Impact of Absolute Antenna Phase Center Corrections on Global GPS Solutions

Ralf Schmid, Daniela Thaller, Peter Steigenberger, Markus Rothacher
Forschungseinrichtung Satellitengeodäsie (FESG), TU München

Manuela Krügel
Deutsches Geodätisches Forschungsinstitut (DGFI), München
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Mean LC Pattern (9 Days in 1994)

Satellite Antenna PCV [mm]

Nadir Angle [°]

Δz_I = 1.149 m
(c.f. Δz_{II/IIA} = 1.315 m, Δz_{IIR} = 1.333 m)

Absolute PCVs applied.
Should be zero!
Mean LC Pattern after Offset Correction

![Graph showing the mean LC pattern after offset correction for different blocks (IIR, II/IIA, I). The x-axis represents the Nadir Angle in degrees, and the y-axis represents Satellite Antenna PCV in millimeters. The graph compares the pattern for Block IIR, Block II/IIA, and Block I.](image-url)
Azimuth-Dependent Satellite Antenna PCVs

Antennas of all existent satellite blocks consist of

- 12 helical elements
- 2 concentric circles
- 4 elements forming the inner circle

Orientation with regard to the y-axis not always clear!

→ **Fourfold pattern** should show up in the PCVs

Block I antenna (Czopek et al., 1993)
Block IIR, Overall PCVs

Overall azimuthal PCVs for a nadir angle of 14°

Sin-curve indicates the use of a non-optimal x-/y-offset

Δx = -1.1 cm
Δy = -1.2 cm
Block IIR PCVs after Offset Correction

![Graph showing residuals vs. azimuth](image-url)
Azimuth-Dependent Satellite Antenna PCVs

Inner circle of Block II/IIA: elements unequally spaced?
Block II/IIA, Horizontal Offsets

IGS horizontal offset
($\Delta x = 27.90 / \Delta y = 0.00$)
Comparison of Global Solutions

- IGS network (about 150 stations)
- Bernese GPS Software
- Daily solutions with estimation of all relevant global parameters (combined to two-week solutions for some of the tests)

**PCVs applied:**
- **Relative:** official IGS set *igs_01.pcv* (receiver PCVs only!)
- **Absolute:** IGS test set *pcv_abs_proposed11.tst* (receiver and satellite PCVs)
Coordinate jumps

- Change in coordinates when switching from **relative** to **absolute PCVs** (two-week solution)
- Systematic effects due to different geocenter positions removed (several mm)
- Systematic change in height due to **change of scale to ITRF** (different for each AC)
- Absolute PCVs include **azimuth-dependent** receiver antenna corrections
Impact of Azimuth-Dependent PCVs

Histogram of Coordinate Differences
(Translations removed): abs. PCV – rel. PCV

North
mean = −1.9 mm

East
mean = −0.5 mm

Height
mean = 8.0 mm

Impact of azimuth–dependent receiver antenna PCVs

North

East

Height

Coordinate Differences [mm]
Impact of Elevation Cut-Off Angle

Elevation Cut-Off: $10^\circ \rightarrow 3^\circ$

Relative PCVs Used

Elevation Cut-Off: $15^\circ \rightarrow 10^\circ$

Relative PCVs Used
Mean: $+4.4$ mm

Absolute PCVs Used

Absolute PCVs Used
Mean: $-0.9$ mm
Comparison of GPS & VLBI Troposphere

<table>
<thead>
<tr>
<th>Station</th>
<th>( \Delta \text{Height (local tie)} ) [m]</th>
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<tbody>
<tr>
<td>ALGO</td>
<td>23.11</td>
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<tr>
<td>FAIR</td>
<td>13.08</td>
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<td>WEST</td>
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<tr>
<td>WTZR</td>
<td>3.10</td>
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</tbody>
</table>

**Theory:** \( \Delta \text{Height} = 10 \text{ m} \)

\[ \rightarrow \Delta ZD \approx 3 \text{ mm} \]

**VLBI:** data of the continuous two-week campaign CONT'02 processed at DGFI

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Mean Bias between GPS and VLBI

- Red diamond: Theory
- Blue square: Estimates (rel.PCV)
- Green triangle: Estimates (abs.PCV)
Comparison of GPS & WVR Troposphere

**WVR**: preliminary data set from Onsala

**Bias using relative PCVs**: 4.9 mm

**Bias using absolute PCVs**: -0.9 mm
Conclusions

Satellite antennas:
• Comparison of Block II pattern from 1994 and 2002: ± 3 mm
• Azimuth-dependent PCVs: ± 4 mm
• Significant differences in the horizontal offsets (center of mass variations due to maneuvers?)

Transition to absolute phase center corrections:
• Better agreement with tropospheric results from VLBI and WVR
• Coordinate jumps of up to 1 cm
• Results less dependent on the elevation cut-off angle
• A must when using data below 10° elevation!