



AUTOMATIC SNOW CLEANING OF GNSS ANTENNAS



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Introduction

It is well known that some GNSS stations, like the ones in the northern part of Sweden, have problems with snow accumulation on the top of the antenna/radome every now and then during the wintertime. Specially if the layer of snow is thick and irregular, this can cause coordinate changes up to several centimetres (see **figure 1** and **figure 2**). To get good GNSS data all around the year, an antenna heater has been developed and tested.

About 20 years ago, the first antenna heating system used in the SWEPOS network were installed at the SPT0 10425M001 (SPT0) and KIRO 10422M001 (KIRO) stations. It was a fan system with warm air blowing in through a pipe under the radome. The system is still working at SPT0, but the system was never further developed or installed at any other stations.

In the end of 2021, we developed a slimmer heating system in co-operation with a Swedish company, IHP AB (International Heating Products AB).

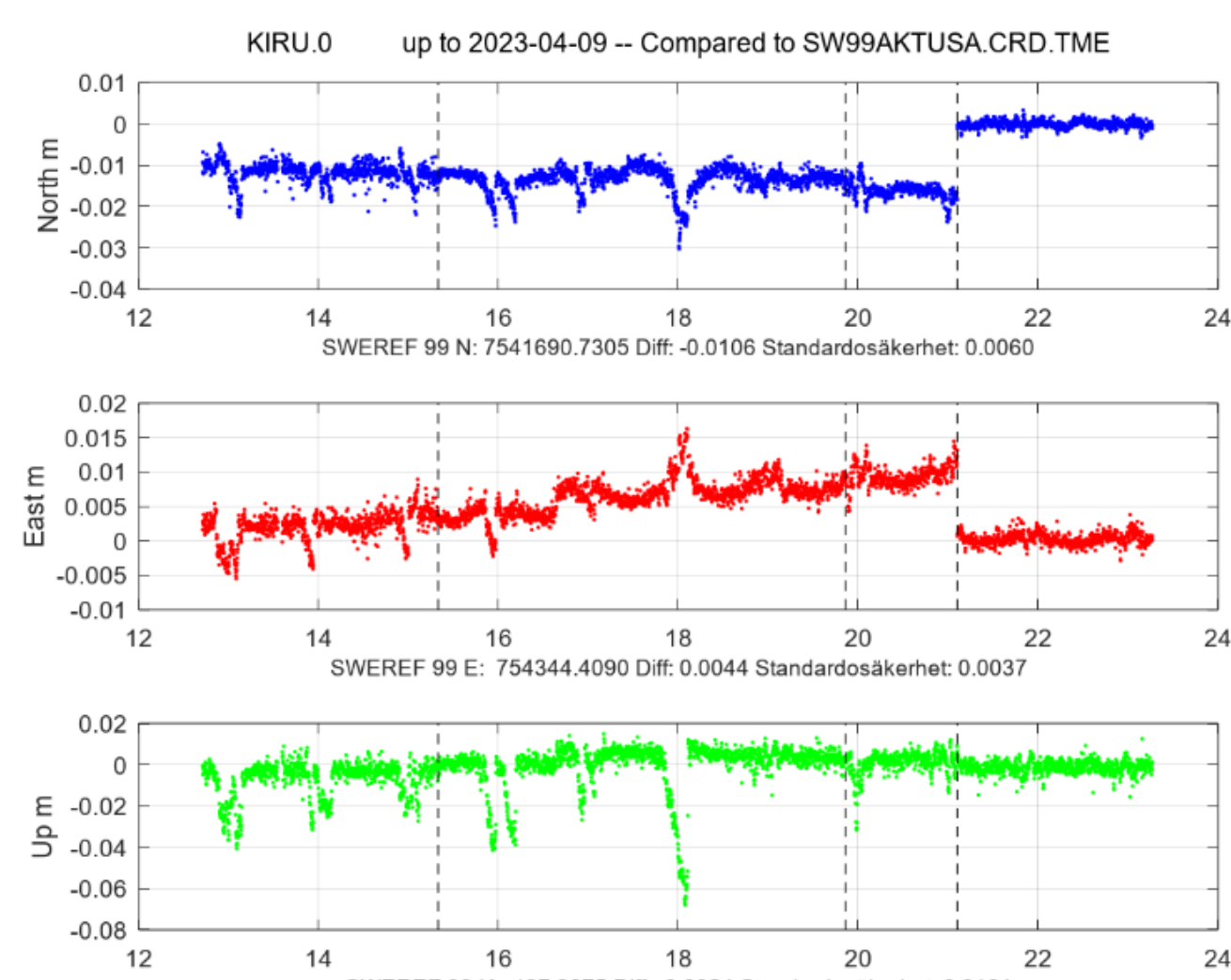


Figure 1. Time serie for KIRO 10422M001 (KIRO).

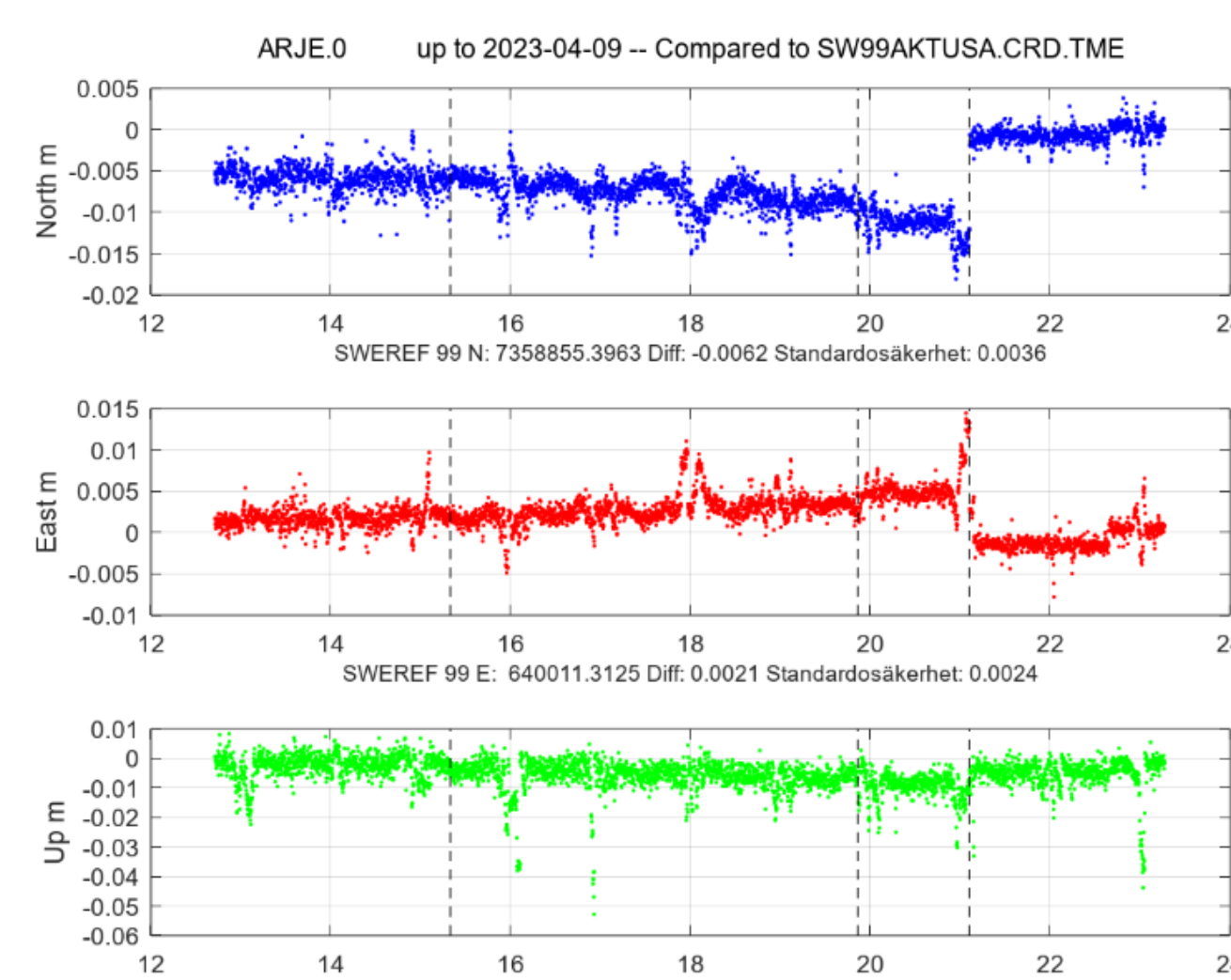


Figure 2. Time serie for ARJ0 10428M001 (ARJ0).

Snow cleaning

In January 2020 we started to clean the antenna at KIRO manually regularly once a week. It has also been done occasionally at other stations, see **figure 4**. Manual cleaning is time consuming and can not be performed at all stations regularly.



Figure 3. ARJ0 10428M001 (ARJ0) January 19, 2023.

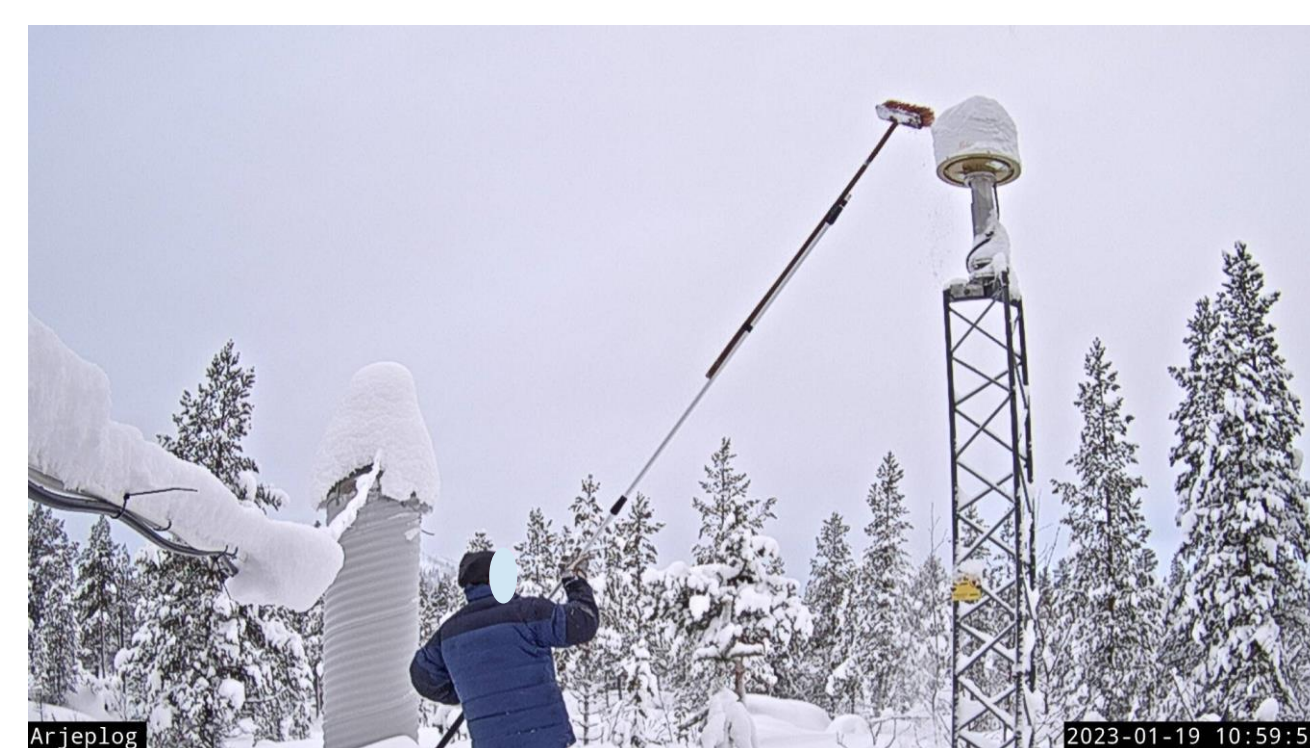


Figure 4. Manual snow cleaning at ARJ0 10428M001 (ARJ0) January 19, 2023.

Antenna heater

The new heating system consists of a silicone heater mat attached with adhesive to the bottom of the antenna. The mat is covered by a 1cm insulation layer made of white silicone in order to force the heat going through the antenna up to the radome and make the snow melt.

A 6 m long electrical cord goes to a 20x20x20 cm control box. A thermostat is included in the box and the temperature can be set manually. During the test, the temperature was set to 25 degrees. The control box runs with 230V as main power source and the power is 100 W. Two different models of antenna heaters were developed, one which runs on AC and one which runs on DC.



Figure 5. Old heating system at SPT0 10425M001 (SPT0).



Figure 6. New antenna heaters.

Test

Both antenna heaters were attached to a JAVRINGANT_DM antenna and tested in the beginning of 2022. Since October 2022 one (DC) of the heaters has been evaluated at a test pillar (KIR7) close to the IGS/EPN stations KIRO and KIR8. The test pillar (KIR7) was equipped with an OSOS radome.

At the original pillar (KIRO) there is a JNSCR_C146-22-1 antenna with a OSOD radome and at the mast (KIR8) there is a LEIAR25.R3 antenna with a LEIT radome. Two web cameras are taking photos of the antennas/radomes once an hour and the photos are saved for analysis. Observation data from all markers has been processed in the ordinary daily processing of the SWEPOS network to get daily solutions.

Antenna calibration

At the mean time, the other antenna heater (AC) attached to another JAVRINGANT_DM antenna has been at Geo++ for calibration, both with the heater turned on and off, as well as without the heater attached. The antenna models from the calibration were used in PPP-simulations to estimate the effect in computed coordinates between the three setups, see **table 1** and **table 2**.

Table 1. Comparison of the heater attached (power off) and without the heater.

JAVRINGANT A0080876	ΔN [mm]	ΔE [mm]	ΔU [mm]
L3, 3° (GPS)	-0.53	0.26	1.00
L3, 25° (GPS)	-0.35	0.81	-0.56
L3, 3° (GNSS)	-0.48	0.07	1.04
L3, 25° (GNSS)	-0.46	0.45	-0.06

Table 2. Comparison of power switched on and power off.

JAVRINGANT A0080876	ΔN [mm]	ΔE [mm]	ΔU [mm]
L3, 3° (GPS)	0.18	-0.10	1.21
L3, 25° (GPS)	0.09	-0.18	4.63
L3, 3° (GNSS)	0.16	-0.11	1.57
L3, 25° (GNSS)	0.18	-0.18	5.12

Result

Although the two original antennas/radomes (KIRO and KIR8) are cleaned manually once a week there can still be a lot of snow on the top of the radome, see **figure 8**. No matter if it was snowing heavily, the snow did never stick to the antenna/radome with the antenna heater (KIR7). It was maximum 1 mm of snow partly covering the radome a few hours, see **figure 7**. Even the electrical cord was free from snow.

Time series from daily solutions for all markers at Kiruna as well as both pillars and masts at two other northern stations (ARJ0/ARJ8 and VIL0/VIL8) can be seen in **figure 9**. ARJ0/ARJ6 was manually cleaned 2023-01-19 and at VIL0/VIL6 the snow disappeared 2023-01-25 due to warmer weather. The coordinates of KIR7 are dependent of the coordinates at KIRO and KIR8 since the process is done as a network solution. Repeatabilities from PPP solutions for the same stations can be seen in **figure 10**. Summer includes 1 June – 31 July, 2022 and winter 1 December, 2022 – 28 February, 2023.

In addition the ionospheric activities have been quite large in January-February 2023, see **figure 11**.



Figure 7. KIR7 January 19, 2023.

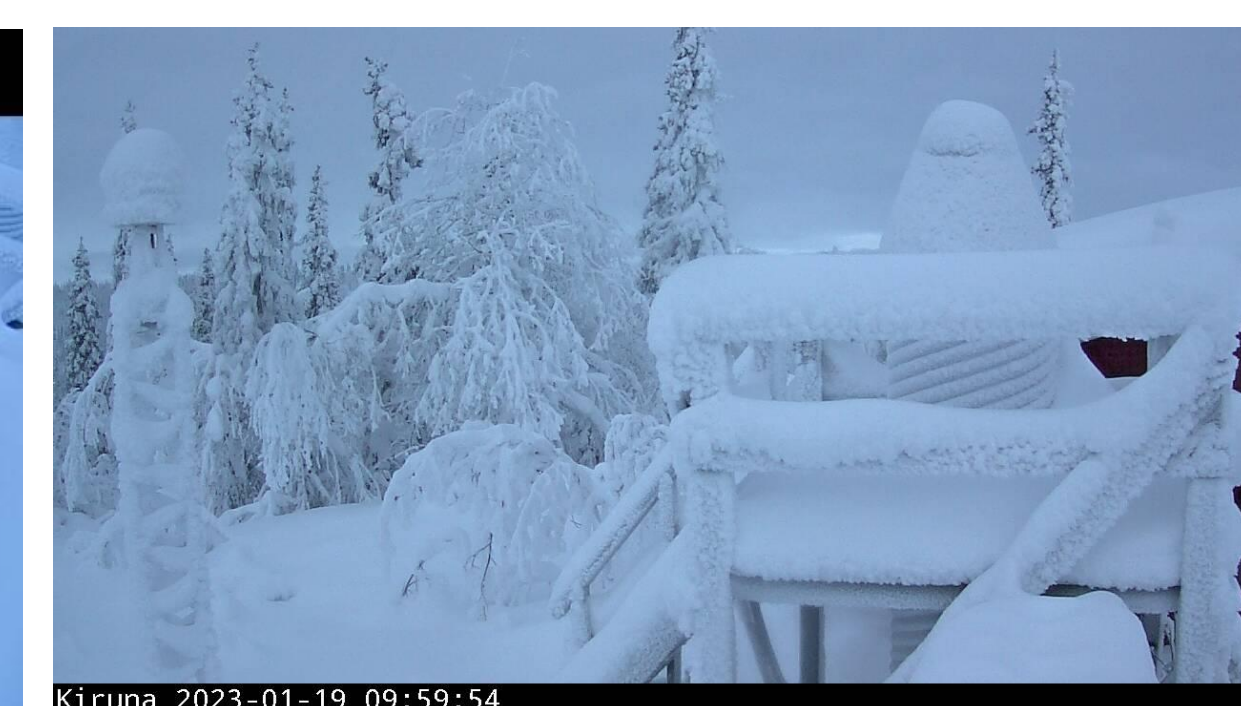


Figure 8. KIRO and KIR8 January 19, 2023.

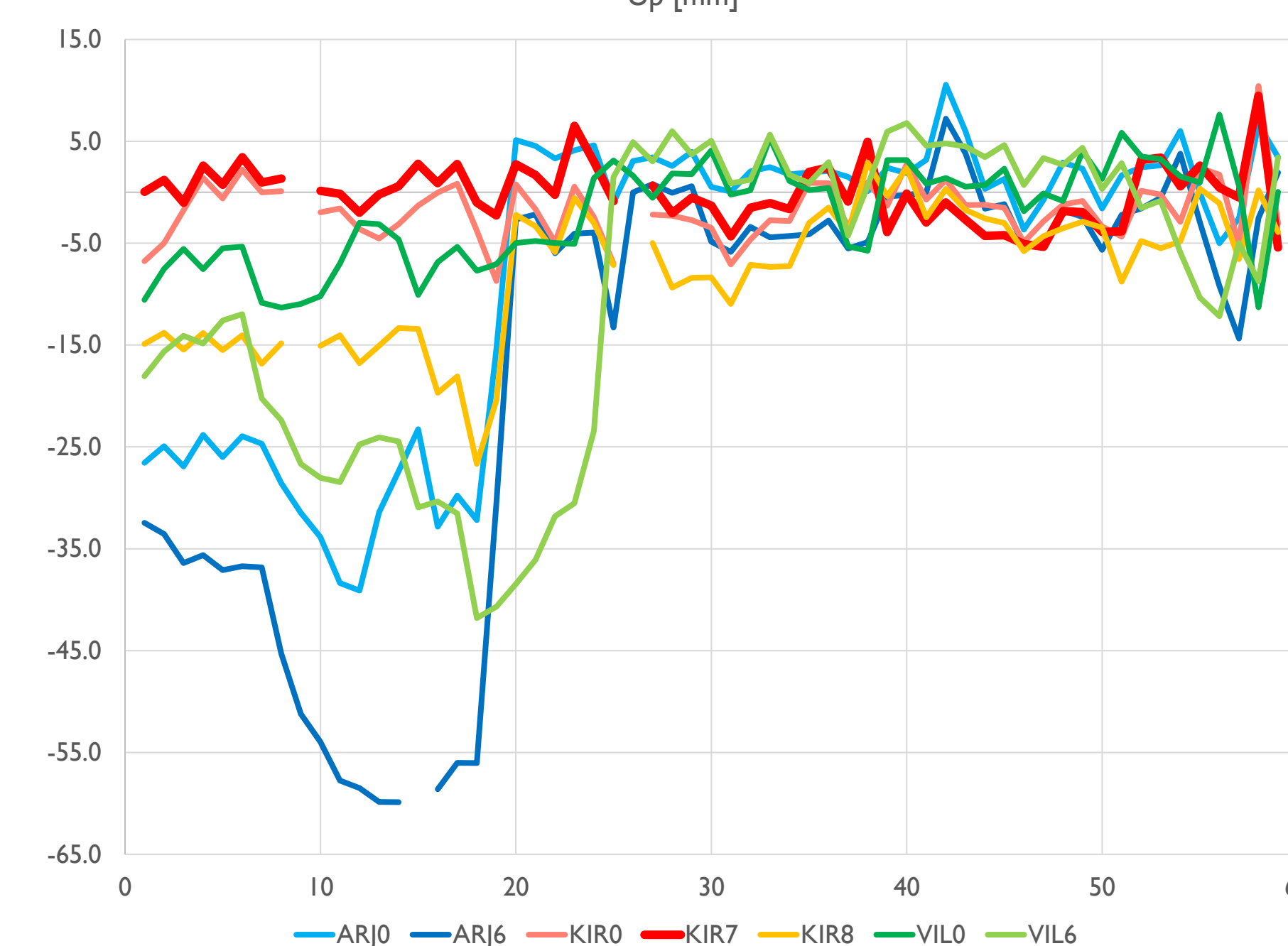


Figure 9. Time series 1 January – 28 February, 2023.

	Summer			Winter		
	East	North	Up	East	North	Up
KIRO	1.16	1.45	4.41	2.39	1.88	6.45
KIR7	-	-	-	2.47	1.71	6.24
KIR8	1.17	1.27	4.38	2.64	3.61	9.13
ARJ0	1.31	1.03	4.93	2.66	3.19	10.83
ARJ6	1.41	1.27	6.09	2.76	2.25	17.03
VIL0	1.27	1.33	4.59	2.63	2.60	7.81
VIL6	1.27	1.46	5.45	2.39	4.96	15.42



Figure 10. Repeatabilities, PPP solutions (unit: mm) Figure 11. Northern lights in Kiruna, 31 January, 2023.

Next step

Next step will be to test the antenna heater even on other antennas, e.g. on LEIAR20 and TPSCR.G5. We will also need to decide where to use the heaters. At all SWEPOS stations? Just class A stations? Just northern stations?