



ANTENNAS ON SWEPOS FUNDAMENTAL STATIONS

NKG WORKING GROUP OF REFERENCE FRAMES MEETING
IN TALLINN, MARCH 30-31 2023
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ANTENNAS ON SWEPOS FUNDAMENTAL STATIONS

- 21 fundamental stations in SwePOS
- Pillars installed 1992-1996
AOAD or Ashtech antennas,
OSOD radomes
- Masts installed 2011-2012
Leica LEIAR25.R3,
LEIT radomes



Sundsvall (SUND.0/SUN0 and SUND.6/SUN6)

WHY DID WE START TO EXCHANGE ANTENNAS AT THE PILLARS 2021?

- In 2021 the use of individual calibrated antennas was highly recommended by EPN
- Many of the antennas at the SWEPOS pillars were pretty old and most of them not calibrated
- 8 of 21 antennas (ASH) could not receive all signals (e.g. L5 and Galileo)
- Another 8 antennas (AOAD) are more sensitive to noise compared to modern antennas
- Two old antennas stopped working in 2020 (KARL.0 and JONK.0)
- In order to calibrate the old antennas at the other stations, we decided to exchange the antennas in a more planned way



Jönköping (JONK.0)/JONO

ANTENNAS AT THE PILLARS - JUNE 2021

June 2021



Station	Antenna type	Set up	Manufactured (year)
ARJE.0	AOAD/M_T OSOD	1993	1993
BORA.0	TRM59800.00 OSOD	2020	2011, calibrated 2019 (Ecco) (GPS+GLO)
HASS.0	JNSCR_CI46-22-I OSOD	2015	2005, calibrated 2015 (GPS+GLO)
JONK.0	JAVRINGANT_DM OSOD	2021-05-28	2014, calibrated 2021
KARL.0	JAVRINGANT_DM OSOD	2020-08-04	2016, calibrated 2017 (Ecco) (GPS+GLO)
KIRU.0	JNSCR_CI46-22-I OSOD	2016	2007, calibrated 2008 (GPS+GLO)
LEKS.0	ASH700936D_M OSOD	1998	1998
LOVO.0	ASH700936A_M OSOD	1995/2005	1995
MART.6	AOAD/M_T OSOD	1994	1994
NORR.0	ASH700936A_M OSOD	1995/2005	1995
ONSA.0	AOAD/M_B OSOD	1994	1994
OSKA.0	ASH700936A_M OSOD	1995/2005	1995
SKEL.0	ASH701945C_M OSOD	2007	2002
SUND.0	AOAD/M_T OSOD	1993	1993
SVEG.0	ASH701945C_M OSOD	2008	2002
UMEA.0	AOAD/M_T OSOD	1993	1993
VILH.0	ASH701945C_M OSOD	2010	2002
VISB.0	AOAD/M_T OSOD	1993	1993
VANE.0	AOAD/M_T OSOD	1995	1995
OSTE.0	AOAD/M_T OSOD	1993	1993
OVER.0	ASH700936A_M OSOD	1995	1995

STRATEGY FOR THE ANTENNAS AT THE PILLARS

- Exchange all Ashtech and AOAD antennas (except ONSA.0)
- Change to individually multi GNSS calibrated antennas
- New antennas? Limited by public procurement
- Decided to use antennas we already had (JAVRINGANT_DM and JNSCR_CI46-22-I) and started a relocation of some antennas at class B stations
- Not exchange all antennas at the same time, in order to be able to determine new “high precision” coordinates for the stations
- → Exchange up to 4 antennas at the same time

PLAN – EXCHANGE OF ANTENNAS AT THE PILLARS

Autumn 2021 (end of August)

- LOVO.0, OSKA.0, OVER.0, SVEG.0

Spring 2022 (end of March)

- LEKS.0, NORR.0, SKEL.0, VILH.0

Autumn 2022 (end of August)

- ARJE.0, UMEA.0, MART.6, VANE.0

~~Spring 2023 (end of March) **POSTPONED**~~

Autumn 2023 (end of August)

- OSTE.0, SUND.0, VISB.0

Not yet decided

- KIRU.0, BORA.0, HASS.0, KARL.0

After autumn 2021



After spring 2022



After autumn 2022



~~After spring 2023~~

After autumn 2023



ANTENNAS AT THE PILLARS - MARCH 2023

March 2023

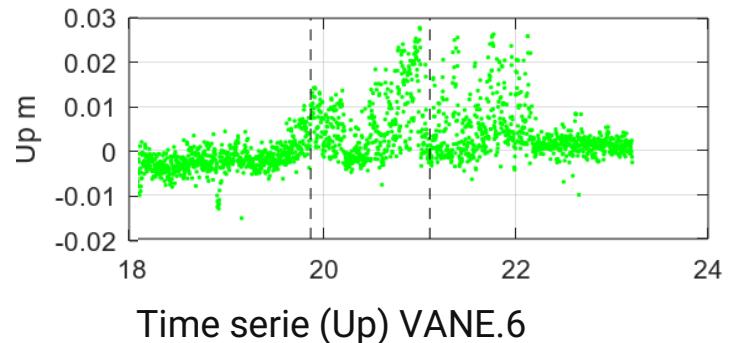


Station	Antenna type	Set up	Manufactured (year)
ARJE.0	JAVRINGANT_DM OSOD	2022-08-27	2010 (new antenna element 2021) calibrated 2022
BORA.0	TRM59800.00 OSOD	2020	2011, calibrated 2019 (Ecco) (GPS+GLO)
HASS.0	JNSCR_CI46-22-I OSOD	2015	2005, calibrated 2015 (GPS+GLO)
JONK.0	JAVRINGANT_DM OSOD	2021-05-28	2014, calibrated 2021
KARL.0	JAVRINGANT_DM OSOD	2020	2016, calibrated 2017 (Ecco) (GPS+GLO)
KIRU.0	JNSCR_CI46-22-I OSOD	2016	2007, calibrated 2008 (GPS+GLO)
LEKS.0	JAVRINGANT_DM OSOD	2022-03-31	2014, calibrated 2021
LOVO.0	JAVRINGANT_DM OSOD	2021-08-25	2013, calibrated 2021
MART.6	JAVRINGANT_DM OSOD	2022-09-02	2009 (new antenna element 2021) calibrated 2022
NORR.0	JAVRINGANT_DM OSOD	2022-03-15	2014, calibrated 2021
ONSA.0	AOAD/M_B OSOD	1994	1994
OSKA.0	JAVRINGANT_DM OSOD	2021-08-24	2013, calibrated 2021
SKEL.0	JAVRINGANT_DM OSOD	2022-03-09	2016, calibrated 2021
SUND.0	AOAD/M_T OSOD	1993	1993
SVEG.0	JAVRINGANT_DM OSOD	2021-08-31	2013, calibrated 2021
UMEA.0	JAVRINGANT_DM OSOD	2022-08-26	2010 (new antenna element 2021) calibrated 2022
VILH.0	JNSCR_CI46-22-I OSOD	2022-03-31	2009, (new antenna element 2021) calibrated 2021
VISB.0	AOAD/M_T OSOD	1993	1993
VANE.0	JAVRINGANT_DM OSOD	2022-08-29	2016, calibrated 2021
OSTE.0	AOAD/M_T OSOD	1993	1993
OVER.0	JAVRINGANT_DM OSOD	2021-08-30	2013, calibrated 2021

WHY DID WE START TO EXCHANGE ANTENNAS AT THE MASTS 2022?

When the masts at the SWEPOS fundamental stations were installed in 2011, the idea was to switch from pillar-based network to mast-based network (more modern and calibrated antennas), but we experienced some problems with the masts:

- Some analysis (2013-2018) showed lower rate of resolved integer ambiguities for the mast-based network compared to the pillar-based network
- The consistencies between the coordinates achieved using the Bern and GAMIT software is better for the pillar than the mast-based network (3-4 mm systematic difference in height)
- The antenna calibrations showed large variations ($\pm 1\text{ cm}$, L3T) between individual antennas but we are not sure if the uncertainties are due to real physical differences
- Lichen growing on the Leica radomes – the surface is a bit knobby
- The snow accumulates easier on the Leica radomes than our OSOD radomes



Time serie (Up) VANE.6



LEIT radome and LEIAR25.R3

ANTENNAS AT THE MASTS - OCTOBER 2022

October 2022



Station	Antenna type	Set up	Manufactured (year)
ARJE.6	LEIAR25.R3	LEIT	Calibrated 2011 (GPS+GLO)
BORA.7	LEIAR25.R3	LEIT	Calibrated 2011 (GPS+GLO)
HASS.6	LEIAR25.R3	LEIT	Calibrated 2011 (GPS+GLO)
JONK.6	LEIAR25.R3	LEIT	Calibrated 2011 (GPS+GLO)
KARL.6	LEIAR25.R3	LEIT	Calibrated 2011 (GPS+GLO)
KIRU.8	LEIAR25.R3	LEIT	Calibrated 2011 (GPS+GLO)
LEKS.6	LEIAR25.R3	LEIT	Calibrated 2011 (GPS+GLO)
LOVO.6	LEIAR25.R3	LEIT	Calibrated 2011 (GPS+GLO)
MART.7	LEIAR25.R3	LEIT	Calibrated 2011 (GPS+GLO)
NORR.7	LEIAR25.R3	LEIT	Calibrated 2011 (GPS+GLO)
ONSA.I	LEIAR25.R3	LEIT	Calibrated 2011 (GPS+GLO)
OSKA.6	LEIAR25.R3	LEIT	Calibrated 2011 (GPS+GLO)
SKEL.8	LEIAR25.R3	LEIT	Calibrated 2011 (GPS+GLO)
SUND.6	LEIAR25.R3	LEIT	Calibrated 2011 (GPS+GLO)
SVEG.6	LEIAR25.R3	LEIT	Calibrated 2011 (GPS+GLO)
UMEA.6	LEIAR25.R3	LEIT	Calibrated 2011 (GPS+GLO)
VILH.6	LEIAR25.R3	LEIT	Calibrated 2011 (GPS+GLO)
VISB.6	LEIAR25.R3	LEIT	Calibrated 2011 (GPS+GLO)
VANE.6	TPSCR.G5	OSOS (762-12004)	2022-03-16
OSTE.6	LEIAR25.R3	LEIT	Calibrated 2011 (GPS+GLO)
OVER.6	LEIAR25.R3	LEIT	Calibrated 2011 (GPS+GLO)

STRATEGY FOR THE ANTENNAS AT THE MASTS – AUTUMN 2022

- All mast stations are EPN stations
- In autumn 2022 the use of individual calibrated antennas were not recommended any longer for EPN stations, but type mean calibrations are needed (multi GNSS preferable)
- To reduce snow accumulations and growing lichen we decided to change to OSOS radomes
- → Calibrate 5 LEIAR25.R3 OSOS for type model



OSOS



OSOD

PLAN – EXCHANGE OF ANTENNAS AT THE MASTS

Exchange antennas at three stations November 2022

- LEKS.0, LOVO.0, SUND.0

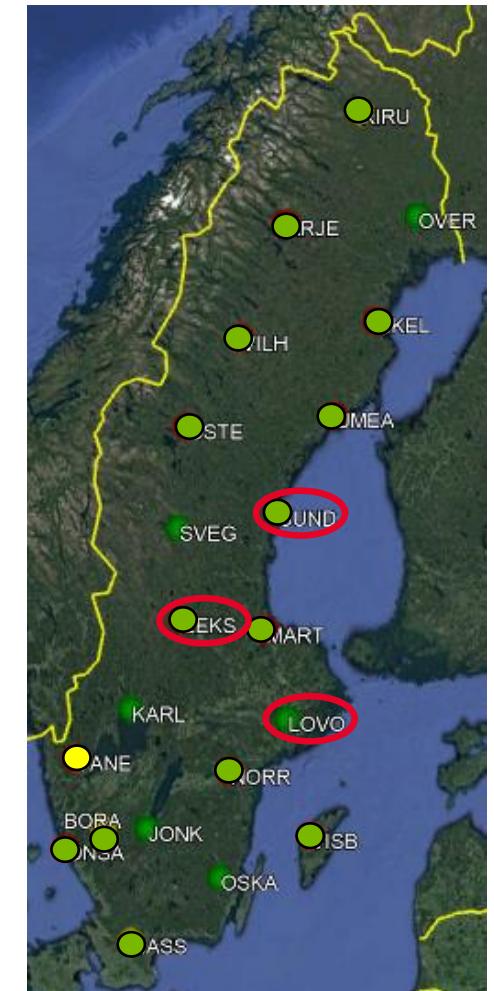
Send five LEIAR25.R3 to Geo++ for calibration with and without OSOS radome

→ Type mean calibration for LEIAR25.R3 OSOS

Next step was to change the LEIT radomes at the other stations to OSOS radomes

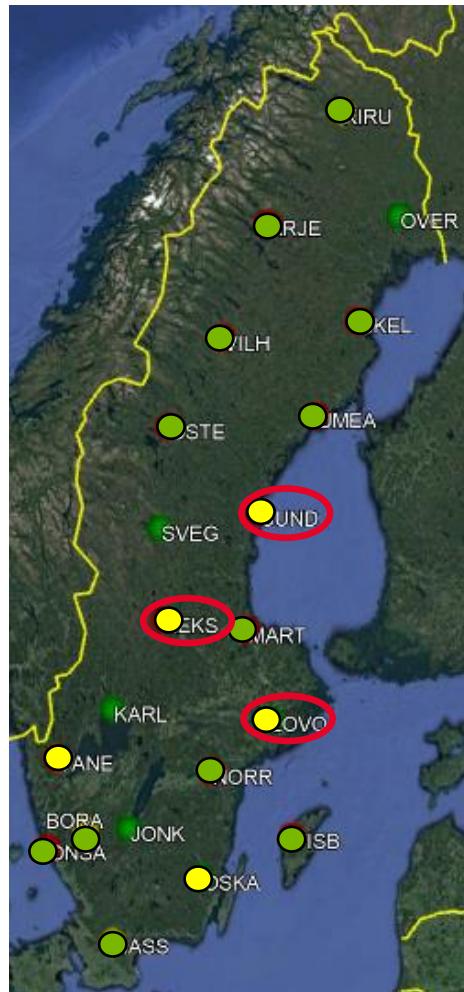
BUT, meanwhile we have developed and tested an antenna heating system and this system has shown very promising results

→ We consider changing to antennas with attached heating system at least at the northern part of Sweden (north of LEKS and MART)



ANTENNAS AT THE MASTS - MARCH 2023

March 2023



Station	Antenna type	Set up	Calibrated (year)
ARJE.6	LEIAR25.R3	LEIT	2011-07-20 Calibrated 2011 (GPS+GLO)
BORA.7	LEIAR25.R3	LEIT	2011-10-07 Calibrated 2011 (GPS+GLO)
HASS.6	LEIAR25.R3	LEIT	2011-06-14 Calibrated 2011 (GPS+GLO)
JONK.6	LEIAR25.R3	LEIT	2011-06-16 Calibrated 2011 (GPS+GLO)
KARL.6	LEIAR25.R3	LEIT	2011-05-10 Calibrated 2011 (GPS+GLO)
KIRU.8	LEIAR25.R3	LEIT	2011-08-12 Calibrated 2011 (GPS+GLO)
LEKS.6	LEIAR20	LEIM (25070043)	2022-11-09 Not calibrated
LOVO.6	TPSCR.G5	OSOS (762-12001)	2022-11-10 Calibrated 2021 w/o OSOS
MART.7	LEIAR25.R3	LEIT	2011-04-27 Calibrated 2011 (GPS+GLO)
NORR.7	LEIAR25.R3	LEIT	2011-06-21 Calibrated 2011 (GPS+GLO)
ONSA.I	LEIAR25.R3	LEIT	2012-01-26 Calibrated 2011 (GPS+GLO)
OSKA.6	TPSCR.G5	OSOS (762-11911)	2023-01-19 Calibrated 2021 without radome
SKEL.8	LEIAR25.R3	LEIT	2011-07-07 Calibrated 2011 (GPS+GLO)
SUND.6	LEIAR20	LEIM (25070044)	2022-11-08 Not Calibrated
SVEG.6	LEIAR25.R3	LEIT	2011-06-20 Calibrated 2011 (GPS+GLO)
UMEA.6	LEIAR25.R3	LEIT	2011-07-06 Calibrated 2011 (GPS+GLO)
VILH.6	LEIAR25.R3	LEIT	2011-07-20 Calibrated 2011 (GPS+GLO)
VISB.6	LEIAR25.R3	LEIT	2011-05-18 Calibrated 2011 (GPS+GLO)
VANE.6	TPSCR.G5	OSOS (762-12004)	2022-03-16 Calibrated 2021/2022 w/o OSOS
OSTE.6	LEIAR25.R3	LEIT	2011-06-28 Calibrated 2011 (GPS+GLO)
OVER.6	LEIAR25.R3	LEIT	2011-08-10 Calibrated 2011 (GPS+GLO)

DIFFERENCES USING OSOS OR NONE

JAVRINGANT_DM A0090946	ΔN [mm]	ΔE [mm]	ΔH [mm]
L3, 3°	0.2	-0.4	0.6
L3, 25°	0.4	-0.5	0.9

JAVRINGANT_DM A0090947	ΔN [mm]	ΔE [mm]	ΔH [mm]
L3, 3°	0.2	-0.3	0.5
L3, 25°	0.2	-0.2	1.1

JAVRINGANT_DM A0090956	ΔN [mm]	ΔE [mm]	ΔH [mm]
L3, 3°	0.2	-0.2	1.3
L3, 25°	0.3	-0.2	2.6

TPSCR.G5 762-12001	ΔN [mm]	ΔE [mm]	ΔH [mm]
L3, 3° (GPS)	0.24	-0.75	0.25
L3, 25° (GPS)	0.13	-1.24	4.53
L3, 3° (GNSS)	0.44	-0.57	2.11
L3, 25° (GNSS)	0.67	-0.93	9.38

TPSCR.G5 762-12004	ΔN [mm]	ΔE [mm]	ΔH [mm]
L3, 3° (GPS)	-0.08	-0.32	1.79
L3, 25° (GPS)	-0.02	0.10	4.55
L3, 3° (GNSS)	0.03	-0.13	3.62
L3, 25° (GNSS)	0.23	0.16	9.12

LEIAR25.R3 08470039	ΔN [mm]	ΔE [mm]	ΔH [mm]
L3, 3° (GPS)	-0.25	0.20	-10.92
L3, 25° (GPS)	-0.10	0.37	-25.03
L3, 3° (GNSS)	0.14	0.23	-7.20
L3, 25° (GNSS)	0.88	0.32	-12.29

LEIAR25.R3 08490012	ΔN [mm]	ΔE [mm]	ΔH [mm]
L3, 3° (GPS)	-0.79	0.13	-12.94
L3, 25° (GPS)	-1.22	0.30	-27.42
L3, 3° (GNSS)	-0.45	0.07	-11.98
L3, 25° (GNSS)	-0.44	0.16	-23.79

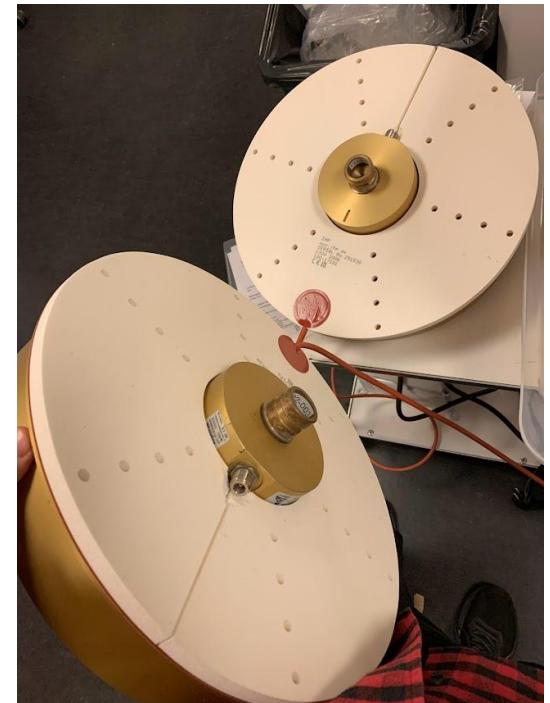
LEIAR25.R3 08520005	ΔN [mm]	ΔE [mm]	ΔH [mm]
L3, 3° (GPS)	-0.18	-0.14	-10.84
L3, 25° (GPS)	0.15	0.46	-26.67
L3, 3° (GNSS)	-0.10	-0.03	-11.29
L3, 25° (GNSS)	0.32	0.47	-25.25

LEIAR25.R3 09030007	ΔN [mm]	ΔE [mm]	ΔH [mm]
L3, 3° (GPS)	0.19	0.25	-12.67
L3, 25° (GPS)	0.71	0.80	-20.23
L3, 3° (GNSS)	0.31	0.27	-9.81
L3, 25° (GNSS)	0.92	0.67	-10.37

LEIAR25.R3 10170020	ΔN [mm]	ΔE [mm]	ΔH [mm]
L3, 3° (GPS)	0.10	0.21	-8.73
L3, 25° (GPS)	0.41	0.23	-16.43
L3, 3° (GNSS)	0.02	-0.16	-10.24
L3, 25° (GNSS)	0.17	-0.31	-20.20

ANTENNA HEATING SYSTEM

- First antenna heating system about 20 years ago at BORA.0 and KIRU.0
- A bit slimmer heating system was developed in late 2021, in co-operation with IHP International Heating Products AB
- The prototype tested since beginning of 2022. Set up in Kiruna October 2022
- At Geo ++ for calibration with JAVRINGANT_DM

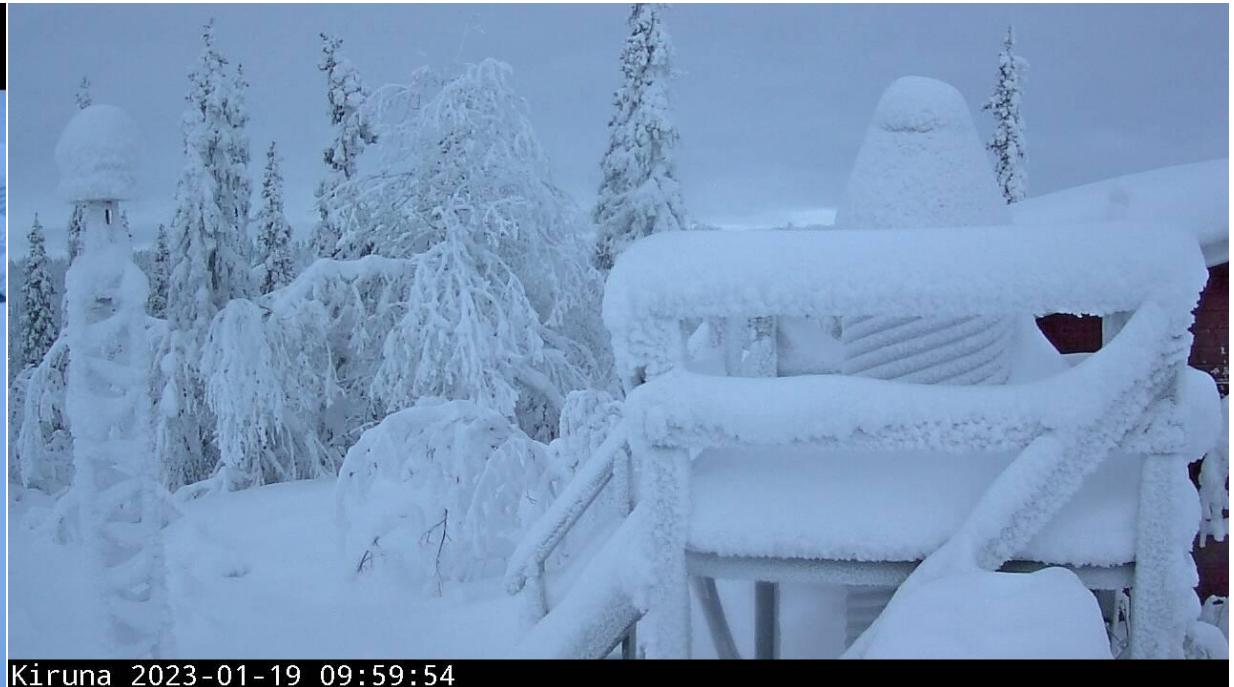


TEST WITH THE ANTENNA HEATING SYSTEM, KIRUNA



Kiruna Antennaheater 2023-01-19 09:59:55

Test pillar KIRU.7



Kiruna 2023-01-19 09:59:54

KIRU.8/KIR8 and KIRU.0/KIRO

NEXT STEPS

- Waiting for, and analyse the antenna calibration of the antenna with the heating system
- Continue the analysis of the effect of the OSOS radome
- Test the heating system even for LEIAR20 antennas
- Decide where to use the heating system. Does the system require the radome to be attached to the antenna?
- Masts: replace the LEIT radomes with OSOS for the most southern stations?
Change to antennas with heating systems in the northern part?
- In addition:
We have calibrated AOAD/M_T antennas and we are considering calibrating some more Ashtech antennas to get multi GNSS type mean calibration for e.g. ASH701946.3, ASH701945C_M and ASH701941.B



THANKS FOR YOUR ATTENTION!

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