

Interim report of the NORDRAD quality assurance project (QA project)

May 10, 2001

Project period: 1.8.2000 - 31.10.2001

Project management group: Asko Huuskonen (FMI, project leader), Ingemar Carlsson (Swedish Armed Forces), Oddbjørn Thoresen (DNMI), Jan Svensson (SMHI, until 31.3.2001), Daniel Michelson (SMHI, from 1.4.2001)

Summary

Aim of the project: The aim of the project is to improve the intensity level harmonisation of the NORDRAD network to within ± 2 dBZ, and to establish workable and efficient quality assurance and maintenance practices. The project is divided into three sub-projects:

SP1 Monitoring of all NORDRAD radars using the NRDTOOLS software.

SP2 Investigation of angular pointing accuracy of all NORDRAD radars, and implementation of improvements to achieve an agreed level of performance.

SP3 Investigation of calibration and radar parameter value accuracy at all NORDRAD radars, and implementation of improvements to achieve an agreed level of performance.

Sub-project SP1 is carried out by FMI on behalf of all parties with their cooperation. Sub-projects SP2 and SP3 are carried out by each Institute separately.

General remarks: The project started in March 1999 with a QA Workshop in Helsinki, where experts of the participating institutes and invited guests from Germany and Estonia met to discuss the project plan. The agreed active project period was from May 1999 until April 2000. However, the project was at standstill at FMI until August 2000, when the project was finally started. First results were presented to NOCORD at its meeting on October 18-19, 2000 in Helsinki. The project management group met in Helsinki on November 21, 2000, in conjunction with the NORDRAD Operations Group meeting. At the meeting the project management group members confirmed their interest in the project, despite the delay in the active project period. It was agreed that the work concentrates to SP1 in the beginning, because work on that project is carried out by FMI, which has already started active work. Other Institutes need time to allocate resources to the project and will start active work towards the latter half of the project.

Work done by April 2001: During the first half of the project the work has focused on SP1. Within SP1, the NRDTOOLS software has been taken into use, a set of radar pairs has been specified, a number of rainy periods has been selected and the tools used to obtain single and paired radar pictures, and web pages have been

created to display to pictures. Finally, an analysis software has been created to get numerical estimates of the calibration difference and the difference in the collection angles. Details are given in the report of SP1.

Work plan: The work in SP1 has advanced according to the project plan and the work will be finalized in September 2001. Details are given in the report of SP1. Towards the end of the project period the work shall focus on SP2 and SP3. At FMI the work on SP2 has already been started. It is expected that the work will provide precision pointing observations which will complement the results of SP1. On the other hand, the advances in SP3 will most probably be limited during the active project period. The active project period ends in October 2001 and the final project report will be ready by the end of 2001.

On behalf of the management group

Asko Huuskonen
project leader

Sub-project 1, SP1

Organization The sub-project leader is A. Huuskonen (FMI) and the contact persons are Oddbjørn Thoresen (DNMI) and Daniel Michelson (SMHI, from 1.4.2001). Jan Svensson was the contact person for SMHI until 31.3.2001.

Aim of sub-project To carry out analyses (using both single radar and paired-radar data) of the NORDRAD network using the software package NRDTOOLS, and to produce regular reports of the relative intensity levels of the participating radars to support other activities in the NORDRAD QA project (i.e. antenna angle, calibration and radar constant parameter investigations).

Work done in SP1

Selection of radar pairs Altogether 15 radars and 15 radar pairs were selected from NORDRAD. These are given in Table 1. Each radar pairs requires the specification of two products, and thus the total number of radar pair products is 30. Only 16 of these are fully new, because data for seven radar pairs has been collected since January 1999. These seven pairs form a chain from Stockholm through Finland to Luleå. The additional eight radar pairs form a chain through Sweden from Stockholm to Luleå, and a chain from Stockholm to Hægebostad in Norway. These radars do not cover the whole NORDRAD network. The aim has been to include all three types (Gematronic/Sigmat, Ericsson, Gematronic) of radars in the comparison, and to limit the number of pairs so that the data processing is manageable with the resources available to the project.

The paired radar data for all these pairs, and the single radar data for all the radars is produced at FMI regularly at 15 minutes intervals and is stored to disk. Presently data for the last 3 months is kept on-line, which gives ample time to find promising rainy periods for the analysis. After the 3 month period the data is discarded. Data for the selected analysis periods is copied to a different location for analysis. The data from the selected analysis intervals is stored for a possible reanalysis.

Selected analysis periods Data from five periods have been analyzed so far. These periods and the radar pairs analyzed in each are given in Table 2. Of the 15 pairs, eight were specified in October, and therefore QA products for these pairs is available only for the last three analysis periods. The last of the five periods is from November 2000. The main reason is that we have tried to find periods where data from all radars would be available. The problems with some radars, explained below, have meant that no such periods have been found from December, January and February. Also, a lot of the resources allocated to the project, i.e. of the working days of the project leader, were spend in the creation and testing of the analysis software. As data is stored for at least 3 months, rainy periods in January-March 2001 can still be analyzed.

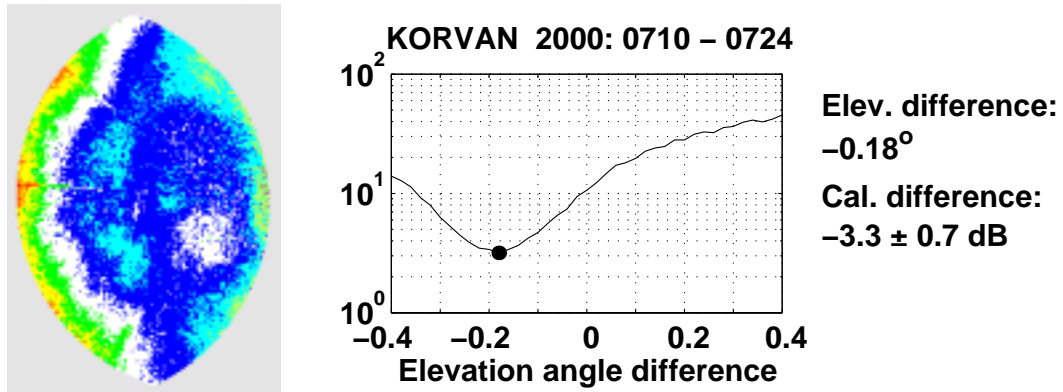


Figure 1: Paired radar result for the Korpo-Vantaa pair (left panel), the residual of the fit as the function of the collection angle difference (right panel). Results are seen on the right.

Data from three pairs have appeared faulty or impossible to use:

- OSUOVI and HUDOSU: Data which was collected during year 2000 cannot be used because the coordinates of the Östersund radar were found wrong. Correct coordinates have been used since December 28, 2000 in the production of the paired radar products. It then appeared that the product generator could not produce correct data for the new area defined. The problems were solved by January 25, 2001, after which correct data has been available.
- UTALUO The product generator problems made the data useless until February 25, 2001.

Analysis results The immediate results are the images produced by the NRDTOOLS software. These include single radar results, which are averages or medians of the radar reflectivity for the analysis period, and paired radar results, which simply stated are averages (or median) of the differences of the reflectivities. These are available at the QA web-pages at nordrad.fmi.fi/qa/qaindex.html. The user name is nordrad and the password is known by the management committee members.

Secondly we have numerical estimates, which are based on the results from the NRDTOOLS software. Presently only the paired radar data is analyzed numerically, and an analysis program has been made, which gives the calibration difference and the difference in the collection angles of the radars. The analysis procedure is explained in a separate document. An example of the results is seen in Figure 1. A summary of the results about the angular difference is presented in Table 3 and for the calibration difference in Table 4 .

A best guess estimate for the collection angle difference is given for 7 of the 12 cases. We see that best guess estimates based on the data and the nominal values for the differences deviate by less than 0.1° , except for ones case. This is KORVAN, where the analysis gives a -0.2° difference, although the difference should be zero.

The calibration differences are mostly less than 2 dB, except in two cases. The

OSLHGB shows a calibration difference of about -5 dB. This is in agreement a 5 dB error in the calibration of the Hægebostad radar, found in December 2000.

Resources The sub-project is done by FMI for all the parties. Most of the work is done by the project leader, supported by the computing branch of FMI. The total amount of working hours is estimated at $200+40=240$ hours by the end of March 2001. Three months of QA products is stored permanently on disk, requiring some 4 GB of disk space. Also, the production of the QA products used some 50 % of the resources of a workstation. The computer resources needed for running the NRDTOOLS and the numerical analysis program are negligible.

Work summary and work plan for SP1

The following table summarizes the work carried out and the work planned in sub-project 1:

	Task	Time period	STATUS
1.	Specification of a set of radars and radar pairs for calculation of the QA products	00/08–00/08	DONE
2.	Setting up NRDTOOLS and creating scripts for copying of data and running the tools	00/08–00/09	DONE
3.	Running the NRDTOOLS software for a number of selected rainy periods	00/08–	ONGOING
4.	Setting up web pages to present the single radar and paired radar pictures	00/10–00/10	DONE
5.	Creating software to obtain calibration differences and collection angle differences from paired radar data	00/10–00/12	DONE
6.	Running the analysis software to get calibration and collection angle difference estimates	00/10–	ONGOING
7.	Improving the numerical analysis software, e.g. to take into account the blocked sectors	01/04–01/09	ONGOING
8.	Specifying graphical output of results on the web server	01/05–01/05	T.B.D.
9.	Analysis of the single radar pictures. This task is carried out time permitting.	01/05—	T.B.D.
10.	Final report of SP1	01/10–01/12	T.B.D.

Sub-projects 2 and 3, (SP2, SP3)

Organization The sub-project leader in Finland is A. Huuskonen (FMI). The contact person in Norway is Oddbjørn Thoresen (DNMI). Presently no contact person for Sweden is nominated.

Aim of SP2 Investigation the azimuth and elevation angle pointing accuracy achieved operationally by radars in the NORDRAD network, and implementation of improvements to achieve an agreed level of accuracy.

Aim of SP3 Investigation of calibration and radar parameter accuracy.

Work done in Finland A work has been started to establish a regular procedure for checking the antenna pointing during each maintenance trip. This includes checking the antenna azimuth pointing by using the sun. The antenna elevation readings are checked against a precision inclinometer to check the linearity of the elevation scale and the changes with time.

Work done in Sweden The work done in Sweden prior to the active project period has been summarized in "Preliminary phase report from NORDRAD QA-project phase 1: 1999-01-01 — 1999-03-31" by Madelen Nilsson.

Table 1: The single radar sites and the radars to which each is paired with. The last column gives the number of paired radar products and the number of new products added during the project period (in parenthesis)

Radars		paired with	# of products
Stockholm	STO	LEK, KOR	2 (1)
Korpo	KOR	STO, VAN	2 (0)
Vantaa	VAN	KOR, ANJ	2 (0)
Anjalankoski	ANJ	VAN, IKA	2 (0)
Ikaalinen	IKA	ANJ, KUO	2 (0)
Kuopio	KUO	IKA, UTA	2 (0)
Utajärvi	UTA	KUO, LUL, LUO	3 (1)
Luleå	LUL	UTA, OVI	2 (1)
Luosto	LUO	UTA	1 (1)
Örnsköldsvik	OVI	LUL, OSU	2 (2)
Östersund	OSU	OVI, HUD	2 (2)
Hudiskvall	HUD	OSU, LEK	2 (2)
Leksand	LEK	STO, HUD, OSL	3 (3)
Oslo	OSL	LEK, HGB	2 (2)
Hægebostad	HGB	OSL	1 (1)
		Total	30 (16)

Table 2: The availability of paired-radar images. Successful cases are denoted by x and unsuccessful ones with o. An empty space denotes that the QA data was not available at all.

	000710	001010	001024	001104	001120
	000724	001016	001029	001109	001129
STOKOR	x	x	x	x	x
KORVAN	x	x	x	x	x
VANANJ	x	x	x	x	x
ANJIKA	x	x	x	x	x
IKAKUO	x	x	x	x	x
KUOUTA	x	x	x	x	x
UTALUL	x	x	x	x	x
UTALUO			o	o	o
STOLEK			x	x	x
LEKHUD			x	x	x
HUDOSU			o	o	o
OSUOVI			o	o	o
OVILUL			x	x	x
LEKOSL			x	x	x
OSLHGB			x	x	x

Table 3: The collection angle difference for the analysis periods. Highly suspicious values are given in parenthesis. The last two columns give an expert guess on the most probable angle, when such a guess can be made, and the nominal angle difference. When two values are given, the latter is valid for the last period. The value is different for that period because some radars in Finland have a higher lowest collection angle in the Summer period and the angles were changed between periods 4 and 5.

	000710 000724	001010 001016	001024 001029	001104 001109	001120 001129	Expert guess	Nominal value
STOKOR	0.08	-0.18	-0.06	(-0.40)	(0.40)	- /-	-0.1/0.1
KORVAN	-0.18	-0.22	-0.22	-0.18	-0.22	-0.2	0.0
VANANJ	0.18	0.22	0.18	0.20	0.12	0.2/0.1	0.1/0.0
ANJIKA	-0.12	(0.20)	-0.08	-0.04	0.06	0.0	0.0
IKAKUO	0.12	(0.34)	0.16	(0.40)	(0.30)	0.1/-	0.1/0.0
KUOUTA	0.08	-0.08	0.02	(-0.24)	0.04	0.0	0.0
UTALUL	(0.40)	0.22	(-0.36)	(-0.40)	(0.40)	-	0.1
STOLEK			0.08	-0.18	-0.08	-0.1	0.0
LEKHUD			-0.06	0.18	(0.38)	-	0.0
OVILUL			(0.36)	(-0.40)	(0.40)	-	0.0
LEKOSL			0.04	0.06	(0.38)	0.0	0.0
OSLHGB			(0.40)	-0.10	0.06	-	0.0

Table 4: The calibration difference in dB for the analysis periods. Highly suspicious values are given in parenthesis. The last column gives the average value of accepted results. Two values are given for KORVAN and VANANJ, due to the re-calibration of the Vantaa radar between periods 3 and 4.

	000710 000724	001010 001016	001024 001029	001104 001109	001120 001129	Average value
STOKOR	1.9	1.6	2.0	(-0.1)	(3.5)	1.8
KORVAN	-3.3	-2.6	-3.0	-0.8	-1.6	-3.0/-1.2
VANANJ	1.2	1.0	-0.3	-1.1	-0.7	0.7/-0.9
ANJIKA	1.7	(3.6)	1.3	2.0	0.5	1.4
IKAKUO	0.4	(0.4)	0.3	(3.9)	(3.0)	0.4
KUOUTA	-0.1	-3.3	-1.2	(-3.8)	-0.8	-1.4
UTALUL	(0.2)	6.1	(-1.3)	(-1.1)	(3.2)	-
STOLEK			6.6	4.9	4.6	5.3
LEKHUD			-2.7	-0.9	(-0.3)	-1.8
OVILUL			(8.3)	(3.3)	(3.4)	-
LEKOSL			-0.4	-0.4	(-0.0)	-0.4
OSLHGB			(-1.9)	-7.3	-4.2	-5.6