Rooftop Antenna Calibration Field at the National Land Survey of Sweden

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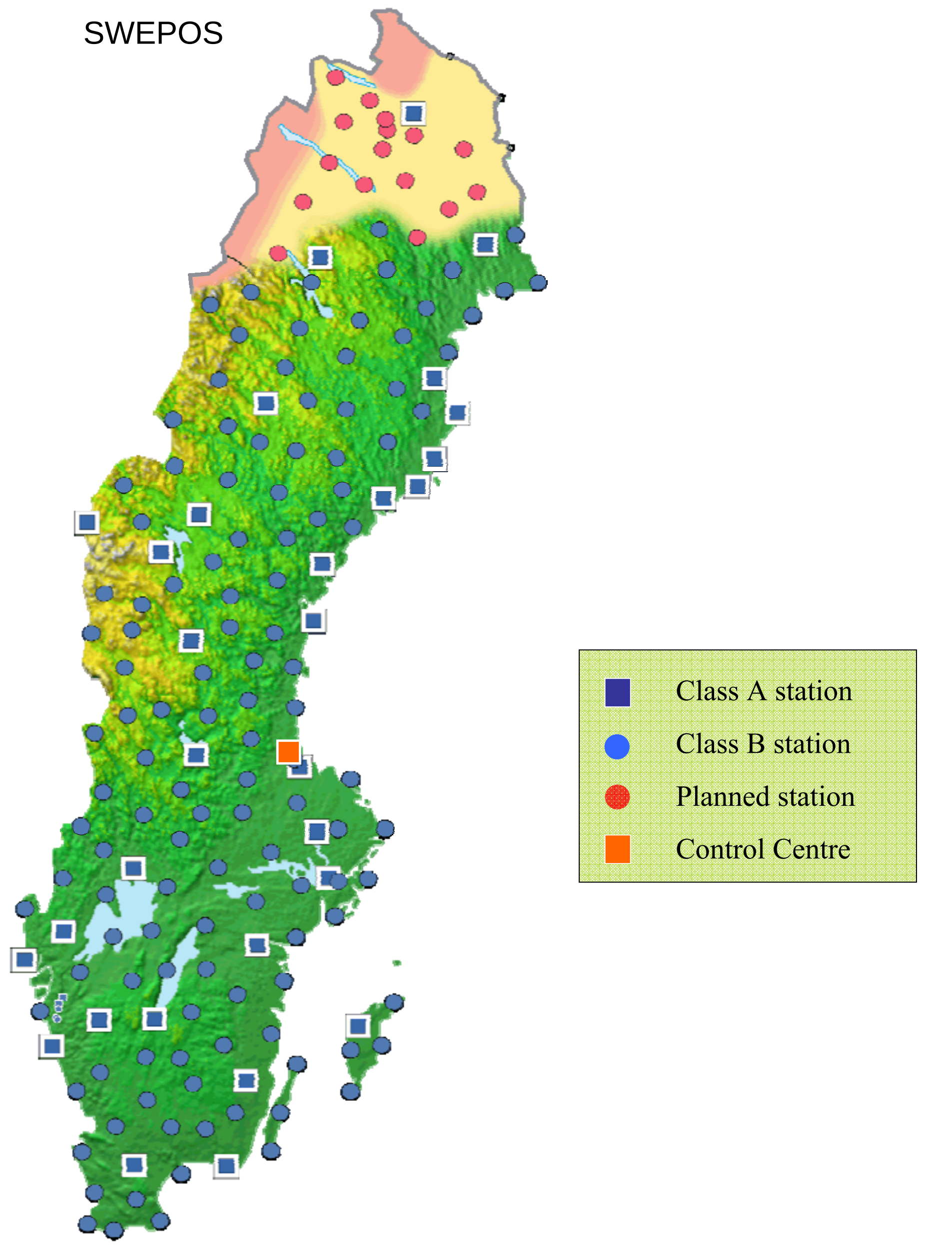
LANTMÄTERIET

SWEPOS



SWEPOS consists of 161 stations with dual frequency GPS/GLONASS receivers (Javad EGGDT) and antennas of the Dorne-Margolin type.

32 are Class A stations: GNSS antenna mounted on a concrete pillars directly on bedrock.
129 are Class B stations: GNSS antenna usually mounted on on roofs.
5 Class A stations are IGS and IGS-RT stations. 7 Class A stations are EPN stations.

SWEPOS Class A station

Arjeplog

SWEPOS Class B station

Hamra

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Summary

An antenna calibration field has been established on the roof of the National Land Survey of Sweden in April 2007, primarily for testing and calibration of the SWEPOS antennas. Up till now 100 calibrations have been performed on the new test field and 85 on older setups in Gävle and Mårtsbo. All new or problematic antennas in the SWEPOS network are tested on the test field. Even if the field is only for relative calibrations it has proved to be an invaluable tool for analyzing equipment in large GNSS networks. In the future we are planning to do an absolute calibration of the reference antenna in the field.

Field calibrations of the SWEPOS Class A stations is also ongoing.

Introduction

During the big expansion of the number of SWEPOS Class B stations in 2004 and 2005 rumours and suspicions about uneven quality of the Dorne-Margolin element led us to start doing antenna calibrations using the Bernese GPS Software. In the beginning two different sites were used. One at the roof of the National Land Survey and one at the Mårtsbo observatory outside Gävle (see below). Later it was decided to build a dedicated antenna test field with room for eight antennas. To make this field as available and secure as possible, it was placed on the roof of the National Land Survey. The antenna pillars are exactly the same as on the SWEPOS Class B stations! The "true" coordinates of the test field have been determined with total station and orientation from GPS measurements on stations 500-800 m away. Estimated accuracy: $\sigma_{horizontal} \approx 0.5$ mm, $\sigma_{height} \approx 0.3$ mm.

Procedure for antenna calibration at National Land Survey

The SWEPOS station Gävle is used as reference for the calibrations. The station was moved to one of the new stands (GAVL.4) when the antenna calibration field was established. No radome is used on this station when performing antenna calibrations. GAVL.4 is equipped with an ASH701945C_M antenna. The relative type model from NGS is used for this antenna.

Each antenna to be calibrated is normally measured three 24 hour sessions. The antenna is rotated 180° after two sessions, i.e. two sessions north oriented and one session south oriented.

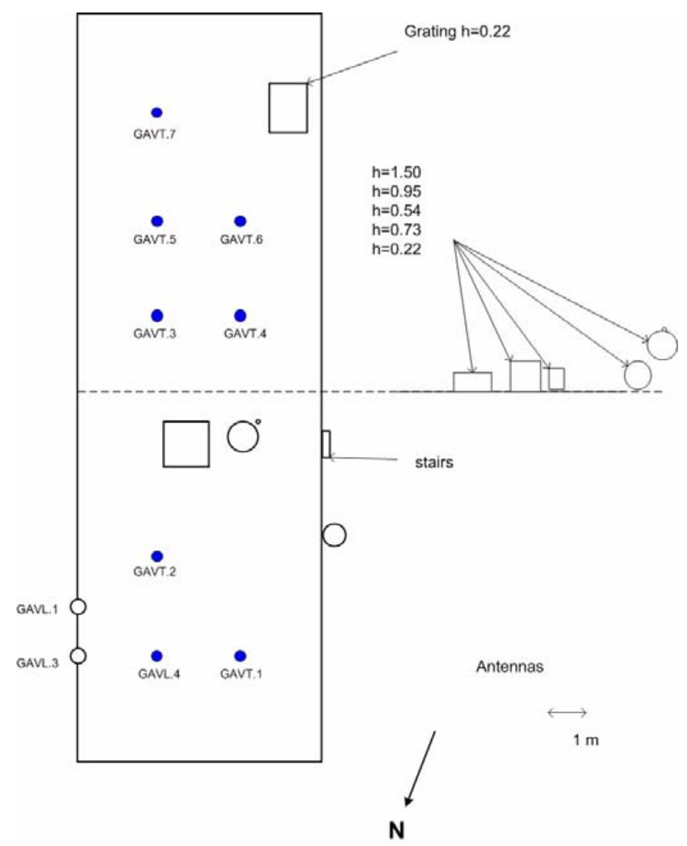
All processing is carried out in the Bernese Software version 5.0. In a first step the short baselines to GAVL.4 are processed on L1, L2 and L3T (ionosphere free linear combination in combination with solving for tropospheric parameters) using the official standard type model for the antenna. Each solution is then compared to the known coordinates. The L3T-solution reflects the coordinate shift we would see in the SWEPOS processing or SWEPOS Automated Processing Service if this antenna was introduced with the standard model. (The effect in the Network RTK service is not as easy to interpret.)

In the next step the antenna phase center offsets (PCO) and phase center variations (PCV) are estimated.. Note that the PCO and PCV are dependent of each other, the same phase pattern could be described by an infinite number of combinations of PCO and PCV corrections. Thus, the calculation of antenna parameters is divided into two parts. First the mean PCO is determined for each frequency (L1 and L2). Then this is kept fixed and just the remaining PCV are determined. Furthermore the mean PCO is dependent on the elevation cut-off angle. To make the estimated antenna models comparable to the models from NGS, the same cut-off angle of 15° is used.

In the Bernese software PCV could be estimated with two alternative models, piece-wise linear function or spherical harmonic function of variable degree and order. Again the options are chosen to correspond to the one at NGS. NGS models the PCVs with a 4th order polynomial and presents the final model in tabular form. We set the degree of the spherical harmonics function to 8 (just even parameters are estimated, which means 4 parameters) and the order to 0 (no azimuthal variations). Just as NGS we use 10° elevation cut-off. A special antenna orientation file is used to keep track on which sessions are south oriented.

The final antenna model for each antenna is computed by taking the average of the model obtained for the north and the south orientation. (Average of north orientation first computed.) This averaging of north and south orientation cancels out the horizontal errors connected to the reference coordinates and the reference antenna.

Before the antenna calibration field was established, antenna calibrations were performed in a similar way on the two existing stands at the SWEPOS station Gävle (GAVL.1 and GAVL.3) and the two pillars at the close by SWEPOS- and EPN station Mårtsbo (MART.0 and MART.6). Different ways of computing the antenna models were evaluated against introduced shifts in the time series at an antenna replacement. The methods evaluated were using north or south oriented observations, taking the average of north and south observations and finally an attempt to reduce the environmental effect by subtracting a model computed for an antenna of the same type as the reference (with the next serial number). The conclusion from this test was that the average antenna model from north and south observations gave the best result.



Repeatability

Some antennas have been calibrated at different setups, either different stands in the test field or both in the test field and in the old setups at Gävle and Mårtsbo. 12 such double measured antennas have been analyzed so far and the repeatability expressed as rms between the PCO estimations are well below 1 mm – see below.

RMS of repeated PCO estimations (mm)					
dN1	dE1	dU1	dN2	dE2	dU2
0.7	0.5	0. 5	0.7	0.8	0.6

Comparison to calibrations perfomed at NGS

Four antennas of the type JNSCR_C146-22-1 have been calibrated also at NGS. The antenna models from NGS have been compared to the result from our own calibrations performed at National Land Survey. Some antennas have been calibrated both at the new test field and at the baseline GAVL.3-GAVL.1. Both a direct comparison between the models and a comparison after correcting the horizontal components for the calibrations perfomed at National Land Survey to relative values (by subracting the absolute values for the AOAD/M_T-antenna) are presented. The calibrations at National Land Survey seem to be systemtically 1-2 mm higher. Agreement in the horizontal components are on the 1 mm level.

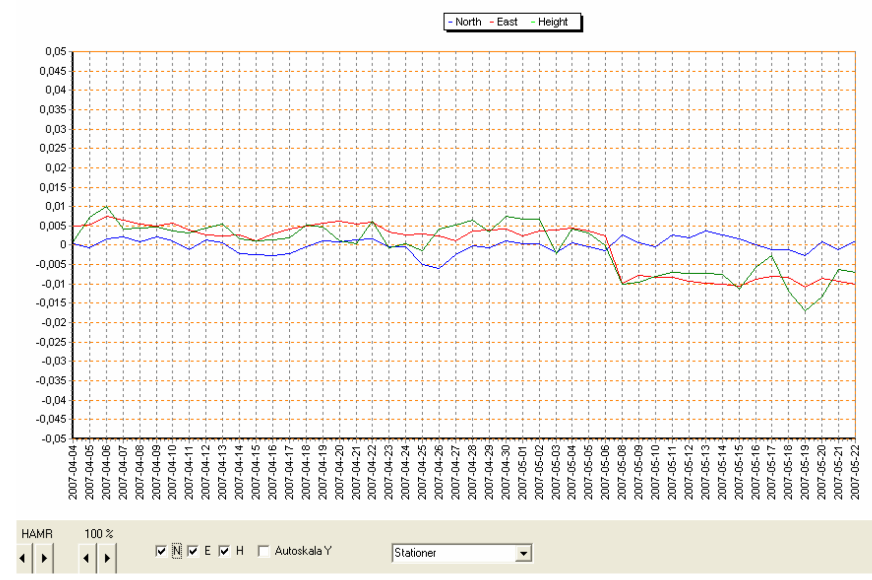
Comparison to NGS calibration for JNSCR_C146-22-1 (direct comparison)							
S/N	Place	dN1	dE1	dU1	dN2	dE2	dU2
244	test field	-0.4	-0.4	1.4	-0.8	-0.6	1.2
275	test field	-0.9	-0.9	2.3	-0.1	0.9	2.0
244	GAVL.1	-0.6	-0.7	1.5	-0.5	-0.7	1.2
275	GAVL.1	0.1	-0.7	1.4	-0.2	-1.0	1.0
284	GAVL.1	0.3	-0.1	1.6	0.2	0.1	1.1
285	GAVL.1	-0.5	-0.5	2.1	0.0	-0.4	1.6

Comparison to NGS calibration for JNSCR_C146-22-1 (horizontal components corrected to relative values)							
S/N	Place	dN1	dE1	dU1	dN2	dE2	dU2
244	test field	-1.0	0.2	1.4	-0.7	0.0	1.2
275	test field	-1.5	-0.4	2.3	0.0	1.5	2.0
244	GAVL.1	-1.2	-0.2	1.5	-0.4	-0.1	1.2
275	GAVL.1	-0.6	-0.2	1.4	-0.1	-0.4	1.0
284	GAVL.1	-0.3	0.4	1.6	0.3	0.7	1.1
285	GAVL.1	-1.1	0.0	2.1	0.1	0.2	1.6

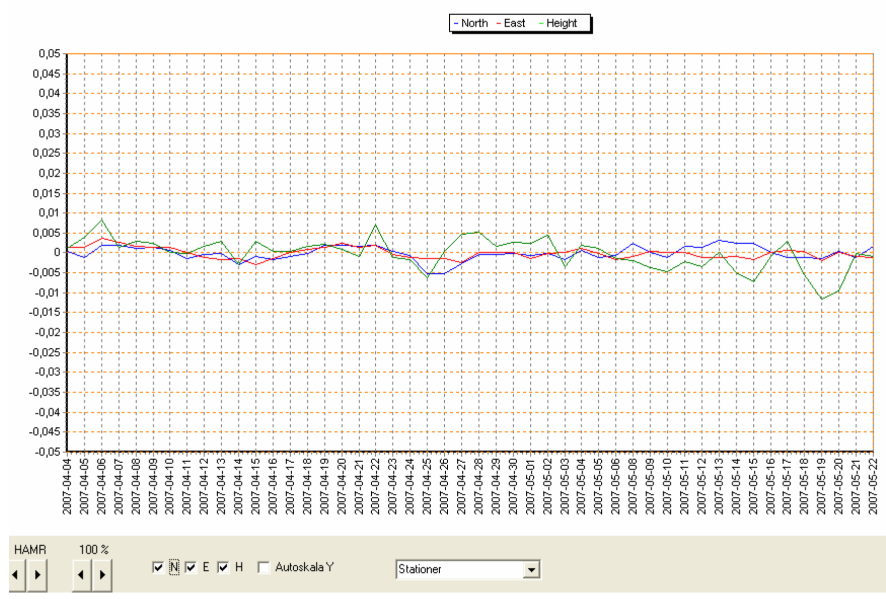
The use of the individually calibrated antenna models

The calibrations of the antennas with Dorne-Margolin element DM C146-20-2 have shown large individual variations, up to 15 mm in the horizontal component in the ionosphere-free linear combination. Thus, the individual antenna models for the antenna type JNSCR_C146-20-2 derived from the antenna calibrations performed at National Land Survey are used in the processing of the SWEPOS network. For all other antenna types used in SWEPOS, including the antenna type JNSCR_C146-22-1, the official type calibrations from NGS are used, as these antenna types have less variations between individuals.

Below is an example where the JNSCR_C146-20-2 antenna was replaced with an JNSCR_C146-22-1 antenna 2007-05-07 at the SWEPOS class B station Hamra. As a comparison, the processing was for some weeks before and after the replacement carried out also with the (inofficial) type model from NGS for the JNSCR_C146-20-2. In this example it is seen that the introduction of the individually calibrated antenna model almost eliminates the shift introduced by the replacement of antennas. For some other stations a shift is still there, but reduced compared to when using the type model. All the antennas with the DM C146-20-2 element in SWEPOS have been replaced with the DM C146-22-1 element!



Time series processed with the (inofficial) type model from NGS for JNSCR_C146-20-2.



Time series processed with the individual model for JNSCR_C146-20-2 from National Land Survey.