Impact of Different Individual GNSS Receiver Antenna Calibration Models on Geodetic Positioning

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Introduction
Since April 2011, the ig2008 txt antenna calibration model is used in the routine IGS (International GNSS Service) data analysis. The model includes mean robot calibrations to correct for the offset and phase center variations of the GNSS receiver antennas. These so-called “type” calibrations are means of the IGS receivers calibrations performed by Geo++ [Wibberen et al., 2006] and are available for a specific antenna/radome combination.

The GNSS data analysis performed within the EUREF Permanent Network (EPN) aims at being as consistent as possible with the IGS analysis. This also applies to the receiver calibration models. However, when available, individual antenna calibrations are used within the EPN analysis, see Figure 1, instead of the “type” calibrations. When these individual calibrations are unavailable, then the EPN analysis falls back to type calibrations identical as the ones used within the IGS (ig2008.txt).

1. Antenna Calibration Methods
Different calibration methods are used. Their usage in the EPN is summarized in Table 1. Each technique is different:

• Robot calibration: the antenna is fixed on a moving robot and observes the signal from the satellites. The robot allows to rotate the antenna in order to determine accurately the azimuth-dependent phase center variation (PCV).
• Chamber calibration: the antenna is in an anechoic chamber and observes a simulated signal. It can also rotate for the determination of the azimuth-dependent PCV.
• Field calibration: the antenna observes the satellites and the differences are made with respect to a calibrated antenna.

The differences between robot and chamber calibrations are summarized in Table 2 and the differences between the calibration values are shown in Figure 4.

To evaluate the influence of different receiver antenna calibration models on precise positioning, a similar approach was followed as the one used by Reberschug et al., 2011. Two separate PPP runs were made in all processing options (satellite antenna calibrations, orbits and clocks, etc.) and are identical except for the receiver antenna calibration model.

• For the receiver antenna calibration model, the ig2008 txt and individual calibrations were used. These differences are performed by the different PPP runs and will give us a daily estimate of the position offset caused by the changed receiver antenna calibration model.
• The final position offset of a station is then obtained by taking the mean of the daily estimates over the considered data set of that station (corresponding to the time frame a specific antenna/radome combination was installed).

Two data sets are analyzed here:
• The 53 EPN stations with individual calibration, from the beginning (2003 for the first individual calibration in the EPN) to April 2011. They are compared to the type calibrations from ig2008.txt.
• The six antennas installed at Royal Observatory of Belgium (ROB). Each of those antennas have been individually calibrated by both Geo++ and Uni-Bonn. The impact of the calibration method on the positioning is investigated by comparing the two calibrations for each antenna.

Figure 2 presents the histogram of the position offsets between individual calibrations and ig2008 txt calibrations, referred here as type calibrations.

3. Impact of Individual Calibration with Respect to ig2008.txt

The position offsets tend to have a greater impact on the vertical component. This is confirmed here and allows to explain the absence of normal distribution in this component. There are 4 position offsets equal to 0 mm in all three components. This is explained by the fact that the ig2008 txt calibrations for those antennas are made with one individual calibration.

Figure 3 presents the position offsets for the TRM55927.00 T2GD:

• Installed in 11 EPN stations and each of these antennas have been individually calibrated.
• All the individual calibrations for this antenna have not been performed by the same institute.
• The type calibration is the mean of Geo++ calibration of 8 antennas

Horizontal position offsets induced by two different individual calibrations reach 2 mm (for the north). The vertical position offsets are more pronounced: -9 mm for BUTE and 10 mm for KLOP. The antenna of KLOP is the only field calibration, and performed by a different institute than BUTE. Moreover, the differences between each calibration and the type calibration on L2 already show that the impact on each observation can reach more than 6 mm, depending on the elevation and the azimuth of the satellite over the station.

Conclusions
To study the impact of the calibration method on geodetic positioning 6 antennas have been installed at ROB. 5 of the 6 antennas are TRM68000.00 NONE, the other one is LEIAR25.R3 NONE. All those antennas have been calibrated by Geo++ and Uni-Bonn.

Figure 4 presents the phase center variation for both Geo++ and Uni-Bonn calibration for two TRM68000.00 NONE as well as the difference between the calibrations. The impact of this difference on the position can be seen on Figure 5 but we can observe that the impact is not straight forward. Indeed, the impact on the position will depend on the convolution of the differences between the calibration and the skyplot of the station, as shown in Figure 6.

• The position offsets can reach 3 mm in the horizontal component.
• There are no enough values to conclude to a negative bias in the vertical component induced by the different calibration methods.
• The vertical component is affected by position offsets up to 7 mm.
• The position offsets are equal or larger than those observed between individual and ig2008.txt calibrations.

Comparisons between station positions computed with

• Individual and ig2008.txt receiver antenna calibrations show that (results for Europe):
  • The position offset can reach 4 mm in horizontal component and 10 mm in the vertical component.
  • The position offsets have a greater impact on the vertical component.
  • For the same antenna model, the position offsets induced by different individual calibrations with respect to ig2008.txt calibrations can reach 2 mm in the horizontal component and 10 mm in the vertical component.

• Individual receiver antenna calibrations from Geo++ and Uni-Bonn show that (results for 6 antennas in Brussels):
  • The position offsets can reach 3 mm in the horizontal component and 7 mm in the vertical component.
  • Position offsets induced by different calibration methods can be larger than those induced by the difference between an individual and type calibrations.