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System dependence of GNSS receiver antenna calibrations

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Introduction

CODE, the Center for Orbit Determination in Europe, acting as one of the global analysis centers of the International GNSS Service (IGS), includes GPS and GLONASS measurements in a rigorous combined processing schema since May 2003.

When the IGS has introduced the absolute antenna phase center model-ing in November 2006, only corrections based on GPS-data were available for the receiver antennas. At the time the model was com-piled the GLONASS constellation was too weak to perform a system-dependent robot calibration. As a lack of alternatives, the GPS-derived receiver antenna corrections have been applied also to the GLONASS measurements.

This situation changes with the recently released igs08.atx model containing separate GPS and GLONASS receiver antenna corrections for selected antenna/radome combinations.

Data and Solutions

The sub-network processed by the CODE analysis center in the years 2009 and 2010 has been re-processed twice:

- using the igs05.atx antenna corrections together with the IGS05 reference frame
- using the new igs08.atx antenna corrections together with the IGS08 reference frame

The currently used procedure to generate the CODE weekly solution for the IGS final product series has been applied.

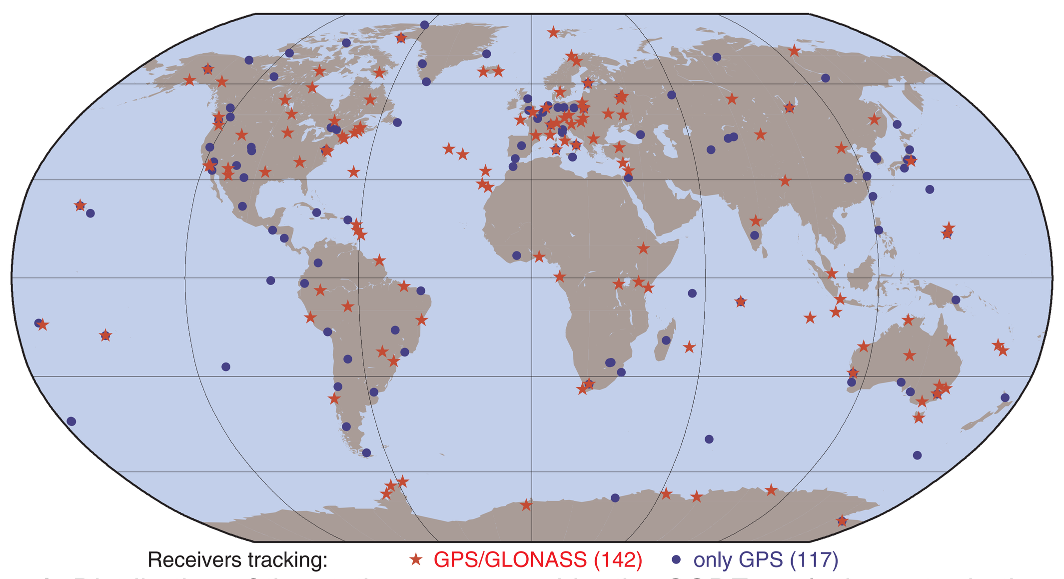

Figure 1: Distribution of the stations processed by the CODE analysis center in the years 2009 and 2010, used as a basis for this study.

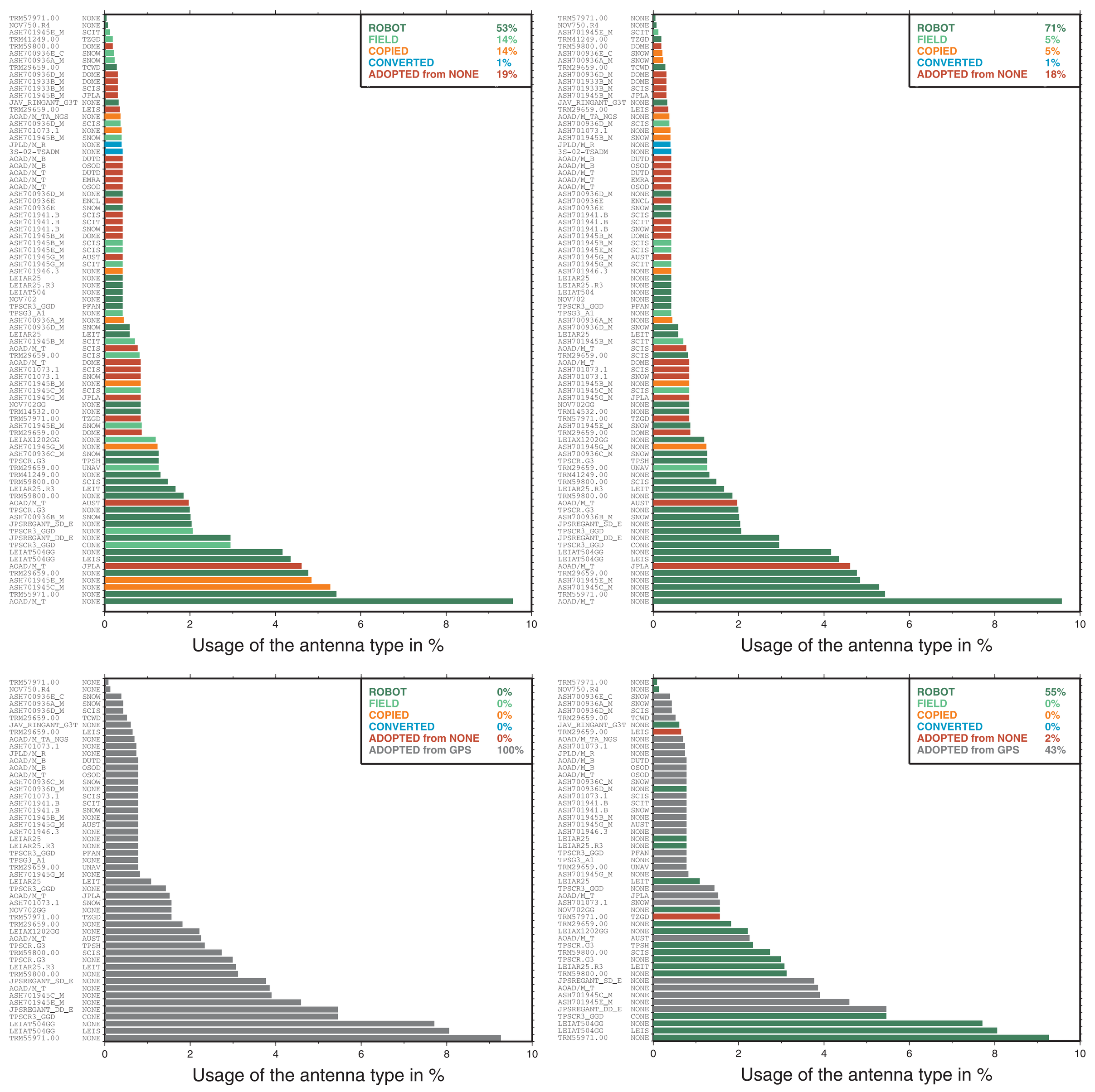

Figure 2: Calibration method of the antennas and their occurrence in the CODE processed network in the years 2009 and 2010 (left igs05.atx, right: igs08.atx; top: for GPS, bottom: for GLONASS measurements).

With the igs08.atx correction set much more ROBOT calibrated antennas became available.

GPS/GLONASS bias parameter

In both solution series (based on IGS05 and IGS08) so called GPS/GLONASS bias parameters are included:

- for the *station coordinates* equivalent to independent sets of weekly coordinates for GPS and GLONASS (applying a zero-mean condition on the XYZ-components inbetween them) and
- the *troposphere* parameters (one constant bias for each week) to absorb a potential mismodeling in the receiver antenna phase center variations.

These extended solutions may be compared with the corresponding default solutions without including these biases.

When adding the GPS/GLONASS bias parameters the RMS of the post-fit residuals for the weekly normal equation is reduced by about 1% - this cannot only be explained by the change of the degree of free-dom (400 additional parameters with respect to 350,000 other param-eters and nearly 27,000,000 observations). This improvement is achieved in both series, based on IGS05 or IGS08 modeling stan-dards.

Note regarding the figures:

- For Figures 4 and 5 the resulting GPS/GLONASS bias parameters have been realigned with respect to the mean bias for those stations that were available in at least 90% of the weekly solutions and where the antenna was not changed in 2009 and 2010 (these are 70 stations).
- For Figures 5 and 6 only stations are selected without an antenna change during the two years, with antenna/radome combinations available with ROBOT calibrations in igs08.atx, and which were available in at least 50 weekly solutions.

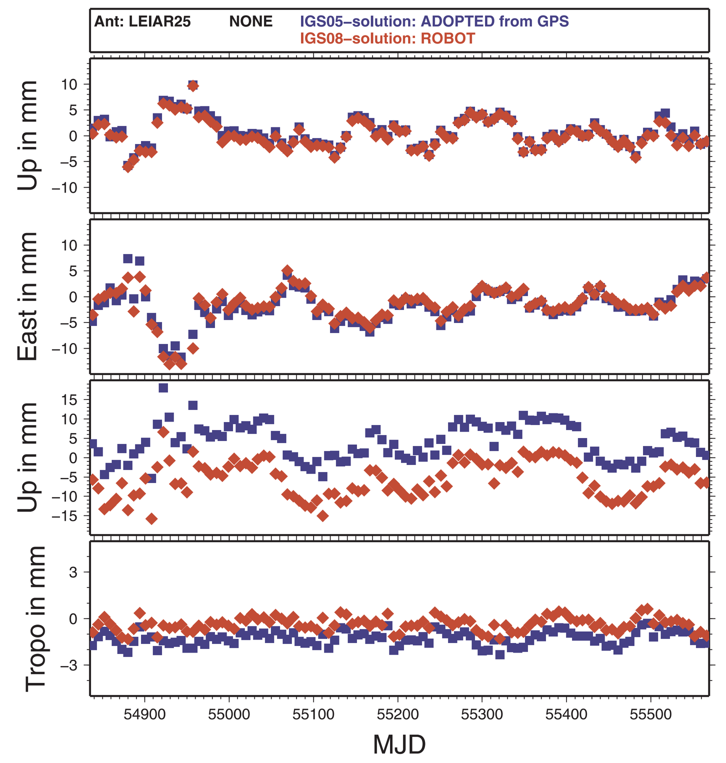

Figure 4: Time series of GPS/GLONASS biases for station ONSA as a typical example. The biases from the IGS05- and IGS08 solutions agree for the two hori-zontal components. There is an offset for the vertical and - as expected - the corresponding bias difference for the troposphere bias. The plots demonstrate the good repeatability of these biases between the weekly solutions.

Figure 3: Change of the repeatability of the weekly coordinate solutions without estimating the GPS/GLONASS biases when switching from IGS05 to IGS08 modeling standards. A positive number indicates an improvement of the RMS of the coordinate time series. If the calibration method of an antenna has changes from igs05.atx to igs08.atx the bar is printed in two columns (left half indicating the calibration method from igs05.atx, right half from igs08.atx). The top plot refers to the GPS-calibration of the GPS-only stations, the bottom plot to the GLONASS-calibration of the combined GPS/GLONASS receivers. Overall, an improvement of the repeatability when switching from IGS05 to IGS08 is indicated, in particular for the north and vertical components. From the comparison of the two solutions it cannot be concluded whether it results from the introduction of system-dependent antenna corrections, from the increased number of ROBOT calibrated antennas, from the improved reference frame or from any other source.

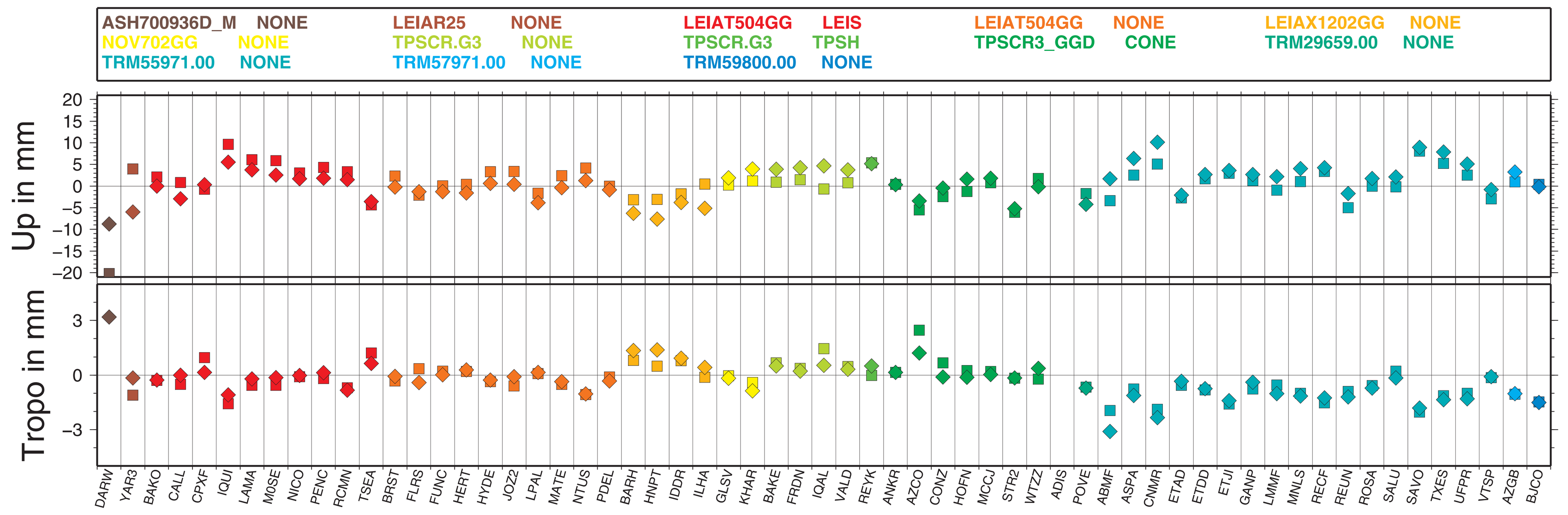

Figure 5: The mean GPS/GLONASS biases for all stations with ROBOT specifically calibrated antennas for GLONASS are plotted. In nearly all cases the differences between the squares (IGS05-based solution) and diamonds (IGS08-based solution) are on the 2 to 3 mm level for the vertical component. Only a few stations show a significant difference, like DARW and YAR3. In the horizontal components both sets of GPS/GLONASS biases agree on the one-mm level.

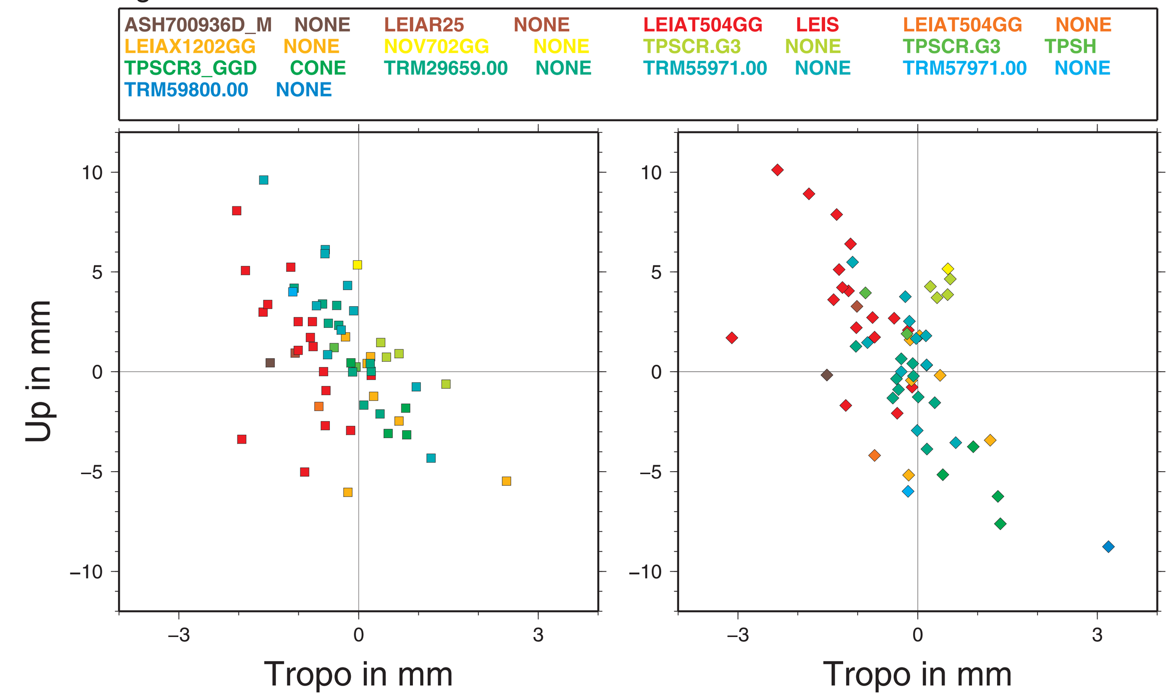

Figure 6: Correlatogram between the GPS/GLONASS bias for troposphere and the vertical component of the stati-on coordinates for the IGS05 (left) and IGS08 (right) solutions.

The red squares (several types of LEICA antennas) do not cross the ori-gin of the correlatogram in the IGS05 solution, which may indicate a system-dependent antenna phase center off-set. This issue seems to be solved in the IGS08 solution, possibly due to the GLONASS-specific antenna phase center corrections.

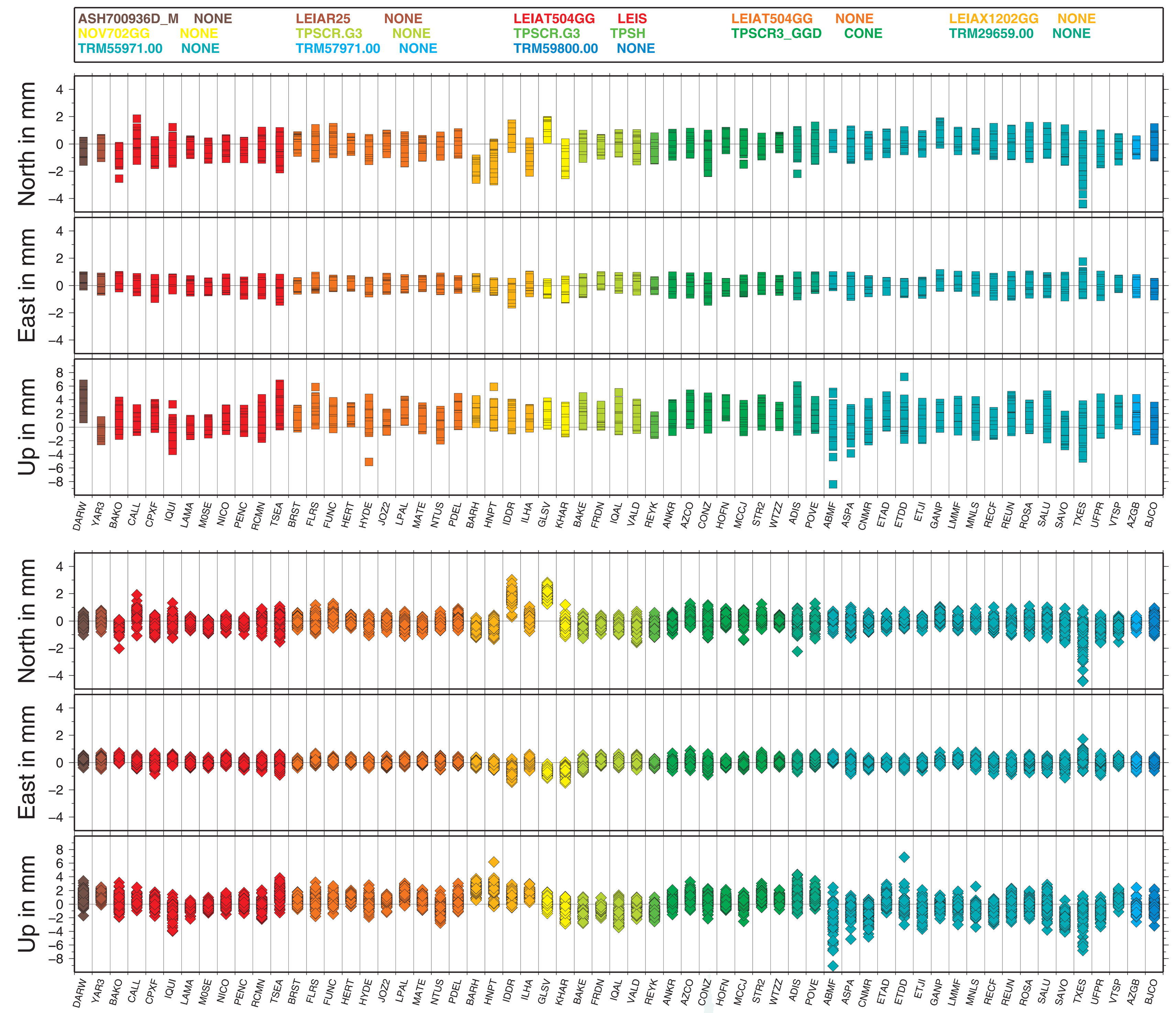

Figure 7: Differences in the computed weekly station coordinates between the default and the solution with the GPS/GLONASS bias estimation. In the top plot the IGS05-based and in the bottom plot the IGS08-based solution is presented.

It is noticeable that all differences in the IGS05-based solution have a positive sign in the vertical component. This may be explained by a GLONASS-related scale inconsistency, e.g., due to the satellite antenna offsets. In the IGS08-based solution this feature is not visible. Nevertheless, there are systematic effects in the vertical component as well, e.g., most of the TRIMBLE-antennas show nega-tive differences but in the results for stations equipped with LEICA- or TOPCON-antennas positive signs dominate.

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