New Anechoic Chamber Results and Comparison with Field and Robot Techniques

B. Görres, J. Campbell, M. Siemes, M. Becker

A critical assessment of the accuracy of antenna calibration is most effectively made by comparison between different calibration methods. We present new chamber calibrations of five different antenna types in an anechoic chamber and a comparison with measurements using the absolute field calibration technique with robot mount of IfE/GEO++.

The accuracy is described using standard error parameters which allow the characterization of the quality of different antennas. The results validate the absolute calibration methods at the 1 mm level and confirm the presence of significant variations in quality between antennas of different design.

In the presentation we include the results of an earlier test made with a set of antennas calibrated successively at five different institutions, two using the absolute field technique with robot mount and three others applying the standard field calibration with reference antenna. Here, the comparisons show good agreement between two different calibrations with robot at the 1 mm level whereas the standard field calibrations display larger variations of 2 mm at L1 and 4mm at L2 against a mean, probably mostly due to multipath.

Estimation and Validation of the IGS Absolute Antenna Phase Center Variations

M. Ge, G. Gendt

To validate the IGS absolute antenna phase center variations (PCV) of GPS receiver and satellite provided by GEO++ and Schmid and Rothacher, EPOS software is adapted for using the absolute PCV corrections and estimating elevation-dependent satellite antenna PCV as well. For estimating, satellite PCV is modeled as a piece-wise constant function of nadir angle and a constraint that the sum of the corrections for each satellite is zero is implemented to prevent the singularity of the normal equation. An additional constraint to parameters belonging to the same block type is possible under requirement for obtaining the estimates for each block type.

Data from 2003 292 to 326 collected at more than 90 IGS stations are processed with the new IGS absolute PCV correction. Their impact on the products is analyzed by comparing the result with that with the relative PCV correction. The elevation-dependent satellite antenna PCV is also estimated with the same data set. The result shows a good agreement with the IGS values generally.

Impact of Absolute Antenna Phase Center Corrections on Global GPS Solutions

R. Schmid, D. Thaller, P. Steigenberger, M. Rothacher, M. Krügel

Since March 2003 a consistent set of absolute phase center offsets and phase center variations (PCVs) for GPS receiver and satellite antennas is available at the IGS CB information system. The receiver antenna corrections stemming from robot measurements in the field were made available by the company Geo++ (Hannover-Garbsen), the satellite antenna corrections were estimated consistently from global GPS data at TU Munich. This test set allows the computation of global GPS solutions avoiding the scale problem of 15 ppb.

We estimated daily global solutions, once introducing the absolute phase center corrections, once introducing the relative official IGS values, in order to show the impact of a PCV switch on global GPS parameters, especially on coordinates and troposphere parameters. For the coordinates, jumps of up to 1 cm in all components have to be expected, the scale being fixed to the ITRF scale stemming from VLBI and SLR. Besides, the coordinate results are less sensitive to the elevation cut-off angle, particularly below an elevation angle of 10 degrees where relative antenna calibration results are missing. For the troposphere results, extensive comparisons with VLBI and water vapor radiometer data have shown that the biases between these different observation techniques are reduced considerably when switching to absolute phase center corrections.

Furthermore, we reprocessed one week of data from 1994 in order to get the pattern of Block I, as up to now only the patterns of the satellite blocks II/IIA and IIR were known.

The Effect of SCIGN Domes on the Vertical Phase Centre Position in Routine Processing of GPS Data

H. Dragert, M. Schmidt

The question of GPS antenna phase centre shifts introduced by the addition of domes is receiving more attention as the precision of solutions continue to improve. Our earliest experiences with clear acrylic domes used in the WCDA Network demonstrated that changes in the vertical position of the phase centre exceeding 1.5 cm could be caused by the use of a dome. More recently, our deployments of SCIGN domes (SCIS) at WCDA sites showed no discernable shifts in the horizontal components but apparent shifts of over 2 cm in the height. Such large shifts have also been observed in practice by others but contradict calibration tests carried out by several calibration centers which indicate maximum vertical shifts of only a few millimetres. Tests with the SCIS dome carried out at PGC5 demonstrate clearly that domes can introduce an elevation-dependent (1/cosZ) delay and consequently, the use of SCIS domes biases the tropospheric zenith delay resulting in an apparent shift in the L3 estimate of station height. Since estimates of the tropospheric delay are strongly dependent on the elevation cutoff used in the analysis as well as local site horizons, it is not possible to provide an "absolute" calibration correction. However, mounting the SCIS dome so that its centre of curvature coincides with the mean position of the L1/L2 phase centres of the Dorne Margolin element significantly reduces this bias. This “dome effect” can be explained in terms of “lensing” of incident plane waves inside the dome.

Local Monitoring of a Fundamental GPS Site

M. Rothacher, V. Lechner, W. Schlüter

In view of the goal to establish a global terrestrial reference frame with an accuracy of about 1 mm over decades, more and more stringent requirements have to be put on the fundamental stations that are part of the global reference frame definition. At the fundamental station in Wettzell (Germany) two GPS permanent networks have been established a few years ago to allow a very detailed monitoring of the site: (1) a foot-print network of 4 sites around the station with an extension of about 10-20 km and (2) a very small local network of about 5 sites at the station itself with a size of about 3-5 m. These two permanent networks are part of a new monitoring concept for fundamental stations we present here in order to ensure the required long-term stability over decades.

The purpose of the footprint network is the monitoring of the local environment of the fundamental site allowing the separation of local movements or effects from regional or global plate tectonics. The coordinate repeatability below 1 mm obtained over three years for this network allows the detection and monitoring of interesting, small seasonal and non-linear signals that are important for the interpretation of the results obtained from global GPS solutions.

The purpose of the very small local network is the monitoring of (a) the performance of the GPS antennae and receivers, (b) the influence of the environment on the GPS data (e.g. snow on the antenna, changes in multipath, ...) and (c) the effect of equipment changes (antenna, receiver, setup, ...) on the site coordinates. In view of future developments (new antenna and receiver technology, Galileo, ...) it will not be feasible to keep the same equipment at a site for decades. Having a few antennae and receivers at a fundamental site allows the mutual monitoring of each of the components in this very small network, so that one of the antennae and/or receivers may be removed or exchanged without destroying the overall tie to the site monuments. We show that, with a repeatability on the level of about 0.2 mm (for two years of data processed), even extremely small changes in the configuration of this network can be assessed. Anomalies that are clearly visible in the results at Wettzell already led to the installation of a web cam to complement the monitoring and detection of environmental changes (like, e.g., snow coverage etc.) and the setup of an addition GPS antenna on a monument equipped with a highly accurate tilt meter.

All these monitoring tools (including the web cam) will help to detect and separate local effects from regional or global geophysical signals, will enable controllable equipment changes, and may even be used to correct for local effects in the global GPS solutions, thus considerably improving the long-term stability of the fundamental site and, therefore, the global reference frame.

Absolute Field Calibration of Carrier Phase Multipath

F. Dilßner, G. Seeber, U. Feldmann, G. Wübbena, M. Schmitz, M. Bachmann

Carrier phase multipath is one of the most dominant error sources for precise GNSS applications in active reference station networks. Depending on different factors, the effect may reach magnitudes in the order of several mm…cm. Multipath is a highly localized error and does not cancel out in observations differences. The bias falsifies all positions and can even effect the correct instantaneous ambiguity resolution.

In order to mitigate multipath propagation, one approach consists of the calibration of a GPS station using a robot with a moving antenna. The basic idea is to decorrelate the multipath on one station due to the (pseudo-)random motion of the robot. The multipath of a second station is now accessible. In order to separate the multipath signal also completely from the receiver clock errors, both units use the same clock. Now, single differences between both stations can be calculated and polynoms can be used to model clock behaviour and estimate multipath signals.

The Impact of the PCV Parameters in the Coordinates Estimate

R. Barzaghi, A. Borghi

The impact of the relative and absolute receiver antenna PCV parameters in the determination of coordinates has been investigated, performing several experiments at the Politecnico of Milano.

A very short baseline (about 4 m of length) has been observed using different couples of antennas: one antenna has been kept fixed and the other one has been changed. The data has been processed using relative and absolute PCV parameters, only depending by the satellite elevation, and absolute parameters from Geo++ Company, which models the PCV in function of the satellite elevation and azimuth.

Results of the experiments are commented in terms of millimetric repeatability of the coordinates under antenna changes.