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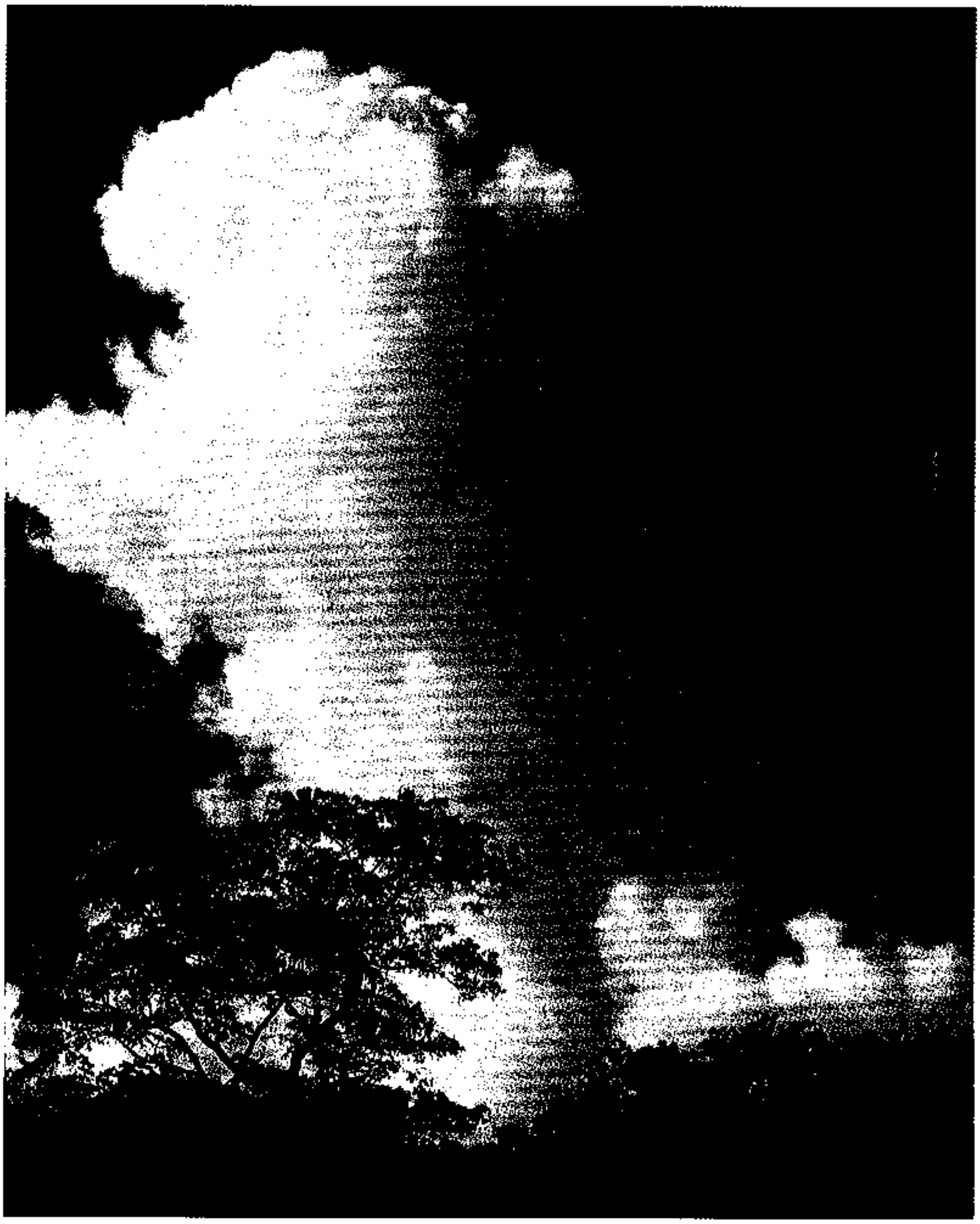
NORDKLIM: Nordic Co-Operation Within Climate Activities

Human Quality Control (HQC) in the Nordic countries

Report no. 32/99

P. Øgland (ed.), E. Hellsten, C. Jacobsson,
H. Madsen, P. Rissanen and F. Vejen

KLIMA



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Human Quality Control (HQC) in the Nordic countries

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PROJECT CONTRACTOR

DNMI - Climatology Division / NORDKLIM

SUMMARY

This report is a part of the NORDMET project NORDKLIM *Nordic Co-Operation Within Climate Activities* and is written as a documentation of parts of the quality control documentation for project task no. 1.2 *Quality Control* following specifications from the first NORDKLIM Quality Control Meeting in Helsinki, 22-23 April 1999.

On the first NORDKLIM Quality Control Meeting it was decided that the structure of quality control should be moduled in entities for Automatic Quality Control at the time of arrival (AQC1), Automatic Quality Control as the observations fill up the database (AQC2) and Human Quality Control (HQC).

It was decided on the meeting that DNMI should be responsible for collecting and editing the present situation for the HQC based on contributions from each of the participating countries. The report is designed to function as input for the second NORDKLIM Quality Control Meeting in Norrköping, 21-22 October 1999.

KEYWORDS

1. Quality Control
2. Meteorological Observations
3. Human Quality Control
4. NORDKLIM

SIGNATURE

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Table of contents

1. INTRODUCTION

In the NORDMET-project NORDKLIM: *Nordic Co-Operation Within Climate Activities,* there are two main tasks. Task 1 is dealing with **Climate Data** and has four subtasks (1.1 Network design; 1.2 Quality control; 1.3 Operational precipitation correction; 1.4 Long-term datasets). At a meeting in Oslo in January 1999, the NORDKLIM Advisory Commitee decided that highest priority within Task 1 should be given to subtask *1.2 Quality Control (QC).* All Nordic countries have an urgent need for improved systems for controlling climate data and correcting suspect values. The main aim in 1999 for Task 1.2 is according to the NORDKLIM project plans to work out a *joint report on Nordic algorithms for QC of climate data, and suggestions for QC routines on real-time data (incl. data from Automatic Weather Stations).*

As a result of the Task 1.2 group meeting in Helsinki, 22 - 23 April 1999, it was decided that work should be divided into three main activities: Real-time quality control (**QC1**), Non-realtime quality control (**QC2**) and Human quality control (**HQC**).

Every participating country within the NORDKLIM project is expected to write status summaries for each of the three quality control modules. DMI is responsible for collecting Nordic information on QC1, SMHI collects information on QC2 and DNMI collects information on HQC.

Each of the three reports are to be presented at the 2nd NORDKLIM Quality Control Meeting 21-22 October 1999 in Norrköping. This report contains the HQC documents provided by each of the Nordic countries.

2. HQC AT DMI

2.1 Introduction

This paper describes the present status at DMI of human quality control, HQC. For the forecaster, flagging of suspected values are not strictly necessary because, by experience, they can easily detect bad data. The main purpose of improving the present QC system is to make better service to internal and external users, e.g. applying quality indexing to all data elements, better flagging of suspected values, improving the data quality to some guarantee level, etc.

Presently, there is one central QC1 at DMI for on-line control of data, but also there is some initial checking at some automatic and semi-automatic stations. There are various QC2 systems in different departments and some of these are still in a developing phase, but there is a need to better co-ordinate the systems. Firstly, the HIRLAM model is using its own QC2 for preparation of data for model run, secondly, some service systems, e.g. for delivering meteorological information for the agriculture, have their own QC1 and QC2. Finally, there are various HQC procedures for detection of suspected values and bad sensors. There are various kinds of graphical user inter phases for plotting and interpolation of data for spatial comparison. Other inter phases are used for control of data series and monitoring of station break-down.

2.2 Station networks

At present (1 September 1999), there are the following station networks in Denmark, Greenland and the Faroe Isles for measurement of the most common meteorological parameters (temperature, wind speed, wind direction, air pressure, precipitation, etc.), but other networks e.g. such as sun stations, hydrographic stations are not mentioned in the list:

	Denmark	the Faroe Isles	Greenland
synoptic stations	50	4	32
automatic climate stations	25	0	0
manual climate stations	13	0	0
tipping bucket precipitation stations	80	0	0
manual precipitation stations	501	-	0
METEO radiosonde stations	2	1	6

At a number of 16 of the automatic climate stations the precipitation amount is measured by a Geonor raingauge.

2.3 HQC - human quality control

2.3.1 HQC - of synoptic stations and automatic climate stations

I the daily control of data a program called OBSSHOW is used. This is a graphical user inter phase that gives the opportunity to plot observations for one observation time over any geographical area, and this can be done for one or more specific parameters. Also, for one station 24 hours of data can be plotted in a diagram and a table. In addition, other programs give the opportunity to detect missing data and various kinds of error at each station, primary at synoptic and automatic climate stations.

For easier detection of minor errors on the parameters in the synoptic code section 1, automatic plotting and Kriging interpolation are done on air temperature, dew point temperature, air pressure, as well as 6 hourly and 12 hourly precipitation amounts. By this mean the most essential parameters, measured at synoptic and automatic climate stations, are controlled by manual inspection giving an clear indication of where the suspected values are found. An example of a plot map is shown in figure 1.

The initial control at the automatic climate stations and QC1 results in information about irregularities in the observation reports, coding errors on synoptic reports, error messages from automatic stations, etc. These error messages are inspected manually every day for eventual correction. Because the checking of QC1 is quite coarse at the moment, it is essential to compare observations in the OBSSHOW program for detection of suspicious values. By this manual random check and monitoring of data it is possible to detect the most of the suspicious parameter values that was not found by the QC1 control. In addition there are checks for irregularities on station operation, i.e. if observations are received as expected, the whole data report as well as each single parameter. A report on missing data is made automatically and is inspected manually as to decide further inspection of a station.

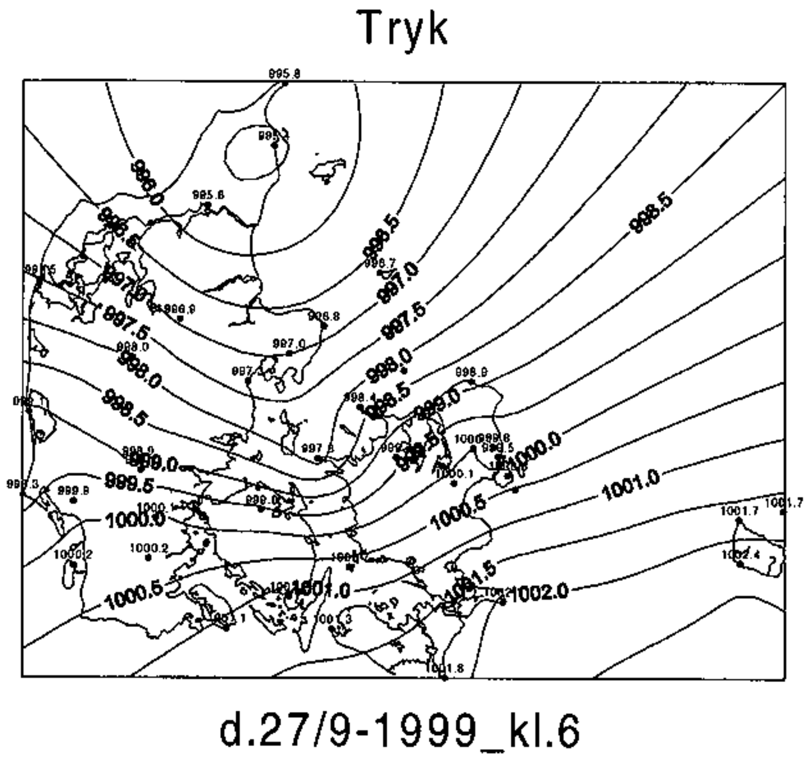


Figure 1. Control of air pressure at synoptic and automatic climate stations 27 September 1999 at 6z.

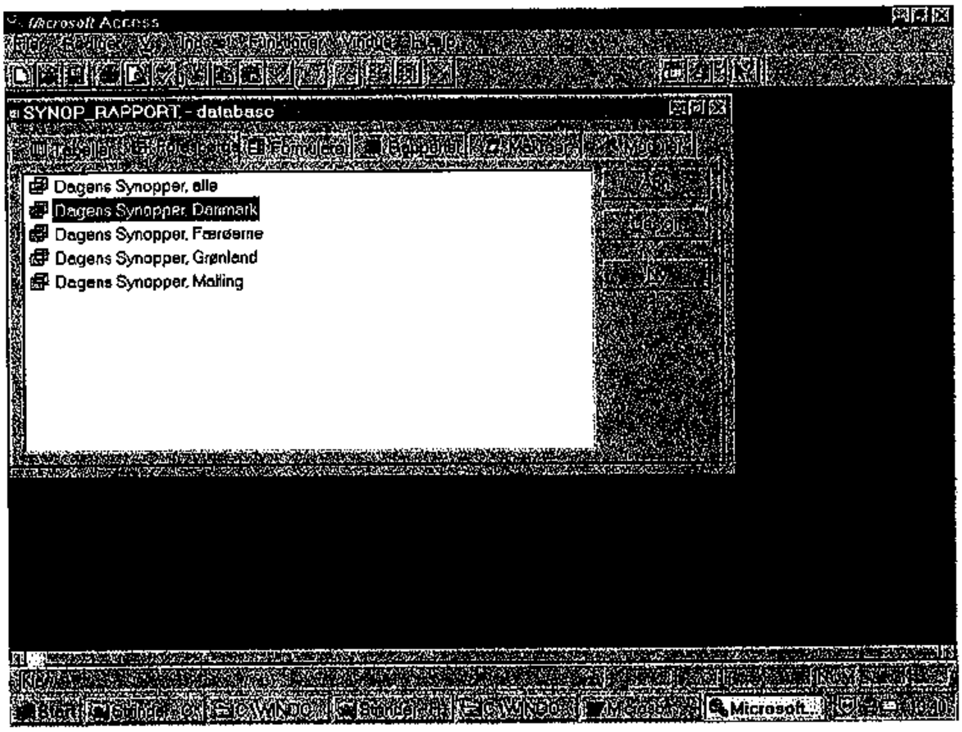


Figure 2. Construction of an enquiry on data from synoptic and automatic climate stations.

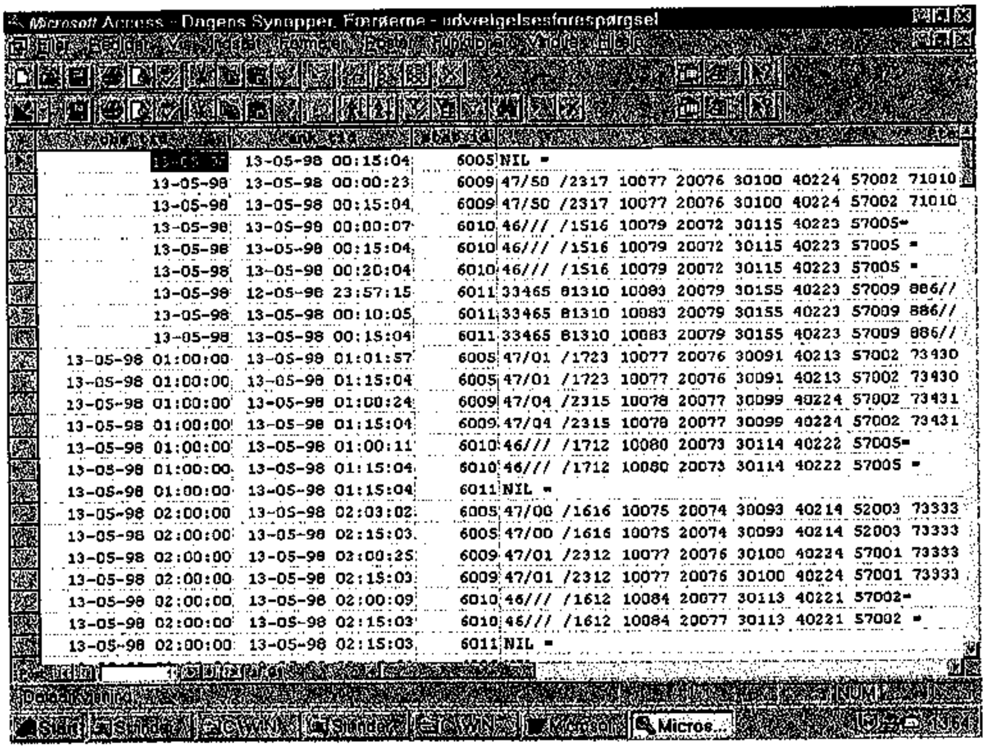
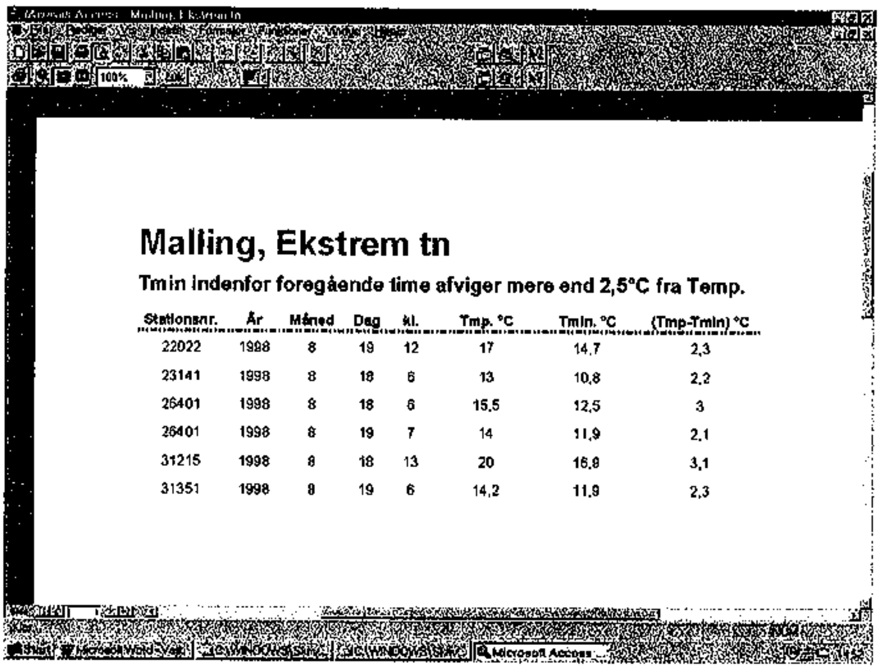


Figure 3. Example on displayed synoptic code reports.

For further inspection of values an user inter phase has been developed in MicrosoftAccess, and data from synoptic and automatic climate stations can be checked for selected regions in Denmark, Greenland and the Faroe Islands. Searching and sorting kriteria can be chosen, and data are displayed in case of a match. For automatic climate stations some kriteria have been defined, e.g. if the maximum/minimum air temperature minus air temperature > |2.5| within the same hour, or if gusts divided by average wind speed > 3, data are displayed. Some of the characteristics are shown in figure 2-4.



Malling, Ekstrem tn

Tmin indenfor foregående time afviger mere end 2,5°C fra Temp.

Stationsnr.	År	Måned	Dag	kl.	Tmp. °C	Tmin. °C	(Tmp-Tmin) °C
22022	1998	8	19	12	17	14,7	2,3
23141	1998	8	18	6	13	10,8	2,2
26401	1998	8	18	6	15,5	12,5	3
26401	1998	8	19	7	14	11,9	2,1
31215	1998	8	18	13	20	16,8	3,1
31351	1998	8	19	6	14,2	11,9	2,3

Figure 4. Example on data from automatic climate stations that satisfies certain sorting and searching criteria.

2.3.2 HQC of tipping bucket raingauge stations

This control consists of checks for missing measurements, technical operation of the equipment and errors on parameter values. For quality control, daily and monthly precipitation amounts are plotted on a map, and automatically maps of interpolated amounts are drawn in the form shown in the example figure 5. These maps give an overview to find out at which stations there may be problems. Especially, extreme precipitation cases with >2 mm/minute are automatically flagged and are subject for further control.

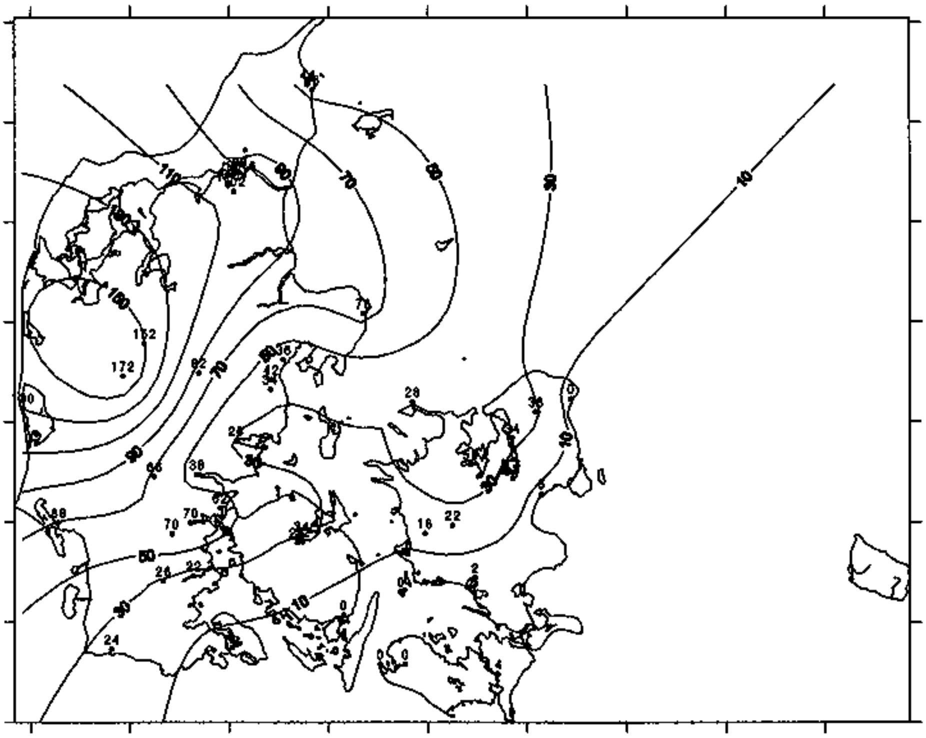


Figure 5. Daily precipitation amount 20 August 1998 (scale is 0.1 mm).

Data from tipping bucket gauges are controlled together with the amounts from manual raingauge stations (Hellmann gauges).

2.3.3. HQC of manual raingauge and manual climate stations

Control of data from manual raingauge stations is made manually on a monthly basis by comparing with neighbouring stations. A simple print of all data values is used for detection of suspicious and erroneous values. Data from manual climate stations are currently being controlled.

3. HQC AT FMI

3.1 Introduction

So far quality control phases AQC 1 and AQC 2 have checked and flagged observation data. Some automatic corrections and calculations for missing and totally erroneous data have been executed. Also grid data are available, it means that for each station a guess of the "correct" observation can be utilized.

It is supposed that only the data which cannot be corrected automatically, will be corrected manually at phase HQC.

3.2 User interface

To activate HQC program www based system maybe a good solution. So far different helping tools (radar images, charts, ...) are developed on www and it is quite easy to combine HQC system to other objects. ArcView element is working as a map presentation (topography) behind the observations. Zooming of a certain area under analysis is necessary.

3.3 User tools

Stations are qualified via flagging on map presentation. As an example (see figure 1.) "white" stations have passed successfully QC tests. "Blue" stations have passed QC tests, but observations are slightly modified. "Red" stations have not passed QC tests and data must be corrected manually.

By zooming one can see stations and topography more closely. By clicking the station with mouse different other screens can be activated. For instance:

- List of data from neighboring stations (observed values and estimated values).
- Graphically represented data (real values and different sums) from 3 or 4 stations. For instance precipitation sums, sunshine hours, global radiation data etc. may visualize possible errors in data.
- Radar images and 12 hours precipitation sums.
- Data from lightning location system (grid data)
- Derived data (dew point temperatures, ...)
- Others?

After correcting a certain value change in flagging has to be taken care of. So feedback to database tables must be handled also concerning flagging.

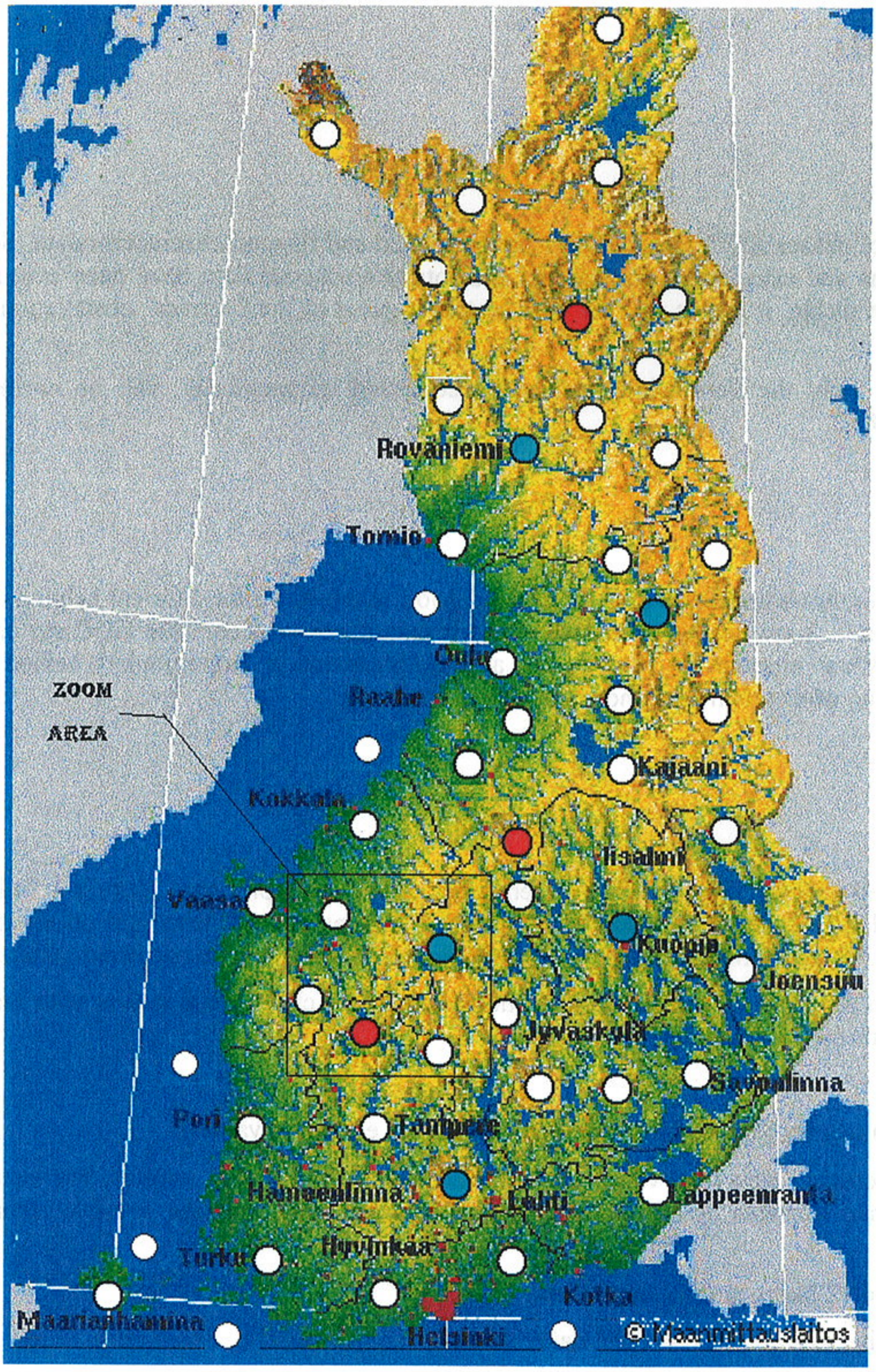


Figure 1. An example of station network when observation data is classified via flagging.

4. HQC AT DNMI

This paper describes the present status at DNMI of human quality control, HQC, from a climatological point of view, assuming that quality control of meteorological observations needed for forecast and model development should be handled by automatic methods or ad hoc human quality control.

The focus in improving the present QC system is to provide a better service to internal and external users, and to make sure that data quality can be presented in numerical terms.

Presently, the QC system of QC1, QC2 and HQC modules is divided among several data processing routines. The most elaborate QC1 system is to be found for the synoptic stations, while the most elaborate QC2/HQC system is to be found for the manual climate stations.

4.1 Station networks

By the end of December 1998, there were 859 meteorological stations run by DNMI or run by DNMI in cooperation with other institutions.

Real-time stations	**Total**	**Climate stations**	**Total**	**Sum**
		manual raingauge stations	557	557
synoptic stations	94	manual weather stations	29	123
automatic weather station	24	automatic weather station	24	48
airports reporting only METAR	35			35
		tipping bucket raingauge stations	22	22
semi-automatic weather station	16			16
airports reporting SYNOP and METAR	15			15
oil rigg stations	11			11
Ships	11			11
Buoys	8			8
radiosonde stations	8			8
		totalisator stations	2	2
		evaporation stations	2	2
weather ship ("station M")	1			1
Sum	223		636	859

4.2 HQC - human quality control

Human quality control for the main data processing routines have been discussed in a sequence of DNMI-reports, this paper contains summaries from some of the most important ones. The general scope on quality control from the current DNMI perspective is presented in [1].

4.2.1 HQC of synoptic stations and automatic climate stations

Although some of the main issues concerning the relationship between automatic and manual quality control was debated in a preparatory report for the first NORDKLIM Quality Control Meeting [2], the system is perhaps best explained by looking at the statistics from the latest DNMI/NORDKLIM status report [3].

The core program for the HQC is the S-T-F problem identifier. This program is run on a daily basis, any time of day, and will point to problems that have not yet been corrected by QC2 methods or problems that were out of reach for the QC2. The program identifies problems related to air temperature, precipitation, snow depth and air pressure. A specification of error detection methods is given in [2], program specification, user statistics and program code may be found in [4].

S-T-F and consequent updates in the TELE real-time datatable are done manually every evening 7 days a week by the Forecast Division in Oslo (VA), and every morning 5 days a week by the Climatology Division. Missing values for the northern stations are also updated manually on a daily basis by the Forecast Division in Tromsø (VNN) as explained in the monthly monitor report [3].

In order to produce various types of climate statistics, such as the monthly climatological overviews, the human quality control makes advantage of the computer program KA_H_STAT that is used for producing this type of statistics. As a partial automatic simulation of what is done in this part of the HQC, a program check CHECK_H_STAT [5] is used for identifying errors in the KA_H_STAT output.

As selected automatic weather stations (AWS) are a part of the DNMI SYNOP network, they are included in the quality control. The updates due to QC2 and HQC in the TELE/SYNOP routine are, however, not stored in the historical database, because there is not sufficient time available in the TELE/SYNOP routine to guarantee that all interpolations and corrections are top quality. This means that all updates in TELE are neglected when the observations are made part of the data processing routine for manual climate stations as will be explained in a section below.

4.2.2. HQC of tipping bucket raingauge stations

This control consists of manually checking if there has been a delay in the time indicator at the station. The test is performed by making lists of daily precipitation from the tipping bucket stations, and compare with neighbouring stations of various kinds that also have daily precipitation observations.

Under planning is a test for registering variation in precipitation intensity.

4.2.3 HQC of manual raingauge and manual climate stations

The data processing routine for handling manual raingauge stations is described in [6]. The HQC is performed on a weekly basis, as observations are inserted into the datatables, and on a monthly basis with emphasis on quality checks for monthly units. There are two types of controls; time-space controls and internal consistency control. The time-space controls consist of checking numerical printouts for sections of the station network. The consistency control checks precipitation against observations of the weather for the relevant period and produces lists of observations to be corrected.

There have been many attempts at producing an automatic or semi-automatic time-space quality control, but the present version ROMRR [7], earlier discussed within the FREYR context [8], is only used for technical monitoring of data quality.

The quality control checks and contents of computer software for data processing for manual climate stations is described in [9]. The central quality control program is called CONTSYN2 and is part of a greater family of quality control programs. There are programs for time-space control and internal consistency control, all programs based on numerical lists. The DATRUT project [10], however, is presently looking into how to modernise the system by including GIS applications and interactions with other data processing routines.

In [11], the manual climate stations are discussed within the context of QC2 and gradually making the HQC a part of the automatic system.

4.2.4 HQC for other types of stations

As described in the station network section above, there are also other types of stations, although few of these have an elaborate HQC, even though there may be fragments of such routines. We have already presented three such routines within the NORDKLIM context: The VINDREG routine [12], the METAR/ALF routine [13] and the real-time AWS/ALA routine [14].

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5. HQC AT SMHI

Before the meteorological observations will be stored in the database (Båk), they will be checked and corrected in a "workfile".
Only observations from every third hour will be checked.
Observations from automatic weather stations, manual synop stations and some climate stations will pass the same routine. All observations will be checked by a control program. This program will flag observations, which may have some errors.

5.1 Manual Synop

About 40 manual synop stations observe cloud, wind, visibility, weather, air pressure, temperature, humidity, precipitation and snow depth. The observations are distributed via Mandat, an electronic distribution system in real time. Some synop stations also report sunshine duration and soil temperature, and these parameters are distributed by mail.
Every tenth day the observers send a journal with all manual synop observed during the last ten days.

5.2 Observations from manual climate stations in real time

About 45 manual climate stations observe temperature, precipitation and snow depth at 06 and 18 UTC. The observation is distributed via telephone. Once every month a journal with all observations is distributed by mail. Different kinds of precipitation, fog and thunderstorm are also observed and marked in the monthly journals.

5.3 Observations from automatic weather stations

About 150 automatic weather stations observe the same parameters as the manual synop stations except clouds and snow depth. Data from these stations are collected every hour via the switched telephone network.

5.4 Error detection

The name of the control program is Che_synop. The program is checking the code, the internal consistency, if the parameters are within the decided limits, the time consistency, if the observation is a complete observation or not and a horizontal check (The horizontal check is not in use to day). All controlled observations will be marked with a flag. The flag is 1, if the observation is OK, the flag is 2, if the observation is suspected wrong and 3 means that the observation is wrong. All suspected errors marked with a flag will be saved in a file. In a text message you can read the errors marked with a flag.

5.5 Correction of observation

Observations from automatic weather stations are collected every hour, but only the observations from every third hour are checked. If any parameter is missing it can be interpolated from other parameters close in time from the same station.

5.6 Manual correction

The manual correction will start with a comparison between the observation arrived in real time and the observation in the journal, if there is a journal.
If the observation is missing, it has to be interpolated.
Only the observations, which are flagged by the control program will be corrected.
Correction of the values are made by comparing internal parameters, comparing observations from neighbour stations, information of the location of the local station and some information about the actual weather situation.

After all corrections are done the control program will be run once more.

5.7 Observations from "small" climate stations

There are about 600 manual climate stations observing precipitation and some of them are observing temperature.
At 06 UTC all stations are measuring precipitation and about 80 also temperature.
At 12 UTC about 55 stations are measuring temperature.
At 18 UTC about 80 stations are observing temperature, including maximum and minimum temperature for the latest 24 hours.
All the observations are written in a journal and sent by mail once every month.
These observations are put in a computer manually or by a scanner, before they are checked and stored in the database BÅK.

5.8 Control program for the temperature

A special temperature program is checking maximum and minimum temperature compared to the observed temperature values at 06, 12 and 18UTC. Suspected values are marked with a flag. The values are corrected manually by comparing values from the neighbour stations. Missing values are interpolated by a program using maximum 10 stations within a radius of 100 km . (Roy Berggrens program, see QC2)

5.9 Checking and correcting the precipitation data

The system for checking and correcting the precipitation data is both an automatic and a manual method. The logic errors can be corrected by an automatic program and for errors without no direct logic explanations, the figures are recommended for manual inspection.
The main steps in the automatic system are as follows:

1. The nearest neighbours to the studied precipitation station are chosen. Generally the six closest stations are considered.
2. The system investigates trivial errors. A special decision table is within the system to handle special situations, which are connected with the case, when the studied station reports dry weather. This part of the system is constructed to minimise manual inspection.

3. The station is tested by a formulae based on "micro-statistics", which means statistics for small samples. The formulae reads as follows:
4.

$$r = \frac{|P - Pnearest|}{|Pmax - Pmin| + \varepsilon} \quad \text{where}$$

P = The investigated precipitation value
Pnearest = The value among the neighbouring values that deviates least from the investigated value (=P)
Pmax and Pmin = The highest value respective the lowest value among the neighbours
ε = a small quantity to avoid zero in the denominator

The value r is then compared by a tabulated value for a selected confidence level.

5. If the value by the test in item 3 above is classified as suspected (the ratio r is larger than the tabulated value) then a further testing is generated. The value is checked for its consistency in time. If for instance the previous days have had too much precipitation as compared with the neighbours and the studied time and station has a lack of precipitation, then a new value is computed based on the previous quantities and with consideration of the spatial pattern (as revealed by the neighbours). If no reasonable explanation can be found to a deviation quantity, then the value is recommended for manual inspection. This can be the case for instance, when isolated showers have passed the field without affecting the neighbouring precipitation stations.
6. Manual inspection. This part of the work is achieved in a PC-environment, where a GIS presentation system is used. The suspected figures are specially marked. Also the already by the program corrected figures are indicated, and it is also possible to change these values.

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SMHI

INVITATION

NORDKLIM/QUALITY CONTROL

Development of Quality Control Methods for Meteorological Observations

Meeting n:o 2.

Place: **Swedish Meteorological and Hydrological Institute, SMHI, Folkborgsvägen 1, S-601 76 Norrköping**

Time: **21-22 October 1999**

The main tasks are to specify quality control methods for different meteorological parameters including real time data, use of different algorithms and metadata. The level of collaborative actions will be defined.

The Nordklim Climate Data Quality Control Group invites following persons to the meeting:

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WELCOME!

Norrköping 1999-09-29

Caje Jacobsson (Leader of the Swedish Quality Control Project)

Distribution:

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AGENDA:

Meeting room: Meteorologen

Thursday	**1999-10-21**		
	12.00– 12.30	Opening of the meeting	Britt Frankenberg
		Information	Caje Jacobsson
		Resumé	Pauli Rissanen
	12.30-15.15	Presentation of Automatic Quality Control of real time data, QC1, by representatives from DMI.	
		Presentation of non real time Automatic Quality Control, QC2, by representatives from SMHI.	
		Presentation of Human Quality Control, HQC, by representatives from DNMI.	
		Quality Control of observations from VViS and in MESAN (Lars Häggmark)	
		Comments	
	15.15.-15.30	Coffee	
	15.30 – 16.00	Each country presents its data base system including platform	
	16.00 – 16.30	Presentation of the QC Systems at SMHI	
	18-	Dinner	
Friday	**1999-10-22**		
	09.00–10.00	About the report, a short discussion lead by representative from FMI	
	10.00-10.15	Coffee	
	10.15-12.00	News from Iceland, Finland, Norway, Denmark and Sweden.	
		Daniel Michelson presents "Comparison of accumulated precipitation using weather radar and SYNOP".	
	12.00–13.00	Lunch	
	13.00–15.00	Future co-operation • Reports • Automatic methods (i.e. Wiski) • The importance of the human controls • Presentations (GIS….) • The users need • Next meeting	
	15.00 –16.00	Visiting the weather central and a presentation on using RIPP as an aid to forecasters.	
	16.00 -	End of meeting	