Absolute Field Calibration of GPS Antennas

Approach, Use, Effects and Need of Absolute PCV Information

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1) INTRODUCTION

The signal reception behavior of the GPS antenna is not homogeneous. The phase center variations (PCV) are an important error source for all precise GPS observations, especially while using the ionospheric free linear combination and estimating a tropospheric parameter. Applications are for example:

- high precision surveys (mixed antennas)
- large networks (even using the same antenna types)

PCV calibration procedures currently carried out are:

- relative calibration (field procedure)
- absolute calibration (anechoic chamber)
- *absolute calibration (field procedure).*

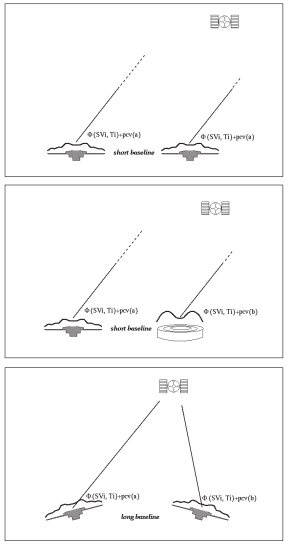

Fig. 1 (a-c): The impact of PCV

2) ABSOLUTE FIELD CALIBRATION

This approach allows the determination of azimuth- and elevation-dependent PCV in an absolute sense through a field calibration. The development was mainly caused by the fact, that existing field calibrations are relative (reference antenna) and correlated with the site (multipath influence). The absolute field calibration makes use of the repeated satellite constellation after a mean sidereal day. In case of unchanged conditions, also the multipath effects repeat with the same period. The observable for the estimation of absolute PCV is the difference of observations between two sidereal days. In order to re-obtain the PCV information, the antenna is rotated and tilted in a calibrated antenna mount on one of the two days. Then a spherical harmonic function serves for the PCV estimation. Main issues of the absolute field calibration are:

- multipath elimination/reduction; not site dependent
- calibration of a single antenna independent from a reference antenna; no reference coordinates
- PCV estimation in one adjustment; no separation of offset and phase pattern, yielding a completely described antenna (combination of offset/reference point + associated PCV)
- good coverage with observations over the whole antenna's hemisphere through rotations/tilts; possibly down to elevation zero.

Fig. 2: Robot

The approach is still evolving. Influence factors to be further investigated are the currently used antenna mount (shading effects, precision, calibration) and remaining differential multipath (rotations/tilts and weather). Due to the technical constraints and also due to the considerable efforts for the calibration procedure, a future goal is an automation. The use of a highly precise robot will even more enhance the accuracy, reliability and therefore the suitability for a faster calibration of more antenna types.

3) MIXED BASELINE APPLICATION

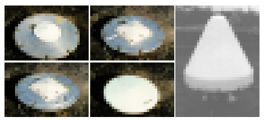

Fig. 3 (a-e): Antenna types used in the mixed baseline test

In order to evaluate (absolute and relative) PCV in a small network, a test (network extension < 20 m) was carried out using five different antenna types.

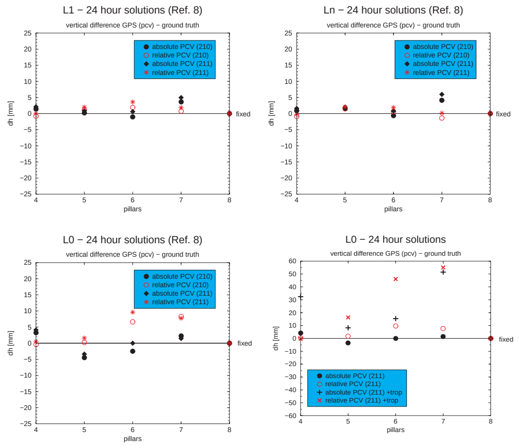

Fig. 4 (a-d): Results of mixed baseline test

The height components of several solutions (24 h) were compared with heights derived from precision levelling. The results show L1-, LN-accuracies of ≤ 5 mm and L0-accuracies of ≤ 10 mm for both PCV sets (degraded while estimating tropospheric parameters, mainly due to the multipath influence at the test site). Short time observations (1h) show the same level of accuracy (0.5h only slightly degraded). Thus, good results can be obtained using the absolute PCV, also compared to other PCV sets. In general, the efforts for precise PCV have not yet reached the 1 mm level.

4) ABSOLUTE PCV USING IDENTICAL ANTENNAS

Relative PCV sets describe the difference PCV with respect to a reference antenna (e.g. Dorne Margolin) with a pattern set to zero. An experiment (network with several IGS Stations) shows the necessity for absolute PCV within expanding networks, even when using identical antenna types.

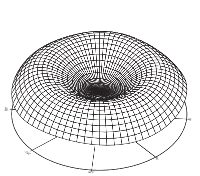

Fig. 5: L1-Phase pattern (qualitative) Choke Ring antenna, here Ashtech CR Dome

The data of several IGS stations with the identical antenna type DM-T was processed two times almost identically (WTZR fixed, IGS precise orbits, 10° elevation mask, L0, estimation of tropospheric parameters). The only difference was the zero-PCV correction in one case (the up-to-date procedure for this antenna type using relative PCV), and the introduction of absolute PCV in the second case. A systematic error shows up and can reach several cm. *Ignoring absolute PCV, the baseline length is biased in the range of 0.014 ppm*, a very considerable scale for larger networks.

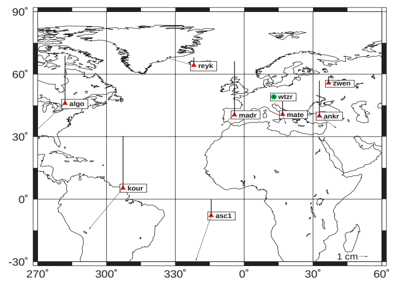

Fig. 6: DM-T network, residuals +/- absolute PCV

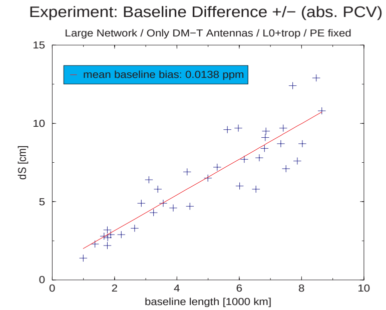

Fig. 7: dS (with/without absolute PCV introduced)

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