- Home
- About Tech Talk
- Directory of Blogs (Site Map)

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How to Use IGS Antenna Phase Center Corrections

February 3rd, 2010 by Ralf Schmid

In November 2006, the International GNSS Service (IGS) switched from relative to absolute antenna phase center modeling. This was one of the most profound changes in the strategy of the various IGS Analysis Centers (ACs) since the start of the IGS in 1994. Phase center corrections *relative* to the reference antenna AOAD/M_T (Dorne Margolin element with chokerings from Allen Osborne Associates) that caused systematic errors on long intercontinental baselines were replaced by *absolute* calibration values independent of a reference antenna. Those can be determined, e.g., by a robot able to rotate and tilt the antenna to be calibrated. The application of absolute *receiver* antenna corrections that were available long before 2006 was only possible due to the simultaneous consideration of the *satellite* antenna behavior.

The phase centers of both the satellite and the receiver antenna are important, as they serve as the end points of the measured distance between the GNSS satellite and the receiver on the ground. Their exact position is modeled by a consistent set of phase center offset (PCO) and variation (PCV) values. The PCO describes the vector from the receiver antenna reference point (ARP) or the satellite's center of mass to the *mean* phase center, whereas the PCV values provide additional zenith- and/or azimuth-dependent corrections to get the *actual* phase center position. Since 2006, the IGS provides the values used for the generation of its products in the ANTEX format (antenna exchange format). The sign convention for the phase center corrections can be found in the corresponding format description.

For the GNSS user, it is important to apply consistent receiver and satellite antenna corrections and not to mix up absolute and relative correction values. When using IGS products, the corresponding IGS phase center corrections used for the generation of the product have to be applied. Moreover, the ARP as defined in the file antenna.gra has to be considered when measuring the antenna height above a certain ground marker. Finally, azimuth-dependent PCVs as well as the horizontal PCO components will only be beneficial, if the antenna is oriented to north. Apart from that it can be noted that for shorter baselines the impact of the satellite antenna and its phase center is only minor. And also relative phase center corrections may still be acceptable in the latter case.

Current IGS model igs05.atx

The current IGS model is called igs05.atx. For reasons of reference frame stability, generally, it is only possible to add correction values for newly launched satellites and new receiver antenna types. That means that the IGS file does not necessarily contain the 'best' values available. New releases of the file called igs05_wwww.atx (wwww denoting the GPS week of the file change) are announced via an equipment file mailing list. The *absolute* phase center corrections from igs05.atx should be used together with the IGS05 terrestrial reference frame which is aligned to ITRF2005 that is based on *relative* antenna phase center corrections. Differences in the station coordinates due to the switch from relative to absolute antenna corrections were computed from a parallel processing of the IGS ACs.

Figure 1. Antenna calibration robot (Photo: Geo++ GmbH).

For most of the receiver antenna types dominating the IGS network, absolute robot calibrations provided by Geo++ GmbH are available. The robot PCVs are azimuth-dependent for all elevations down to the horizon. These quality characteristics are mandatory for new stations entering the IGS network since 2009. In order to have phase center corrections for all existing stations, the robot calibrations are completed by converted field calibrations provided by the National Geodetic Survey (NGS). As regards the impact of radomes, the situation is similar. Since 2004, it is no longer allowed to add uncalibrated antenna/radome combinations to the IGS network. However, for existing stations with an uncalibrated combination, the corresponding calibration for the antenna without radome is used. Thus, the coordinate time series is useful, whereas the height of these stations cannot be considered to be measurable with respect to any external marker to better than a few cm.

Although much effort has been invested during the last two decades in refining antenna designs (e.g., extended ground planes, additional chokerings) and in-receiver processing algorithms, site-dependent errors like multipath and diffraction still can seriously affect the GNSS observables. Reflecting surfaces (e.g., concrete pillars, steel pylons, tribrachs, tripod heads) located in closest vicinity of the antenna ('near-field region') are considered to be most critical as their presence may change the overall antenna phase center characteristics due to induced currents caused by coupling effects. Due to its long periodic signal character, this 'near-field effect' generally does not average out over time, but systematically falsifies the solved-for parameters, particularly the vertical station coordinates. Depending on the antenna type, the processing strategy and the satellite geometry, biases in the station heights on the mm to cm level may arise.

So far, only three German institutions meet the current IGS requirements for receiver antenna calibrations. They all use more or less the same robot procedure developed in cooperation between Leibniz Universität Hannover and Geo++ GmbH. However, NGS will probably close the gap in Northern America with an independent procedure in the near future. And as soon as the new anechoic chamber of the University of Bonn is operational, the IGS could be able to provide phase center corrections for future GNSS signals.

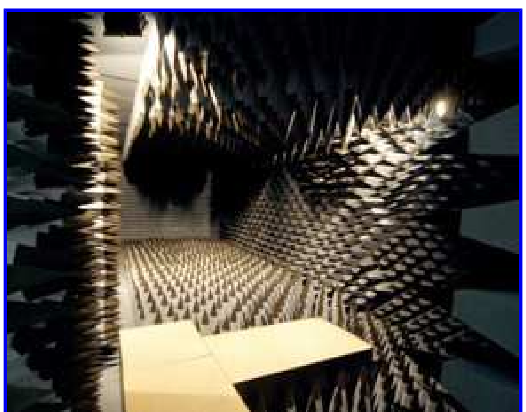

Figure 2. Anechoic chamber (Photo: University of Bonn).

The GPS satellite antenna corrections contained in igs05.atx were estimated by Deutsches GeoForschungsZentrum (GFZ) and by Technische Universität München (TUM) by reprocessing more than ten years of IGS data. The corresponding GLONASS corrections were provided by the Center for Orbit Determination in Europe (CODE) after processing more than one year of data. Although azimuth-dependent PCVs are present, the igs05.atx model is limited to block-specific purely nadir-dependent PCVs. In contrast, satellite-specific *z*-offsets are given, whereas *x*- and *y*-offsets are fixed to manufacturer's values. At the time the satellite antenna corrections were estimated, the solutions could only be aligned to IGb00, the IGS realization of ITRF2000, that was based on relative receiver antenna corrections.

Future IGS model igs08.atx

In view of the upcoming switch from ITRF2005 to ITRF2008 an updated IGS antenna phase center model is under preparation that will be called igs08.atx. The results of the first IGS reprocessing campaign will be used to generate a new set of satellite-specific *z*-offsets for all *GPS* satellites. However, as the PCVs were not set up as parameters in the reprocessing, it will not be possible to update the block-specific PCV values contained in igs05.atx. For the update of the phase center corrections of the *GLONASS* satellites a separate solution will be necessary, as GLONASS observations were not considered for the reprocessing campaign at all. Due to an improved orbit constellation, a better tracking network and an additional AC (European Space Operations Centre), the updated GLONASS corrections are expected to have better quality than the igs05.atx values. Although present, azimuth-dependent satellite antenna PCVs will probably not be considered for igs08.atx.

Figure 3. GPS Block IIA satellite antenna (Photo: Geo++ GmbH).

As regards the receiver antennas, the switch to a new reference frame provides the opportunity to consider the latest calibration results for each antenna type. The resulting jumps in station coordinates can be accepted, as comparable jumps are caused by the reference frame change. So, several converted field calibrations (purely elevation-dependent PCVs down to 10 degrees only) will be replaced by robot calibrations. Besides, also the existing robot calibrations can be updated with type mean values based on a bigger number of individual calibrations. The more individually calibrated antennas, the better the type mean phase center corrections. For a considerable number of GLONASS-capable antennas also GLONASS-specific phase center corrections will be provided.

The switch to ITRF2008 together with igs08.atx within the IGS can be expected for spring or summer 2010.

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