Calibration (Adopted by IGS in 2006)**

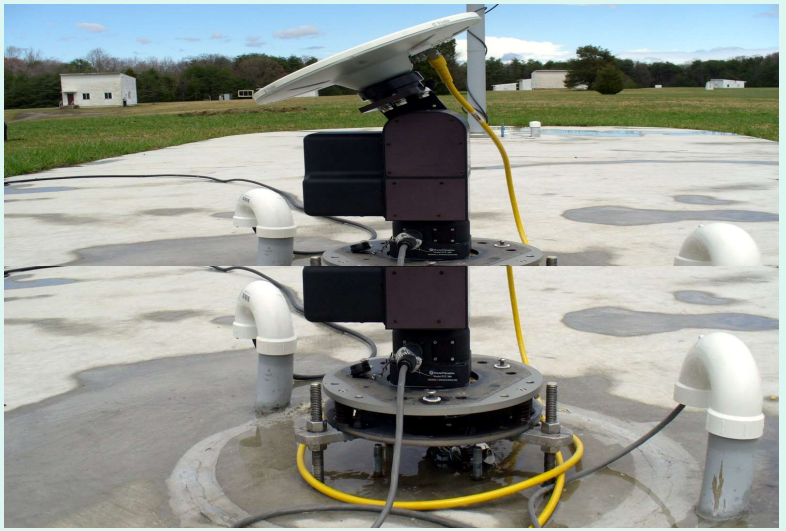
① Anechoic chamber

② Multi-axes robot(many institutes e.g. NGS, LGN Hannover, TU Dresden, University of Bonn and Geo++)

1 Introduction

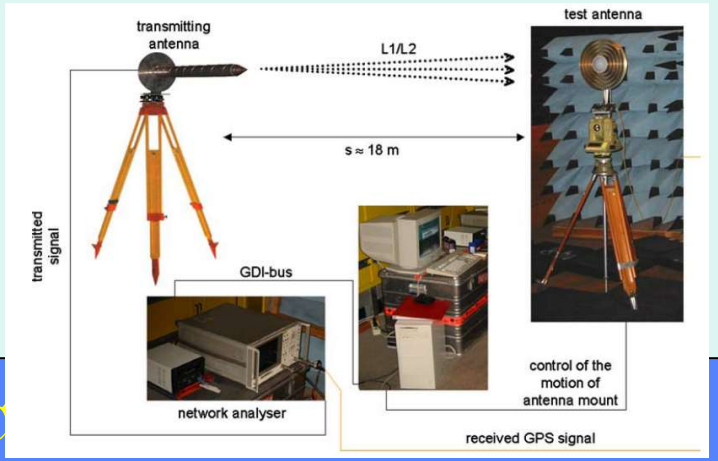
PCV Calibration Platform

Relative PCV Calibration(NGS,USA)



Absolute PCV Calibration(NGS,USA)

Calibration Robot
(geo++,Germany)



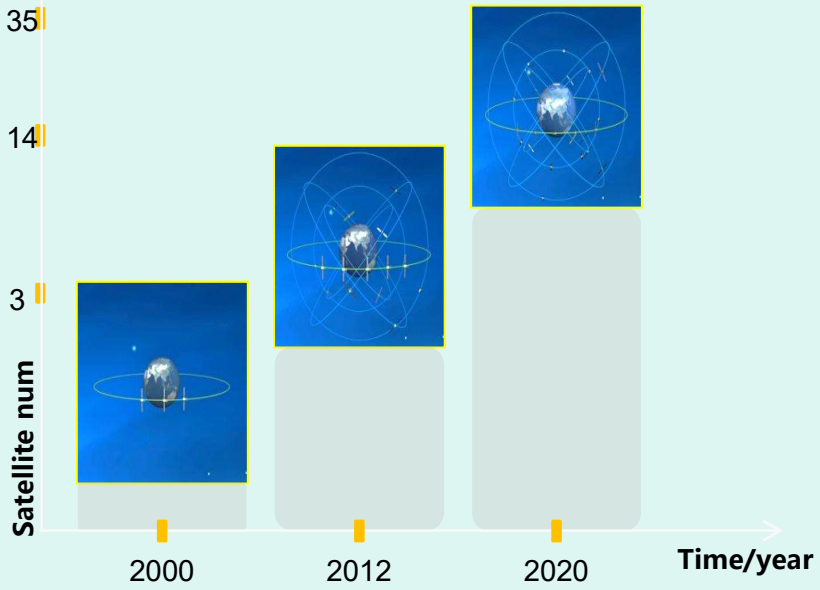
Chamber
Bonn Uni.

2 BDS/GPS Absolute PCV Field Calibration at WHU

BDS Absolute PCV Field Calibration

BeiDou Navigation System

- 15 BD2 SVs in constellation
- 16 BD3 SVs in commissioning
- 10+ BD2 SVs available in/around China
- Feasible to carry out BeiDou high accuracy application



BeiDou absolute PCV is a top priority for any high accuracy Applications!

BDS Absolute PCV Field Calibration

Necessity for field calibration

- Pan motions

  rotations about a vertical axis aligned with local up

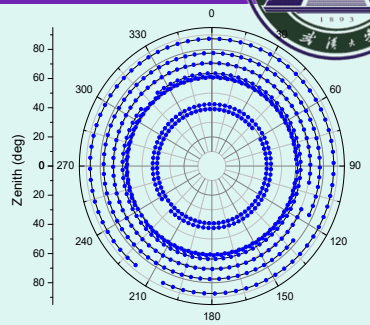
- Tilting motions

  tile around one horizontal axis

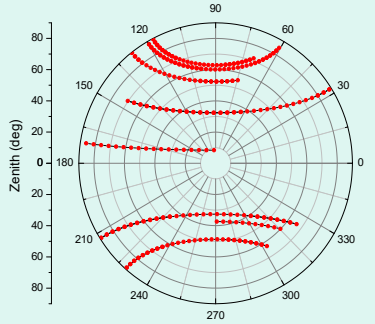
Advantages:

① Accelerate sample coverage

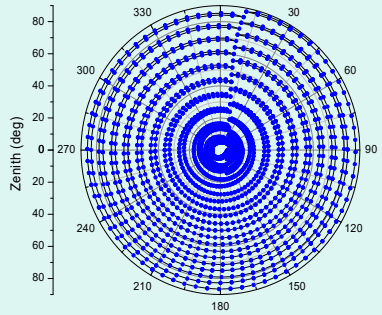
② Can reach any angle on antenna



Pan motion



Tilting motion

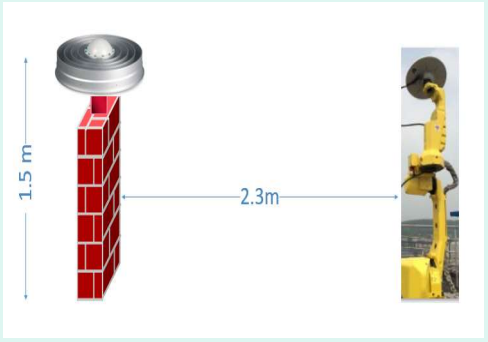


One pass(G26) R & T

BDS Absolute PCV Field Calibration

So as to rotate and tile, we use a FANUC robot

- automatic
- 6 axes
- Phase windup correction
- 2.3m - very short baseline
- <0.2mm accuracy for robot frame positions (nominal)
- Difference between epochs to remove MP and separate the test antenna's absolute PCO and PCV from DD observations.
- Unifying Time and Coordinate between GNSS and robot



3 BDS/GPS Absolute PCV Initial Results

BDS Absolute PCV Initial Results

Absolute Calibration Test 1

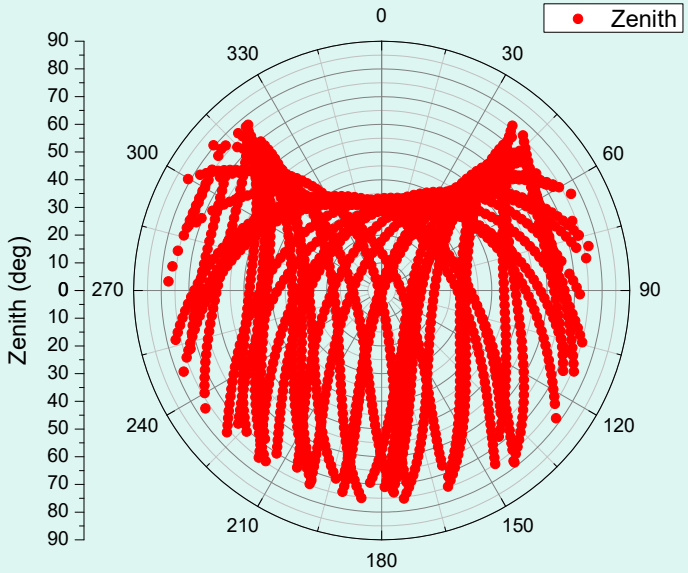
- **Observation Duration: 5 sessions, about 8 hours each session**
- **Trimble Net R9 receivers, available for GPS/BeiDou**
- **Tested antenna type: *TRM57971.0***

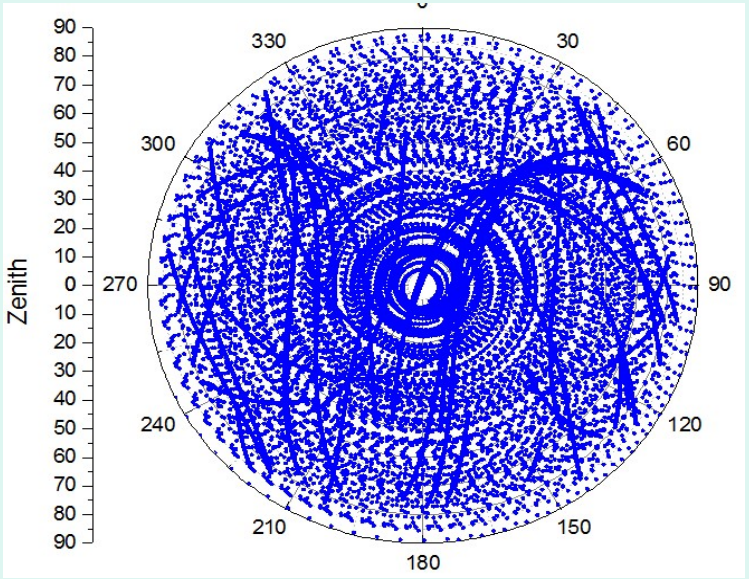
  (known from igs_05.atx file, geo++ calibrated, as true values)
- **PCO is first estimated, followed by PCV**

Trimble receiver

TRM59791.0

BDS Absolute PCV Initial Results





- **Sample Coverage**

  Antenna fixed

- **Sample Coverage**

  Antenna with Robot

BDS Absolute PCV Initial Results

Estimated Absolute PCO

GPS L1 PCO

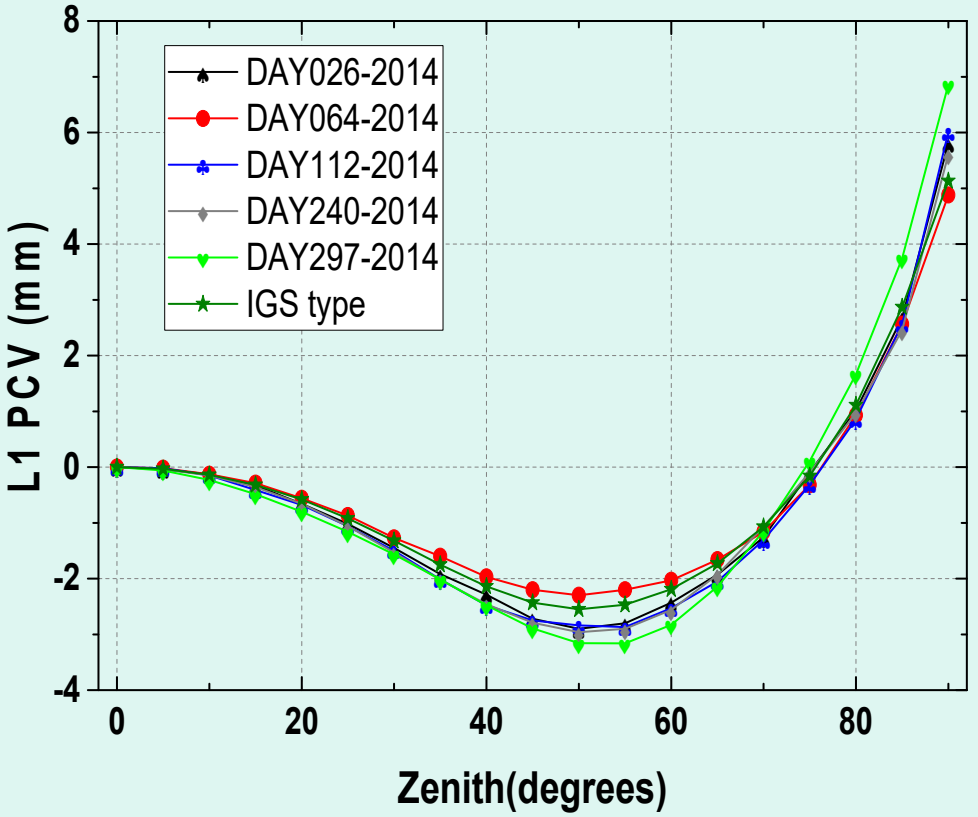
PCO	N(mm)	E(mm)	U(mm)
IGS	1.19	-0.34	66.88
Estimated	1.11	-0.28	67.02
|IGS-Estimate|	0.08	0.06	0.14

<1mm, compared to IGS05 type mean values

BDS Absolute PCV Initial Results

Estimated Absolute PCV

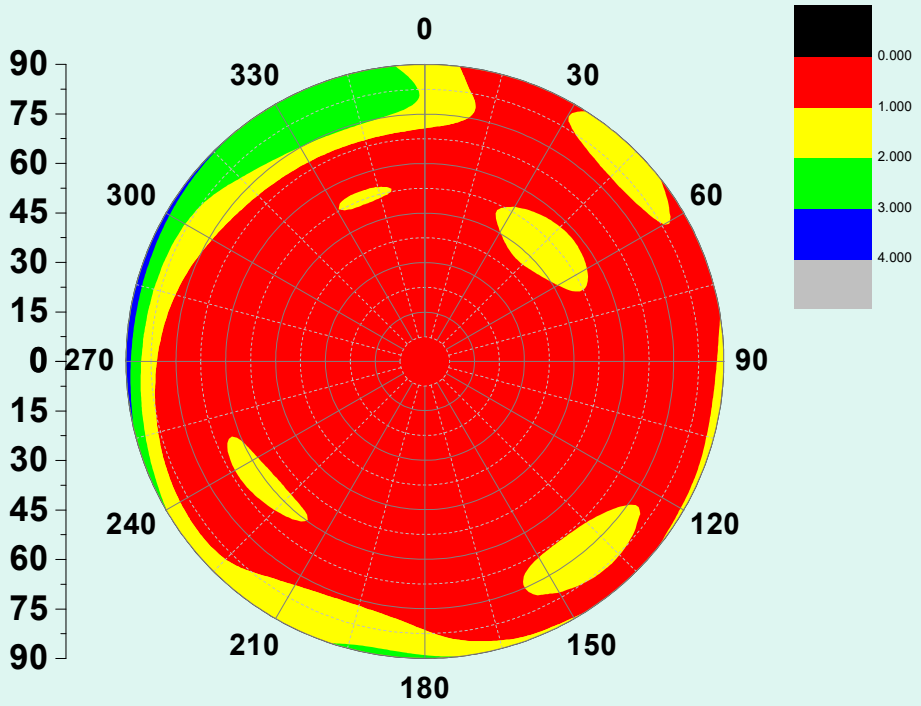
GPS L1 PCV



<1mm, compared to IGS05 type mean values

BDS Absolute PCV Initial Results

Estimated Absolute PCV (azimuth & elevation)



GPS L1 PCV (abs(IGS05 - Estimated))

<1mm, compared to IGS05 type mean values

BDS Absolute PCV Initial Results

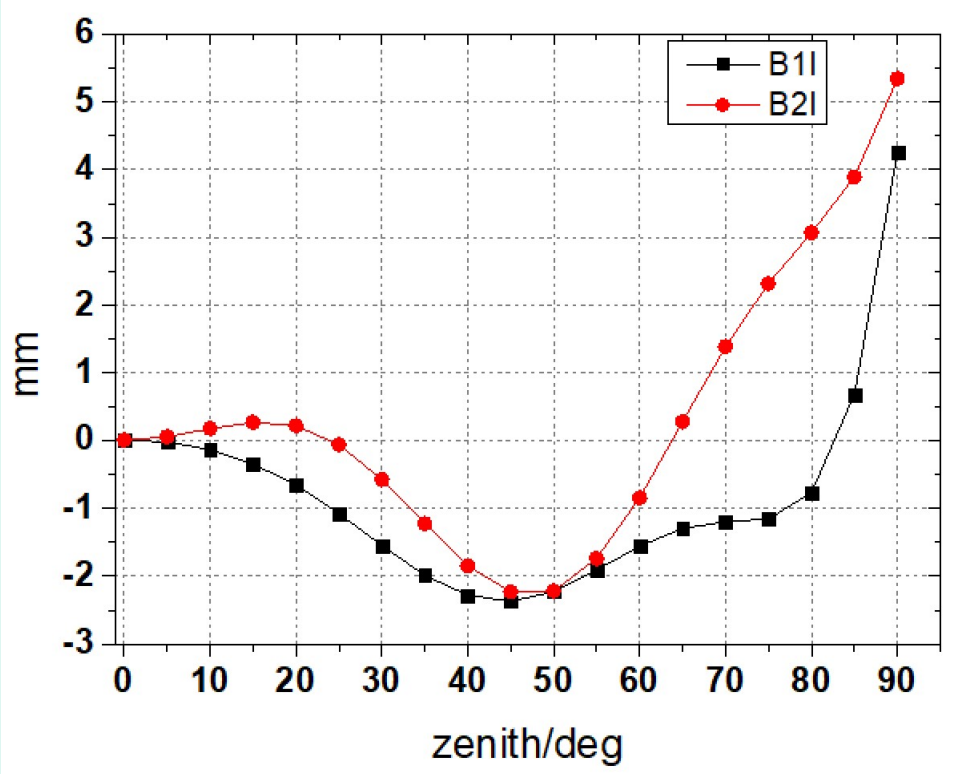
Estimated Absolute PCO

BeiDou B1&B2 PCO

PCO	N(mm)	E(mm)	U(mm)
B1	0.91	-0.55	66.47
B2	0.04	-0.02	57.69

BDS Absolute PCV Initial Results

Estimated Absolute PCV



BDS B1&B2 PCV

PCVs range from -4 to 10mm with zenith

BDS Absolute PCV Initial Results

Absolute Calibration Test 2

- Observation data: 5 sessions, 6 hours for each session
- Tested antenna type: DYWGNSSR044P00C
  (Shenzhen DingYao Co., Ltd., China)

Without DORM

With DORM

BDS Absolute PCV Initial Results

Estimated Absolute PCO

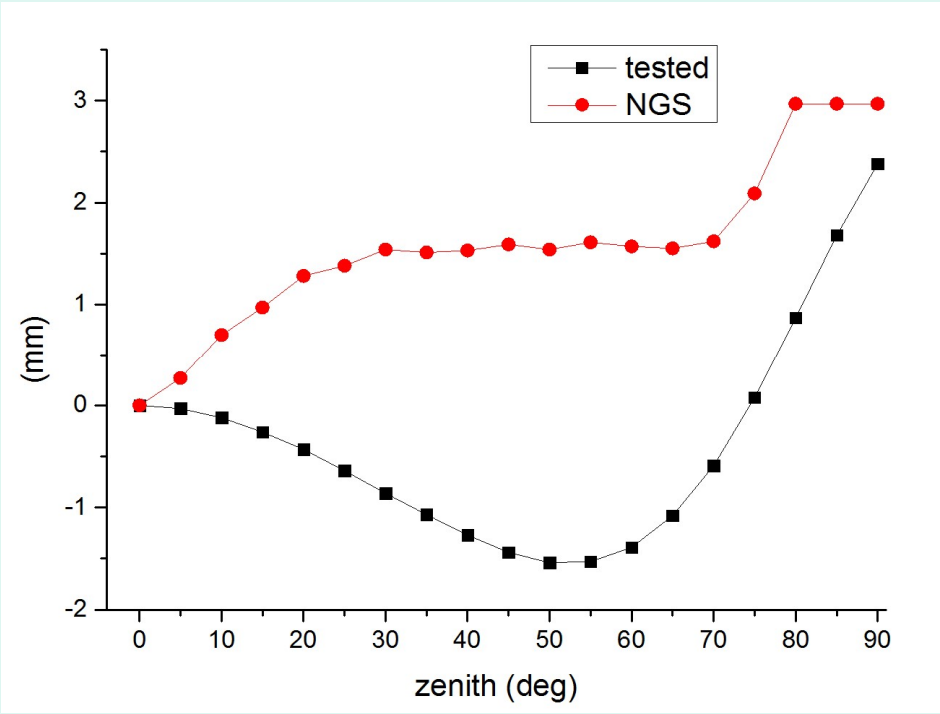
GPS L1 PCO

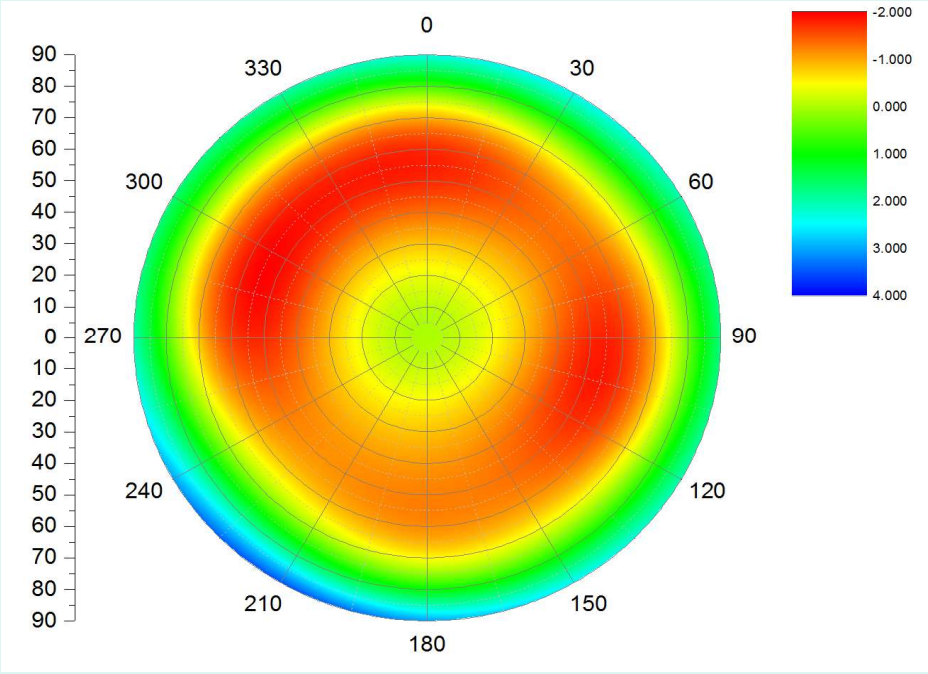
N(mm)	E(mm)	U(mm)	By
0.31	-0.25	139.31	WHU
-0.47	2.08	138.05	NGS

Difference: 1-2mm with respect to NGS

BDS Absolute PCV Initial Results

Estimated Absolute GPS L1 PCV





PCV elev-only: diff:2-4mm

Estimated full PCV

BDS Absolute PCV Initial Results

Estimated Absolute PCO

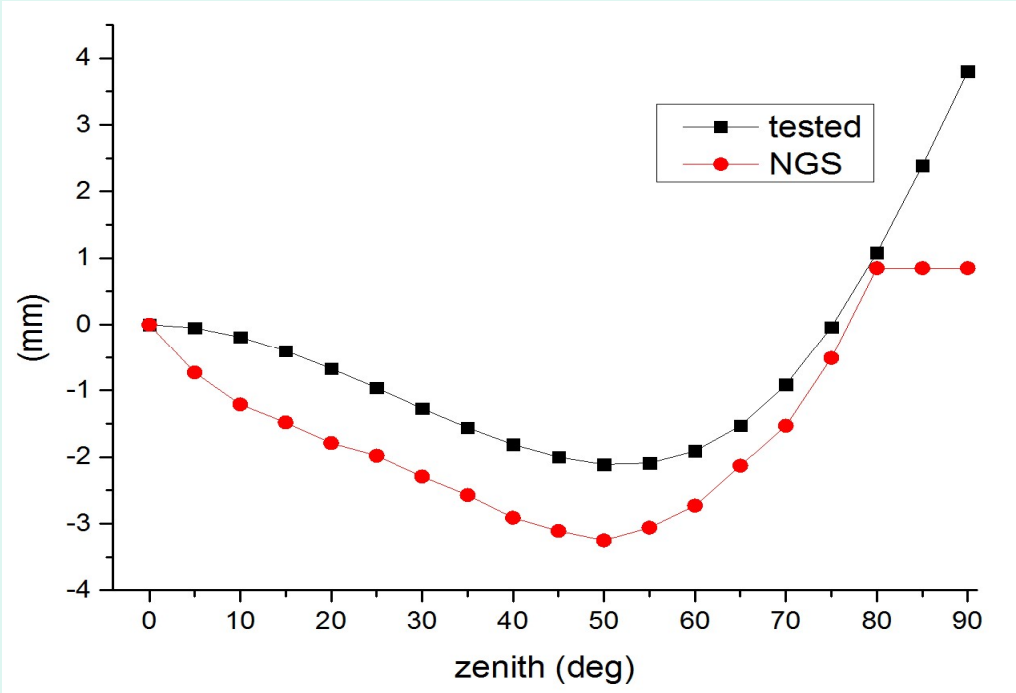
GPS L2 PCO

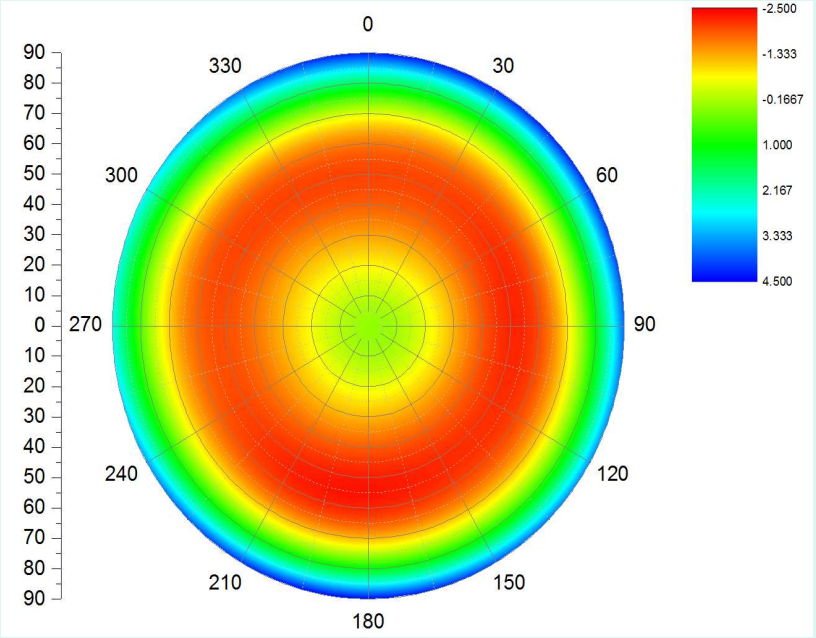
N(mm)	E(mm)	U(mm)	By
0.59	-0.24	150.81	WHU
-0.29	0.42	148.65	NGS

PCO L2 difference is 1-2mm.

BDS Absolute PCV Initial Results

Estimated Absolute GPS L2 PCV





PCV elev-only: diff:1-2mm

Estimated full PCV

4 Conclusion

Conclusion

Trimble TRM57971/NONE was calibrated and the estimated values were further compared to the geo++ results from igs05.atx:

- <1 mm PCO calibration accuracy level can be achieved
- <1 mm PCV elevation only calibration accuracy level can be achieved
- PCV with elevation and azimuth calibration accuracy is mostly within 1mm

Conclusion

And an antenna type “DYWGNSSR044P00C” produced by Shenzhen DingYao company was calibrated and the obtained values were compared with NGS results:

- <1-2 mm GPS PCO consistency accuracy level can be achieved
- <2-4mm GPS elevation-only PCV consistency accuracy level can be achieved

Future work

- BDS/GNSS PCO/PCV models for geodetic antennas can be calibrated in the near future at WHU.
- The calibrated BDS PCO/PCV models should be validated in the high precise applications, such as PPP, and long baseline relative positioning etc.

Thanks for your attention!