DNMI

NORDKLIM – Nordic co-operation within Climate activities

Nordic Methods for Quality Control of Climate Data

Pauli Rissanen (ed), Caje Jacobsson, Henning Madsen, Margareth Moe, Þóranna Pálsdóttir, Flemming Vejen

Report 10/00

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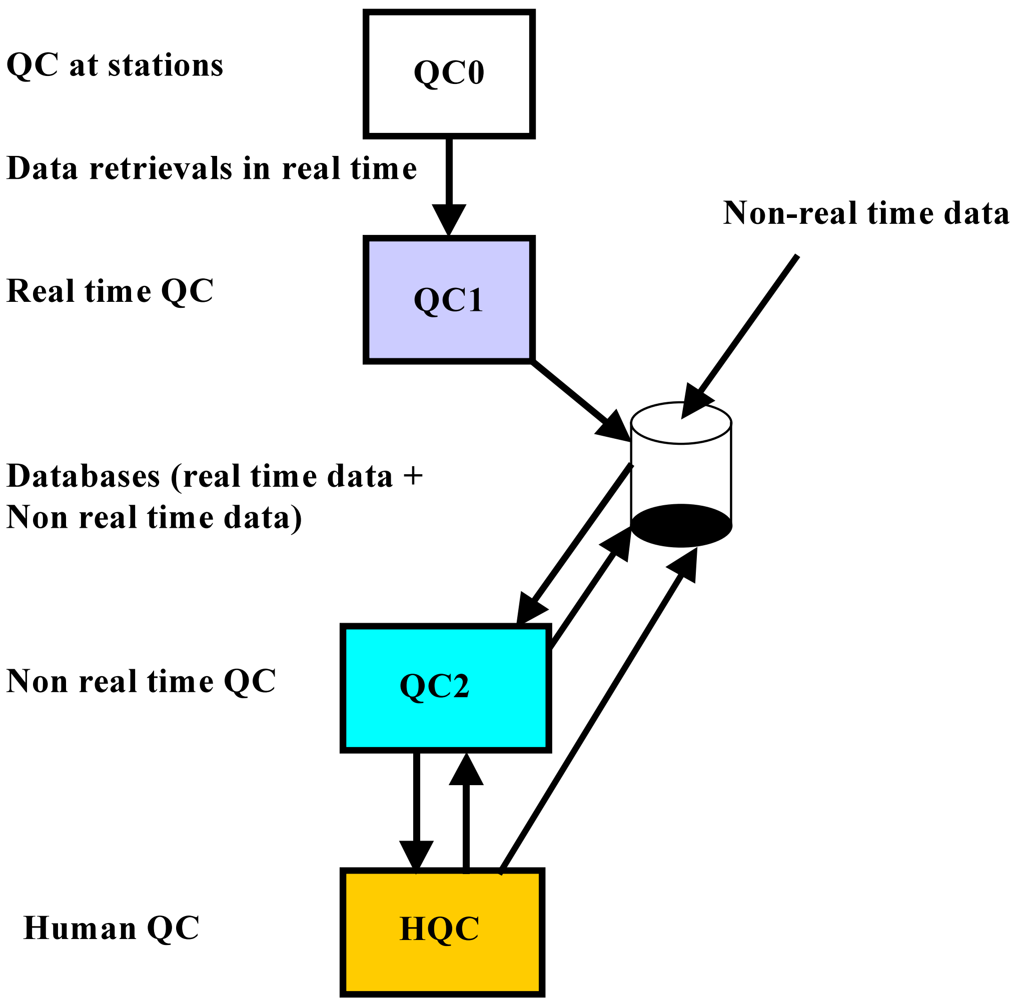

DNMI - REPORT

NORWEGIAN METEOROLOGICAL INSTITUTE
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ISSN 0805-9918

REPORT NO.
10/00 KLIMA

DATE
10.04.00

TITLE

Nordic Methods for Quality Control of Climate Data

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PROJECT CONTRACTORS

NORDKLIM/NORDMET on behalf of the National meteorological services in Denmark (DMI), Finland (FMI), Iceland (VI), Norway (DNMI) and Sweden (SMHI)

SUMMARY

This report is prepared under Task 1 in the Nordic NORDKLIM project: Nordic Co-Operation Within Climate Activities. The NORDKLIM project is a part of the formalised collaboration between the NORDic METerological institutes, NORDMET.

During the recent years use of meteorological observation data has changed. Automation of stations effects in different ways on observation data. Huge amounts of data are received in real time. New instruments automatically observe phenomena earlier observed manually. Also data may be delivered immediately to customers, and weather services are using real time data in their products. All these changes, both in observation methodology and use of data, raises new needs for quality control.

This report presents a survey of different methods used in quality control in the Nordic countries, and gives suggestions for methods that should be used in quality control at different phases of data flow from site to customers. More detailed descriptions of the methods from different countries are presented as attachments.

KEYWORDS

Quality control, Meteorological observations, NORDKLIM

SIGNATURES

....	....
Eirik J. Førland	Bjørn Aune
NORDKLIM Activity Manager	Head of the DNMI Climatology Division

Foreword

This report is prepared under task 1 in the Nordic NORDKLIM project: *Nordic Co-Operation Within Climate Activities.* The NORDKLIM project is a part of the formalised collaboration between the NORDic METerological institutes, NORDMET.

The main objectives of NORDKLIM are:
1). Strengthening the Nordic climate competence for coping with increased national and international competition
2). Improving the cost-efficiency of the Nordic meteorological services **(*i.e. by i*mproving procedures for standardized quality control & more rational production of standard climate statistics)**
3). Coordinating joint Nordic activities on climate analyses and studies on long-term climate variations

The NORDKLIM project has two main tasks:
1. Climate data (Network design, Quality control, Operational precipitation correction, long-term datasets)
2. Climate Applications (Time series analysis, use of GIS within climate applications, mesoscale climatological analysis). A detailed decription of the project is given by Førland et al., 1998.

NORDKLIM is coordinated by an Advisory Committee, headed by an Activity Manager. Each of the main tasks is headed by a Task manager.

The Advisory Committee in NORDKLIM is presently consisting of:

Bengt Dahlström, SMHI
Eirik J. Førland, DNMI (**Activity Manager**)
Raino Heino, FMI
Trausti Jónsson, VI
Lillian Wester Andersen, DMI

The present NORDKLIM Task Managers are: **Task 1**: Pauli Rissanen (FMI), **Task 2**: Ole Einar Tveito (DNMI)

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NORDKLIM

Climate data / Quality Control

Nordic Methods for QC of Climate Data

1. Introduction

During the recent years use of meteorological observation data has changed. Automation of stations effects in different ways on observation data. We are receiving huge amounts of data in real time, i.e. data are retrieved from few minute intervals up to few hour periods and data are from different sources (road, marine and aviation authorities, others). New instruments automatically observe phenomena earlier manually observed, for instance visibility, weather phenomena, precipitation and cloudiness. Also data may be delivered immediately to customers and weather services are using real time data in their products.

All these changes, both in observation methodology and use of data, raises new needs for quality control:

- How to quickly control quality of data not retrieved in synoptic times?
- How do new observation techniques fit to manual observations?
- How to handle varying station network from hour to hour?
- What is the reliability of automatically and manually observed data?
- What are required from quality control programs?
- How to present quality control information to the users?

Several countries in Europe are in the same position concerning quality control of observation data including automatic station observations. There are different quality control procedures at different phases of data flow, but not comprehensive quality control at all levels, where sophisticated methods should be applied. It is evident that data quality flagging is of most importance when using the data, and should be implemented on all levels of the quality control.

NORDKLIM/Climate Data/Task 1.2 under NMD/NORDMET umbrella is a new opportunity to gather all experience, knowledge and methods used in the Nordic countries in quality control of observation data. The main purposes are

a) to improve methods for operational quality control of meteorological data,
b) exchange experiences and ideas and
c) to create recommendations for different phases of quality control and metadata.

This document presents a summary of different methods in quality control used in Nordic countries and makes proposals for methods that should be used in quality control at different phases of data flow from site to customers. More detailed descriptions of the methods from different countries are presented in attached references.

2. Definitions, comments and data flow

2.1Real time data:

Data that are retrieved by ADP (Automatic Data Processing) methods from the site (almost) in real time to some collecting centre, where data can be delivered to users, are called real time data. For instance synop messages and AWS (automatic weather station) data are considered to be real time data.

In different quality control (QC) phases of observation data the following concepts are used:

2.2QC0: Quality control at the site

Includes siting, installations, instrument service, training of personnel, hardware and software used in producing observations and possible QC methods, data retrieving systems and warnings. This phase may include quality flagging. Some automatic stations produce error reports attached to the messages they send. QC0 may be fully automatic or involve human resources (i.e. the observer)."Quality starts from the site".

2.3QC1: Real time quality control before storing data to databases

Quick automatic quality control of the observation data per site. Checks internal consistency of observation data, controls data within rough (statistical) limits and finds out missing observations. Neighbouring site observations are usually not available, but it is possible to apply different parameter fields produced by prognosis models. Preliminary quality flagging is included to this phase. The main purpose is to prevent the use of totally erroneous data.

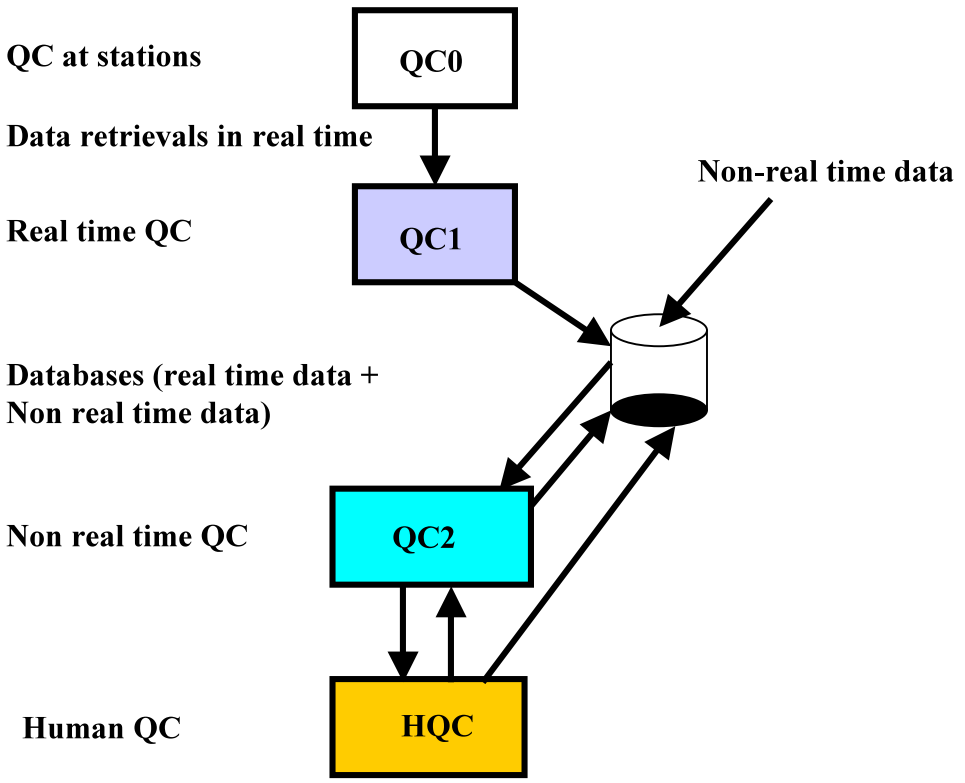
2.4QC2: Non- real time quality control after storing data to databases

Automatic quality control. Test from QC1 and horizontal tests are applied by using neighbouring station data read from databases. More exact statistics, Kriging method and mesoscale analysis (parameter fields of prognosis models, radar and satellite data) can be applied in quality control. Comprehensive quality flagging of data should be included to this phase at least in the future. Missing data will be detected and it is possible to calculate or interpolate values to compensate the missing data.

2.5HQC: Human quality control

After QC2 databases may include some unsolved errors in observation data. HQC is the final phase in quality control procedure. HQC is today mostly based on different paper formats, error lists and possible graphical fields. It is planned that in the future HQC is based mainly on map presentations of data where GIS interface is used. Today this tool is only slightly used. The aim is that only erroneous or suspicious values will be checked manually. It is planned that in the future HQC will be based mainly on map presentations of data where GIS interface is present. Erroneous or modified values are found via flagging. Manual control can change or accept values and these modifications have effects on flagging. Visualisation of data is important (sums, graphical presentations of data, observations of neighbouring stations etc.) From this phase it is possible to return to phase QC2.

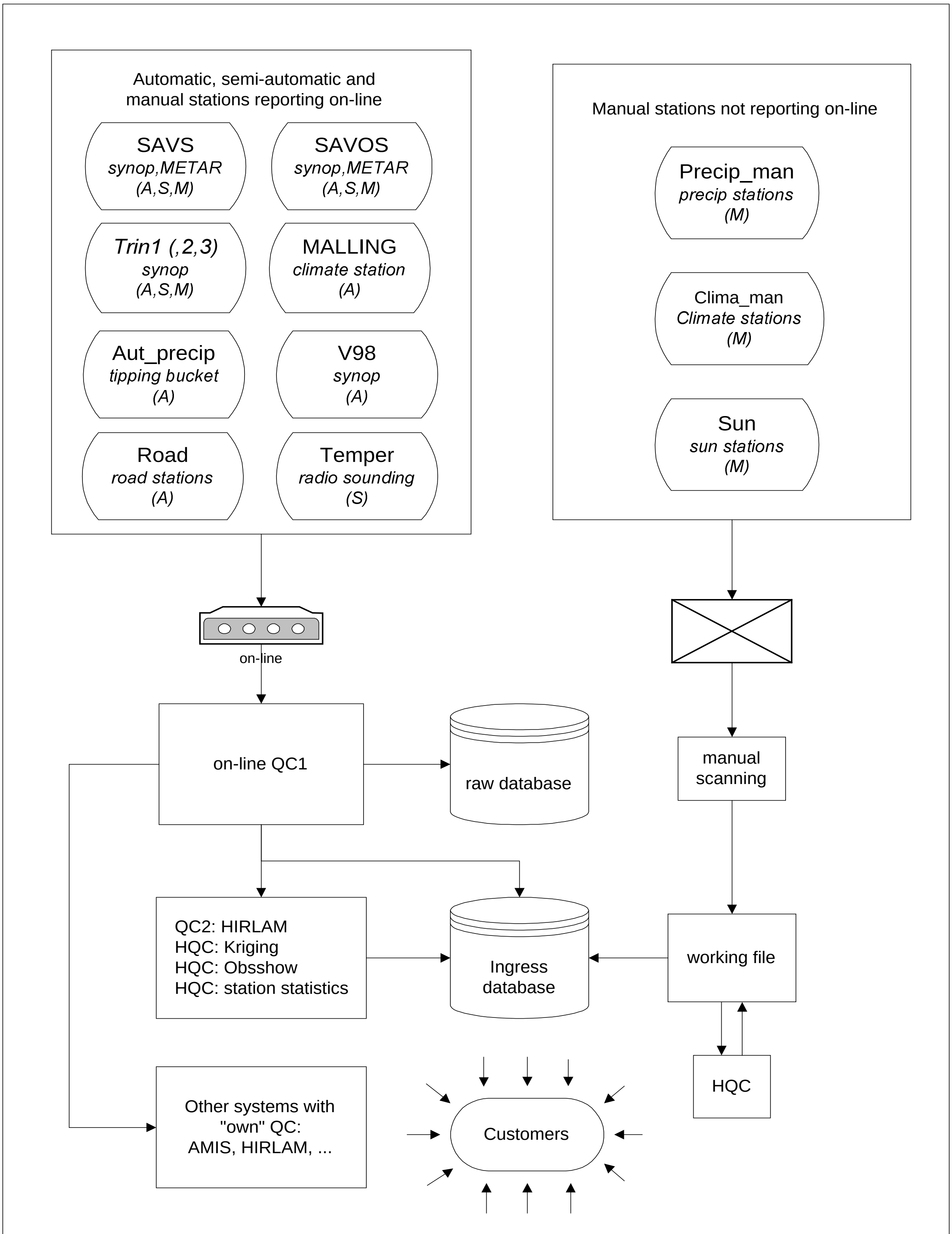
2.6General data flow from stations to databases



The previous figure presents the general data flow from site to databases. Normally data come from different types of stations and so the figure is more complicated than the general case.

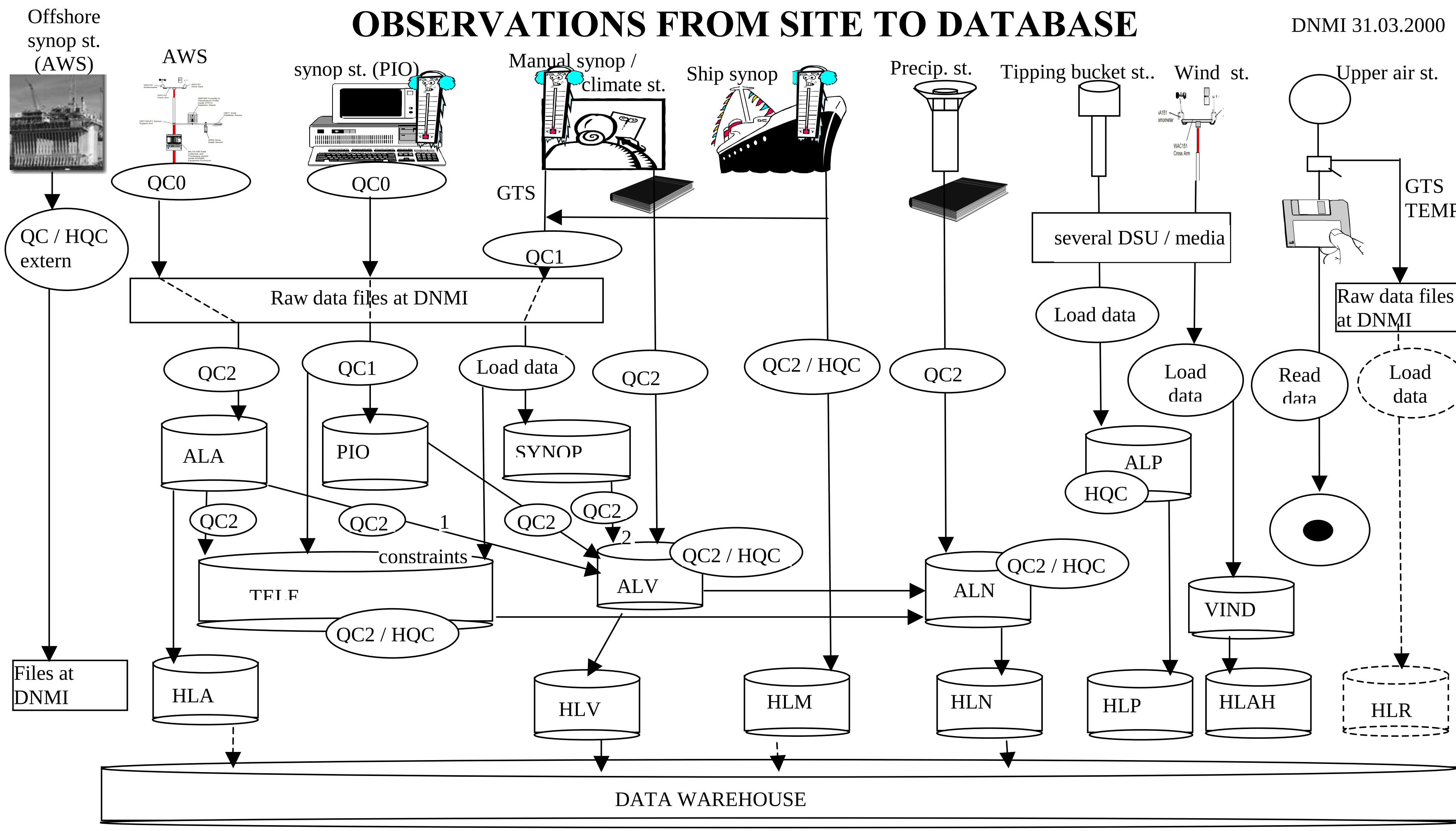
In the following chapters 2.7 – 2.10 the flow of data and QC controls in Nordic countries are presented in a more detailed way.

2.7Data flow and QC controls at DMI



TITLE:	Quality Control System						
COMPANY:	DMI			CREATOR :	FV		
DATE:	03-10-00	TIME :	13:32	PG	1	OF	1 PGS
FILENAME:	qcflow.vsd						

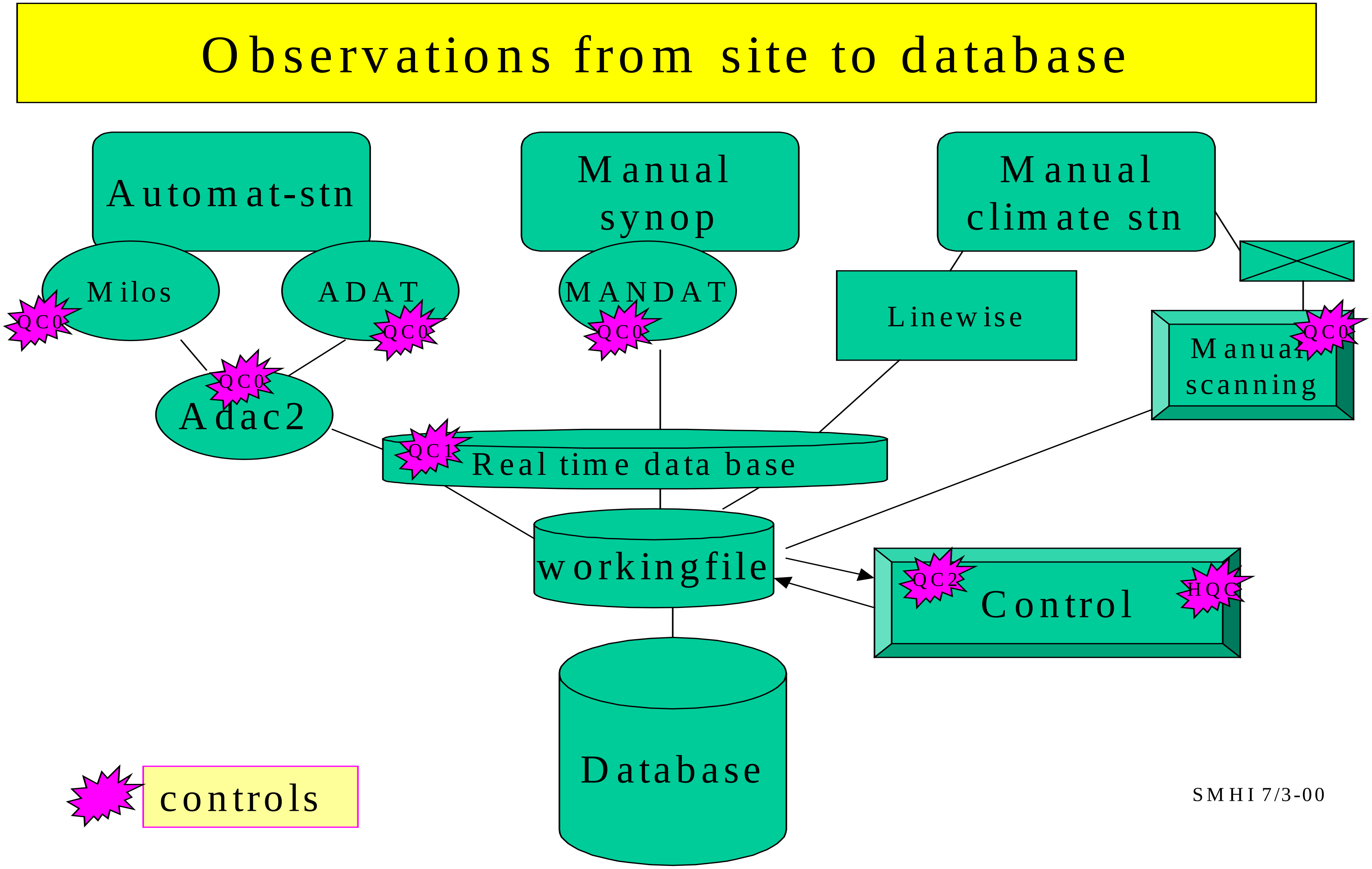
2.8 Data flow and QC controls at DNMI



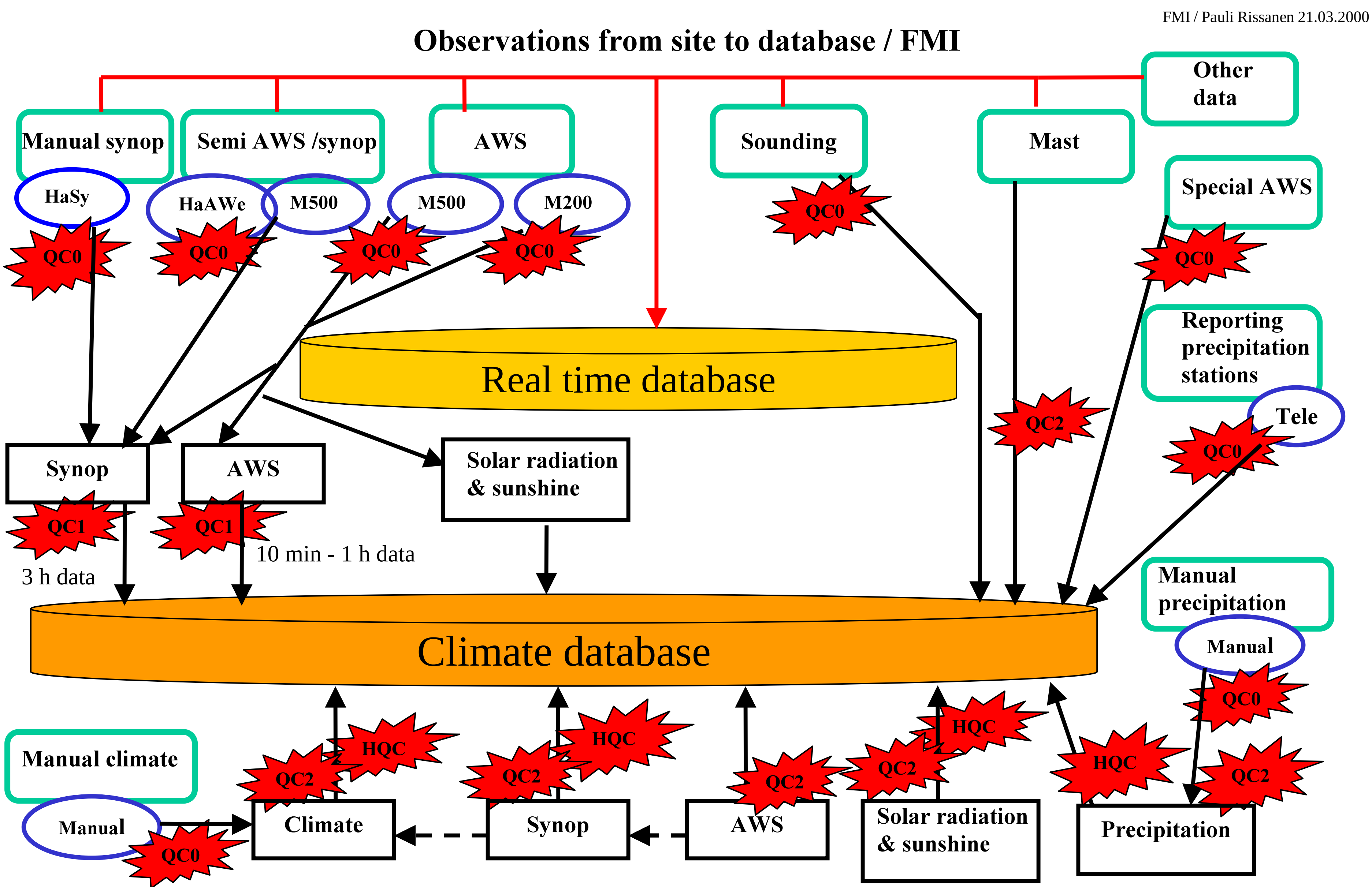
1 Only update of missing synoptic values from SAWS

2 Maritime observations not loaded into ALV

2.9 Data flow and QC controls at SMHI



2.10 Data flow and QC controls at FMI



2.11 Type of the site

It has been difficult simply to categorise stations with different observation times, transmission techniques, instrument / observation methods and so on into named categories such as synoptic, climate, precipitation, AWS- stations. The site types are varying from country to country and even inside one country the observation repertoire for instance on "climate stations" can be different. Also observations can be retrieved in real time, but also they can be delivered by mail. In this document we try to avoid expression "type of the station" especially concerning manual stations, if possible. We rather speak of real or non-real time data.

3. QC0: Quality control at the site

3.1General overview of QC0

A lot of different aspects are included into this quality control phase. The following conditions that effect on data quality are just briefly mentioned and not further discussed in this document though they play an important role in quality:

- Siting defines the quality of observations. Observations from badly sited station are never good.
- Installation of instruments must be done carefully, cabling and grounding included. Noise in electric measurements (interference fields) leads into undesired results.
- Instrument service and calibrations are important. After service and calibrations the function of the site has to be checked.
- Delivery of observations (messages) should be done using accepted data transmission protocols.
- Training of personnel is required.
- The functionality of hardware and software used at the site has to be taken care of.
- Planned, periodic inspections and daily following up of the station and observers.
- Maintaining of metadata has to be done. Should be computerized.

Concerning manual observations without any possibilities to use ADP techniques, QC0 is based just on observer's skill and training.

When ADP techniques are present, for instance in feeding observations into the system, different QC methods can be applied. It is possible to apply in testing single parameters the following basic checks:

a) range check (e.g. limits within which values should fall)
b) step check (e.g. limits how much temperature can change in 3 hours, frozen anemometer, AWS checks between successive measurements)

c) missing value check (e.g. certain observation is missing though it should be observed)
d) format / code check (e.g. errors in format of message or wrong code)
e) consistency check (e.g. error, if temperature is more than +10 degrees and it is snowing or relationship between dry bulb and wet bulb temperature)

These limitss can be defined for instance on monthly basis.

Also some instrument manufacturers include internal checks (test algorithms) of sensors with error reports in their products. These results can be used in quality control part QC0 at the site and also later on in QC1. In some cases suspicious observations are deleted automatically by these test algorithms. Usually any corrections are not made automatically at the site.

As a summary the following methods / tools are used:

DMI: PC- program (manual synop), AWS test algorithms, Geonor + present weather sensor, checks in delivery.

DNMI: range and missing data tests (AWS).

Vedurstofa: PC- program (manual synop). Some range checks.

FMI: HaSy (manual synop), HaAWe (semiautomatic synop), AWS test algorithms, precipitation checks.

Sweden: Mandat (manual synop), AWS test algorithms (e.g. present weather modifications), checks in delivery (Mandat for manual synop, ADAT/MILOS for AWS observations).

More exact information on parameter level is given below in table 1 "QC0 checks in Nordic countries"".

Parameters	DMI	DNMI	SMHI	Vedurstofa	FMI
Temp (including max/min), 2 m level	x	x	x	x	x
Clouds (including types, height)	x	x	x	(x)	x
Hum (including wet bulb, dew point)	x	x	x	x	x
Pressure (including tendency)	x	x	x	x	x
Wind	x	x	x	x	x
Visibility	x	x	x	x	x
Weather (including ww, W1, W2)	x	x	x	x	x
Precipitation	x	x	x	x	x
Depth of snow		x		x	x
State of ground		x		x	x
Surface temp (close to ground)				x	x
Soil temp					
Sunshine duration					x
Solar radiation					x

Table 1. QC0 checks in Nordic countries (autumn 1999). (x) indicates that tests are not complete.

3.2Conclusions and recommendations attached to QC0

It is obvious that manual observations that are not handled with ADP tools at the site, are lacking sufficient QC methods. Observers are totally responsible for the quality.

In every Nordic country QC0 is performed, but there is a great potential in improving the existing tests and implementing new.

If different weather parameters are observed automatically, there are difficulties in defining different weather phenomena in certain cases. Some automatic corrections to code formats should be done. Better algorithms defining weather phenomena must be designed / implemented.

The use of ceilometers in defining cloudiness leads into different results compared to manual observations. New algorithms should be developed, for instance solar radiation observation should be taken into use.

SMHI stated following future plans (Jacobsson et al, 1999, p. 5):

- *A plan for the future is to find an automatic system to check all observations already at the measuring site.*

- *A plan for the future is to find an automatic distribution system in real time with an automatic control program to check the code formats and the reliability of the observations.*
- *Some errors can maybe be corrected automatically e.g. the code formats.*
- *In the future corrections of meteorological parameters should be done already at the site.*

Recommendations:

- Attention to installations, service and calibrations etc.
- Data delivery must be reliable.
- ADP methods in controlling observations should be taken into use as much as possible at the site.
- Suspicious data should be flagged if possible.
- The internal test results of automatic stations have to be taken into use.
- Observations produced by other authorities are problematic. Some devices to handle these observations (co-operation) should be developed.
- Metadata files have to be maintained (new measuring techniques, service control etc.).

References:

Hellsten E., 1999 a, Jacobsson C. et al, 1999, Vejen F. et al, 1999, Ögland P., 1999 a - e

4. QC1: Real time quality control

4.1 General overview of QC1

The basic problem in QC1 is how to control observation data coming in real time so that users are not receiving bad data. Certain guarantee level should be reached and suspected data flagged. All this should be done before storing data to databases if possible.

The observation network is varying from hour to hour. It depends on the stations included to the system. The quantity of observations in different times is not constant. There may be also some extra observations for instance at 06 UTC (precipitation stations in Finland).

Observations are coming to the NMS (National Meteorological Service) in random order. It means that the use of observations from neighbouring sites is impossible. Usually there is no time to wait until certain amount of observations is received. So the quality control is mainly based on code, internal consistency and range limits plus completion checking. Range limits may be more dependent on location of the site than in QC 0, because better statistics are available. So just single parameter checks are mainly used in Nordic countries.

SMHI has implemented HIRLAM forecast products and spatial interpolation in the QC 1 system. 3 - 9 h NWP forecast is used in QC 1.

As a summary the following methods / tools are used:

DMI: Hourly control of data from manual, semiautomatic and automatic stations: basic checks as in QC 0.

DNMI: S-T-F model, VINDREG, MND2ALA, basic QC 0 tests.

FMI: SYNOP, AWS and precipitation controls, basic QC 0 tests.

Vedurstofa: Basic QC0 tests, no flagging.

Sweden: SYNCHE (synop cheque program), HIRLAM, basic QC 0 tests.

Below in table 2 the current situation of QC1 in Nordic countries is presented.

Parameters	DMI	DNMI	SMHI	Vedurstofa	FMI
Temp (including max/min), 2 m level	x	x	x	x	x
Clouds (including types, height)	x	x	x	x	x
Hum (including wet bulb, dew point)	x	x	x	x	x
Pressure (including tendency)	x	x	x	x	x
Wind	x	x	x	x	x
Visibility	x	x	x	x	x
Weather (including ww, W1, W2)	x	x	x	x	x
Precipitation	x	x	x	x	x
Depth of snow	x	x	x	x	x
State of ground	x	x		x	x
Surface temp (close to ground)			x	x	x
Soil temp					
Sunshine duration					
Solar radiation					

Table 2. QC1 checks in Nordic countries (autumn 1999).

The difference compared to QC0 checking is that more observation parameters are included to quality control at least in some countries (depth of snow, state of ground).

In general QC1 phase is quite complicated. The flow of data from different sites is usually split into different subroutines (AWS, synop, climate etc.).

4.2 Conclusions and recommendations attached to QC1

All controls are quite similar in the Nordic countries. Only SMHI is presently using HIRLAM model in QC1 and in spatial interpolation. DMI, DNMI and FMI are planning to implement HIRLAM in QC1.

Procedure for flagging of data is varying from country to country. Flagging is used but not enough i.e. flagging is not concerning all observed parameters.

Some countries may have problems how to insert and update data and flags in real time databases and climate databases.

It is problematic how to handle suspicious and wrong values. Should they be corrected during QC1 or at a later phase? How to do the interpolation?

Recommendations:

- Users have stated that quality control close to real time is important.
- Sophisticated methods should be taken into use (HIRLAM, radar fields).
- Internal test results from AWS stations should be benefited in controlling quality and to help starting service operations quickly.
- More comprehensive flagging of data is needed.
- Original values (errors included) should be stored for QC2 and later on considerations.
- Metadata play an important role in controlling quantity and quality of data.
- Flagging should concern also real time databases.

It has turned out that many NMSs don't use all data produced by automatic stations. Ceilometers and present weather sensors are measuring data continuously. To get the best information of present weather and clouds all the measurements should be benefited. This requires changes in data retrievals and in storing the data to databases.

Also different combinations of observations should be taken into use. For instance solar radiation measurements attached to automatic cloudiness observations provide better cloudiness data.

Grid data from lightning location system can be applied in defining the present weather in thunder cases at the site, if present weather sensor is not able to observe thunder.

References:

Hellsten E., 1999 b, Jacobsson C. et al, 1999, Vejen F. et al, 1999, Ögland P., 1995, 1998 a - b, 1999 a - e

5. QC2: Non-real time quality control

5.1 General overview of QC2

This automatic phase of quality control takes place when observation data have been stored to databases. Use of databases makes it possible to control time consistency of observations and how observations represent horizontally the present weather situation. Also missing or erroneous observations can be substituted by interpolated values.

Automatic QC2 is based on different ADP methods: prognosis model data (HIRLAM), statistical methods (Kriging, interpolations, other horizontal tests) and possible special methods for certain products plus methods applied in QC0 and QC1. One basic item is to flag the data as much as possible.

As a summary the following methods / programs are used:

DMI: On daily basis HIRLAM, AMIS (Agro Met. Information System)

DNMI: S-T-F model, VINDREG, ALF/METAR, AUTOKONTR

FMI: Kriging, some parts of SYNOP, CLIMATE, AWS, RADIATION and PRECIPITATION routines

Vedurstofa: Old and primitive ADP (on manual data) without using prognosis model data, complicated statistical methods, radar data. Partly ADP and partly HQC checks on hourly data.

Sweden: HIRLAM, MESAN, CHE_SYNOP, NBDCHK, VVis, Roy Berggren's method

Table 3 illustrates the present situation of QC 2 in Nordic countries.

Parameters	DMI	DNMI	SMHI	Vedurstofa	FMI
Temp (including max/min), 2 m level	x	x	x	x	x
Clouds (including types, height)		x	x	x	
Hum (including wet bulb, dew point)		x	x	x	x
Pressure (including tendency)	x	x	x	x	x
Wind	x	x	x	x	x
Visibility		x	x	x	
Weather (including ww, W1, W2)		x	x	x	
Precipitation		x	x	x	
Depth of snow		x	x	x	
State of ground		x	x	x	
Surface temp (close to ground)			x	x	
Soil temp					
Sunshine duration			x		
Solar radiation			x		

Table 3. QC2 checks in Nordic countries (autumn 1999).

5.2 Conclusions and recommendations attached to QC2

QC2 methods differ from each other in the Nordic countries. Besides HIRLAM and Kriging there are special programs making QC2 for certain purposes.

QC2 may act on hourly, daily or monthly level depending on the solution in question. The main issue is to control the data with ADP methods.

QC2 will be strongly developed in the Nordic countries. Radar, satellite, lightning location system etc. data should be applied in QC2 in the future.

QC2 controls huge amounts of data and it will be the only possibility to control all observation data including observations from AWS stations. It calculates or interpolates missing or erroneous values and flags the data. QC2 is crucial for automatic detection of values that should be checked further in the final HQC.

Recommendations:

- QC2 should compensate large amount of human work.
- QC2 should cover all observations and flag them preliminary.
- QC2 should handle data at least down to 1 h intervals.
- QC2 should start the quality control as soon as possible with no extra delay.

- QC2 controls via flagging the phase of HQC, when suspicious or wrong values will be detected.
- The better QC2 works the less work is required in the phase of HQC.
- QC2 should compensate at least at some level different monthly routines.
- Fields of prognosis models, radar, lightning location system and satellite data should be applied.
- Special measurements (solar radiation, sunshine, different combinations) should be also controlled by QC2.
- The use of human experience is important when designing / specifying the controls.

References:

Hellsten E., 1999 c, Jacobsson C. et al, 1999, Vejen F. et al, 1999, Ögland P., 1995, 1998 a - b, 1999 a - e

6. HQC: Human quality control

6.1 General overview of HQC

So far observation data have passed through different automatic QC tests in the phases of QC0, QC1 and QC2. Sometimes it is slightly difficult to separate phase QC2 from HQC, because they go together so easily.

As a summary the following methods / programs are used:

DMI: OBSSHOW (graphical user interface), Kriging, plotting, interpolations, others

DNMI: S-T-F model, CHECK_H_STAT, TELE/SYNOP, VINDREG, METAR/ALF, others

FMI: Kriging, some parts of SYNOP, CLIMATE, AWS, RADIATION and PRECIPITATION routines, radar images (manual)

Vedurstofa: Using maps, OBSSHOW and printed lists for final checking (manually)

Sweden: CHE_SYNOP, AWS time correlated program, precipitation, others

Table 4 illustrates the present situation of HQC in Nordic countries.

Parameters	DMI	DNMI	SMHI	Vedurstofa	FMI
Temp (including max/min), 2 m level	x	x	x	x	x
Clouds (including types, height)		x	(x)	x	x
Hum (including wet bulb, dew point)		x	x	x	x
Pressure (including tendency)	x	x	x	x	x
Wind	x	x	x	x	x
Visibility	x	x	x	x	x
Weather (including ww, W1, W2)	x	x	x	x	x
Precipitation	x	x	x	x	x
Depth of snow	x	x	x	x	x
State of ground		x	x	x	x
Surface temp (close to ground)	x		x	x	x
Soil temp			x		(x)
Sunshine duration			x	(x)	x
Solar radiation	x		x	(x)	x

Table 4. HQC checks in Nordic countries (autumn 1999). (x) indicates that tests are not complete.

Usually HQC is split into different routines (synop, climate, AWS, precipitation, solar radiation etc.).

HQC is based on several methods. Some corrections are based on error lists or paper formats or onto screen displayed data produced by QC2, where bad data are classified. More advanced methods include calculations and proposals for wrong values (SMHI / precipitation routine, DNMI / S-T-F problem identifier). DMI provides for instance graphical user interfaces for pressure fields and for daily precipitation sums. At FMI areal precipitation sums are calculated and radar images as help are used in manual corrections as well some WEB products are used in quality control.

6.2Conclusions and recommendations attached to HQC

The HQC phase is quite complex in Nordic countries. Many different routines and methods are applied. Also control points may vary. All controls are not centred to certain personnel. The activities in different institutes are differing from each other. Some institutes may handle also hydrological data or special data. In general too much human work is needed.

Though manual corrections are based on different computer products, a good user interface and presentation systems are lacking. In some cases it would be reasonable to have a look on radar or satellite images and HIRLAM products, compare observations from neighbouring sites and have sums and other graphical presentations on the screen. Topographical background (GIS) on the screen will help users to define the appropriate corrections. User interface should include also the possibility to correct the data and this should also affect on flagging.

Recommendations:

- Good user interface is needed.
- GIS tools should be applied.
- Possibility to correct data directly on the screen is needed.
- Different graphical presentations should be included.
- WEB tools will help in making HQC.
- As much automatic controls as possible should be implemented in the phase of QC2 to save work at the phase of HQC.

References:

Hellsten E., 1999 d, Jacobsson C. et al, 1999, Vejen F. et al, 1999, Ögland P., 1999 f

7. Further plans

All the different QC phases need development. Especially flagging is not at on that level where it should be for different QC parts and there is great potential to improve flagging system. Sophisticated methods (HIRLAM, radars, satellites, comprehensive statistics incl. Kriging) should be used in quality control.

Due to the fact that every Nordic country has different data retrieving systems, databases and QC0, QC1 and QC2 programs, development of these parts mainly takes place separately in every country. Of course change of methods, ideas and experiences belong to normal activities within Nordic countries / Nordklim.

The discussion within Nordklim has revealed that the HQC phase is at a quite complex level in the Nordic countries. Several methods and phases are applied in HQC and a good user interface is missing, where the possibility to correct data is present. It is possible to create standards for HQC so that a common Nordic program can be developed.

Development of such a system is required in all Nordic countries. To avoid parallel programming, gather experience and requirements from all Nordic countries and save manpower, a common HQC system should be specified and developed. By cooperation on this, all Nordic countries will have a common HQC- system earlier and more “complete” than if every country develops their own ones. This will also result in better quality of the climate databases.

The HQC phase is presently quite time consuming in all Nordic countries, and a joint Nordic HQC system will both improve the data quality and reduce the manpower needs. Consequently in NORDKLIM project plan 2000 - 2001 the main focus in task 1.2 "Quality Control" is planned to be HQC.

The quality control methods recommended in this report do not include control methods that are based on analyses of long time series of data such as homogeneity testing and double mass analyses, which for example can be used to see if station conditions have changed significantly over time. The report only concerns methods that are used for quality control of real time and near real time data by analysing data on a shorter time scale, on the other hand by using instant data and on the other by analysing data spatially and temporally.

References

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Attachments

QC tables from FMI
QC tables from DMI
QC tables from SMHI
QC tables from DNMI

QC0: QC at the site / FMI

Line (L)	Element	Range check	Step check	Missing value check	Format / code check	Consistency check	Spatial check	Comments
1	Precipitation (12 h, 24h)	X		X	X	X (X)		Observer checks at the site. HaSy & HaAWe programs
2	Precipitation (automatic)	X		X	X			FD12P algorithm
3	Temperature	X	(X)	X	X	X		HaSy & HaAWe programs, AWS (Milos 500) checks
4	Clouds (N, Nh, CCC)	X		X	X	X		HaSy & HaAWe programs, Ceilometer checks and codes
5	Humidity (RH,TD, TW)	X	(X)	X	X	X		HaSy & HaAWe programs, AWS (Milos 500) checks
6	Pressure	X	X (X)	X	X			HaSy & HaAWe programs, AWS (Milos 500) checks
7	Wind	X	X (X)	X	X	X		HaSy & HaAWe programs, AWS (Milos 500) checks
8	Visibility	X		X	X	X		HaSy & HaAWe programs, FD12P algorithm
9	Weather (ww,W1, W2)	X		X	X	X		HaSy & HaAWe programs, FD12P algorithm
10	Snow	X		X	X	X		HaSy & HaAWe programs
11	State of ground	X		X	X	X		HaSy & HaAWe programs
12	Surface temp.	X		X	X	X		HaSy & HaAWe programs AWS (Milos 500) checks
13	Soil temp	X		X	X			AWS (Milos 200) checks, manual observations too.
14	Sunshine dur.	X		X	X			Radiation & sunshine program
15	Solar rad.	X		X	X			Radiation & sunshine program

(X) in automatic Milos 500 stations

QC1: Real time QC at FMI

Line (L)	Element	Range check	Step check	Missing value check	Format / code check	Consistency check	Spatial check	Comments
1	Precipitation (12 h, 24h)	X		X	X	X		Synop- routine
2	Precipitation (automatic)	X		X	X	X		Raw data
3	Temperature	X	X	X	X	X		Synop- routine AWS- routine
4	Clouds (N, Nh, CCC)	X		X	X	X		Synop- routine AWS- routine
5	Humidity (RH,TD, TW)	X		X	X	X		Synop- routine AWS- routine
6	Pressure	X	X	X	X	X		Synop- routine AWS- routine
7	Wind	X		X	X	X		Synop- routine AWS- routine
8	Visibility	X		X	X	X		Synop- routine AWS- routine
9	Weather (ww,W1, W2)	X		X	X	X		Synop- routine
10	Snow							Synop- routine
11	State of ground	X		X	X	X		Synop- routine
12	Surface temp.	X		X	X	X		Synop- routine
13	Soil temp							Raw data
14	Sunshine dur.							Radiation & sunshine program
15	Solar rad.							Radiation & sunshine program

QC2: Non real time QC at FMI

Line (L)	Element	Range check	Step check	Missing value check	Format / code check	Consistency check	Spatial check	Comments
1	Precipitation (12 h , 24h)	X		X		X		Synop-, Climate- and precipitation routines
2	Precipitation (automatic)							No checks
3	Temperature	X		X		X	X	Synop-, Climate- and AWS-Routines, Kriging
4	Clouds (N, Nh, CCC)	X		X		X		Synop- and Climate-routines
5	Humidity (RH,TD, TW)	X		X		X	X	Synop-, Climate- and AWS-routines, Kriging
6	Pressure	X	X	X		X	X	Synop-, Climate- and AWS-routines, Kriging
7	Wind	X	X	X		X	X	Synop-, Climate- and AWS-routines, Kriging
8	Visibility	X		X		X		Synop-, Climate- and AWS-routines
9	Weather (ww,W1, W2)	X		X		X		Synop- and Climate-routines
10	Snow	X	X	X		X		Synop-, Climate- and precipitation routines
11	State of ground	X		X		X		Synop-, Climate- and precipitation routines
12	Surface temp.	X		X		X		Synop- and Climate-routines
13	Soil temp							
14	Sunshine dur.	X		X		X		Radiation & sunshine program
15	Solar rad.	X		X		X		Radiation & sunshine program

HQC: Human QC at FMI

Line (L)	Element	Range check	Step check	Missing value check	Format / code check	Consistency check	Spatial check	Comments
1	Precipitation (12 h)	X		X		X	X	Synop-, Climate- and precipitation routines
2	Precipitation (automatic)							No checks
3	Temperature	X	X	X		X	X	Synop-, Climate- and AWS-Routines, Kriging
4	Clouds (N, Nh, CCC)	X		X		X	X	Synop- and Climate-routines
5	Humidity (RH,TD, TW)	X		X		X	X	Synop-, Climate- and AWS-routines, Kriging
6	Pressure	X	X	X		X	X	Synop-, Climate- and AWS-routines, Kriging
7	Wind	X	X	X		X	X	Synop-, Climate- and AWS-routines, Kriging
8	Visibility	X		X		X	X	Synop-, Climate- and AWS-routines
9	Weather (ww,W1, W2)	X		X		X	X	Synop- and Climate-routines
10	Snow	X	X	X		X	X	Synop-, Climate- and precipitation routines
11	State of ground	X		X		X	X	Synop-, Climate- and precipitation routines
12	Surface temp.	X		X		X	X	Synop- and Climate-routines
13	Soil temp							
14	Sunshine dur.	X		X		X	X	Radiation & sunshine program
15	Solar rad.	X		X		X	X	Radiation & sunshine program

QC0 at DMI

(1) QC0 at SAVOS synoptic stations (Semi Automatic Weather and Observation Station).

This kind of station is still placed at a few airports and is a quite old design, developed in the eighties, consisting of a PC to which all observations are put, manually and/or automatically. Stations of this type are not equipped with automatic equipment to the same level; they are more or less manual. If the parameter is observed manually it is entered into a computer program and must be accepted by the QC0 module before data can be transmissed.

Man. = manual QC
Aut. = automatic QC
Metar = QC at Metar stations

Line (L)	Element	Range check	Step check	Missing value check	Format / code check	Consistency check	Spatial check	Comments
1	Precipitation (12h/6h)	Man.			Man. Aut. Metar	Man.		
3	Temperature	Man.			Man. Aut. Metar	Man. Metar		
4	Clouds (N, Nh,CCC)	Man.			Man. Aut. Metar	Man. Metar		
5	Humidity (RH,TD,TW)	Man.			Man. Aut. Metar	Man. Metar		
6	Pressure	Man.			Man. Aut. Metar			
7	Wind	Man.			Man. Aut. Metar	Man. Metar		
8	Visibility	Man.			Man. Aut. Metar	Man. Metar		
9	Weather (ww,W1, W2)	Man.			Man. Aut. Metar	Man. Metar		
10	Snow	Man.			Man. Aut. Metar			
11	State of ground	Man.			Man. Aut. Metar			
12	Surface temp.	Man.			Man. Aut. Metar			
13	Soil temp							
14	Sunshine dur.							
15	Solar rad.							

QC0 at DMI

(2) QC0 at manual Level1, Level2 and Level3 stations.
These kinds of station were developed in the early nineties.
Level1 station: all observations are done manually and put into a PC program, and data are transmitted only if accepted by a quality control module.
Level2 station: used at un-manned (automatic) as well as manned (semi-automatic) stations. Temperature, humidity, min. and max. temperature, wind speed and -direction, air pressure and pressure tendency are observed automatically, and at a few stations also precipitation. Other parameters can be observed manually and put to a PC in the same way as for Level1 stations.
Level3 station: further development of Level2 station with new software and based on a Vaisala datasampler.

Man. = manual QC
Aut. = automatic QC
Metar = QC at Metar stations

Line (L)	Element	Range check	Step check	Missing value check	Format / code check	Consistency check	Spatial check	Comments
1	Precipitation (12h/6h)	Man.		Man.	Man. Aut.	Man.		
3	Temperature	Man.		Man.	Man. Aut.			
4	Clouds (N, Nh, CCC)	Man.				Man.		
5	Humidity (RH,TD, TW)	Man.			Man. Aut.			
6	Pressure	Man.			Man. Aut.			
7	Wind	Man.			Man. Aut.	Man. Aut.		
8	Visibility	Man.			Man. Aut.	Man.		
9	Weather (ww,W1, W2)	Man.		Man.	Man. Aut.	Man.		
10	Snow	Man.			Man. Aut.			
11	State of ground	Man.						
12	Surface temp.	Man.			Man. Aut.			
13	Soil temp							
14	Sunshine dur.							
15	Solar rad.							

QC0 at DMI

(3) QC0 at SAVS synoptic stations (Semi Automatic Weather Station)
This kind of station consists of an improved design compared to the older station types. It consists of a PC to which all observations are put, manually and/or automatically. Stations of this type are not equipped with automatic equipment to the same level; they are more or less manual. If the parameter is observed manually it is entered into a computer program and must be accepted by the automatic QC0 module before data can be transmissed.

Man. = manual QC
Aut. = automatic QC
Metar = QC at Metar stations

Line (L)	Element	Range check	Step check	Missing value check	Format / code check	Consist ency check	Spatial check	Comments
1	Precipitation (12h/6h)	Man.		Man.	Man. Aut. Metar	Man.		
3	Temperature	Man.		Man. Metar	Man. Aut. Metar	Man. Metar		
4	Clouds (N, Nh,CCC)	Man.		Metar	Man. Aut. Metar	Man. Metar		
5	Humidity (RH,TD,TW)	Man.		Man. Metar	Man. Aut. Metar	Man. Metar		
6	Pressure	Man. Metar		Metar	Man. Aut. Metar			
7	Wind	Man. Metar		Man. Metar	Man. Aut. Metar	Man. Metar		
8	Visibility	Man. Metar		Metar	Man. Aut. Metar	Man. Metar		
9	Weather (ww,W1, W2)	Man. Metar		Metar	Man. Aut. Metar	Man. Metar		
10	Snow	Man.			Man. Aut. Metar			
11	State of ground	Man.			Man. Aut. Metar			
12	Surface temp.	Man.			Man. Aut. Metar			
13	Grass temp	Man.		Man.	Man.			

QC0 at DMI

(4) QC0 at V98 automatic stations

A totally new design where all parameters are observed and checked automatically.
The first station was established in 1998.

Line (L)	Element	Range check	Step check	Missing value check	Format / code check	Consistency check	Spatial check	Comments
1	Precip. amount (1h)	Aut.	Aut.		Aut.	Aut.		
2	Precip. amount (6h/12h)	Aut.	Aut.		Aut.			
3	Temperature	Aut.	Aut.		Aut.			
4	Clouds (N, Nh, CCC)	Aut.			Aut.			
5	Humidity (RH, TD, TW)	Aut.	Aut.		Aut.			
6	Pressure	Aut.	Aut.		Aut.			
7	Wind	Aut.	Aut.		Aut.			
8	Visibility	Aut.			Aut.	Aut.		
9	Weather (ww,W1, W2)	Aut.			Aut.	Aut.		
10	Snow	Aut.			Aut.			
11	State of ground							
12	Surface temp.	Aut.	Aut.		Aut.			
13	Soil temp	Aut.	Aut.		Aut.			
14	Sunshine dur.	Aut.			Aut.			
15	Solar rad.	Aut.	Aut.		Aut.			

QC0 at DMI

(5) QC0 at aut_precip (tipping bucket) automatic precipitation stations

Line (L)	Element	Range check	Step check	Missing value check	Format / code check	Consistency check	Spatial check	Comments
1	Precipitation	x						
2	Temperature							
3	Clouds (N, Nh, CCC)							
4	Humidity (RH, TD, TW)							
5	Pressure							
6	Wind							
7	Visibility							
8	Weather (ww,W1, W2)							
9	Snow							
10	State of ground							
11	Surface temp.							
12	Soil temp							
13	Sunshine dur.							
14	Solar rad.							

QC1 at DMI

Line (L)	Element	Range check	Step check	Missing value check	Format / code check	Consistency check	Spatial check	Comments
1	Precipitation	x		x?	x	x		
2	Temperature	x		x	x	x		
3	Clouds (N, Nh, CCC)				x	x		
4	Humidity (RH,TD, TW)				x	x		
5	Pressure	x		x	x	x		
6	Wind	x		x	x	x		
7	Visibility				x	x		
8	Weather (ww,W1, W2)				x	x		
9	Snow				x	x		
10	State of ground							
11	Surface temp.							
12	Soil temp							
13	Sunshine dur.			x				
14	Solar rad.			x				

QC2 at DMI

Line (L)	Element	Range check	Step check	Missing value check	Format / code check	Consistency check	Spatial check	Comments
1	Precipitation							
2	Temperature						x	
3	Clouds (N, Nh, CCC)							
4	Humidity (RH,TD, TW)							
5	Pressure						x	
6	Wind						x	
7	Visibility							
8	Weather (ww,W1, W2)							
9	Snow							
10	State of ground							
11	Surface temp.							
12	Soil temp							
13	Sunshine dur.							
14	Solar rad.							

HQC at DMI

Line (L)	Element	Range check	Step check	Missing value check	Format / code check	Consistency check	Spatial check	Comments
1	Precipitation						x	
2	Temperature						x	
3	Clouds (N, Nh, CCC)							
4	Humidity (RH, TD, TW)						x	
5	Pressure						x	
6	Wind						x	
7	Visibility							
8	Weather (ww,W1, W2)						(x)	
9	Snow							
10	State of ground							
11	Surface temp.							
12	Soil temp							
13	Sunshine dur.							
14	Solar rad.							

QC0 at SMHI

Line (L)	Element	Range Check	Step check	Missing value check	Format / code check	Consistency check	Spatial check	Comments
1	Precipitation (12 h)				M	M		
	(24 h)					P		
2	Precipitation (automatic)	A VViS						
3	Temperature	A VViS				M		Special VViS control program
4	Clouds (N, Nh, CCC)	A				M		
5	Humidity (RH,TD, TW)	A VViS				M		
6	Pressure	A			M			
7	Wind	A VViS				M		
8	Visibility	A				M A		
9	Weather (ww,W1, W2)	A				M		
10	Snow	A						
11	State of ground							
12	Surface temp.	VViS						
13	Soil temp							
14	Sunshine dur.							
15	Solar rad.							

SMHI/ UF,CJ 2000-03-15
A = Automatic Weather Station
VViS = Automatic Weather Station belonging to the Swedish Road Company
M = Manuel weather station
P = Manuel climate station, observation sends by mail. When scanned the scanner is checking the sum against the sum written in the journal.

Observations from the manuel climate station are sending via Linewise and a very rough check is made by delivery.

QC1 at SMHI

Line (L)	Element	Range check	Step check	Missing value check	Format / code check	Consistency check	Spatial check	Comments
1	Precipitation (12 h)	X	X	X				
2	Precipitation (automatic)	X	X					
3	Temperature	X	X	X		X		
4	Clouds (N, Nh, CCC)			X	X	X		
5	Humidity (RH,TD, TW)	X	X	X		X		
6	Pressure	X	X	X	X	X		
7	Wind	X		X	X	X		
8	Visibility			X	X	X		
9	Weather (ww,W1, W2)			X	X	X		
10	Snow	X		X				
11	State of ground							
12	Surface temp.	X		X		X		
13	Soil temp							
14	Sunshine dur.							
15	Solar rad.							

SMHI/UF,CJ 00-03-15

QC2 at SMHI

Line (L)	Element	Range Check	Step check	Missing value check	Format / code check	Consistency check	Spatial check	Comments
1	Precipitation (12 h)	X		X 1)		X		Real time data
	(24 h)						X	All data
2	Precipitation (automatic)						X	Only 24 h data checked + Homogeneity test 5)
3	Temperature	X	X	X 1)		X		Real time data + Homogeneity test 5)
	Temperature					X 2)		Non real time data
4	Clouds (N, Nh, CCC)			X 1)		X		
5	Humidity (RH,TD, TW)	X	X	X 1)		X		
6	Pressure	X	X	X 1)		X 3)		+ Homogeneity test 5)
7	Wind	X	X	X 1)		X 4)		
8	Visibility	X		X 1)		X		Only manual stations
9	Weather (ww,W1, W2)	X		X 1)		X		Only manual stations
10	Snow	X	X	X		X		Real time data
11	State of ground			X				Only if snow exist but not state of ground
12	Surface temp.							
13	Soil temp							
14	Sunshine dur.	X		X				
15	Solar rad.	X		X		X		

2000-03-15/UF, CJ

1) If the observation exist but the parameter is missing 2) Against max and mintemp

3) Against presser tendency 4) Against maxwind

5) Hans Alexanderssons homogeneity test

HQC at SMHI

Line (L)	Element	Range Check	Step check	Missing value check	Format / code check	Consistency check	Spatial Check	Comments
1	Precipitation (12 h)	X		X		X		Real time data
	(24 h)						X	All data
2	Precipitation (automatic)						X	Only 24 h data checked
3	Temperature	X	X	X		X	X 1)	Real time data
	Temperature					X 2)	X 1)	Non real time data
4	Clouds (N, Nh, CCC)			X		X		
5	Humidity (RH,TD, TW)	X	X	X		X		
6	Pressure	X	X	X		X 3)	X 5)	
7	Wind	X	X	X		X 4)		
8	Visibility	X		X		X		Only manual stations
9	Weather (ww,W1, W2)	X		X		X		Only manual stations
10	Snow	X	X	X		X		Real time data
11	State of ground			X				Only if snow exist but not state of ground
12	Surface temp.							
13	Soil temp							
14	Sunshine dur.	X		X				
15	Solar rad.	X		X		X		

2000-03-15/UF,CJ

1) Monthly mean deviation. Tables with temperature differences of ($T_{max} – T_{12\ UTC}$), ($T_{min} – T_{6\ UTC}$), ($T_{12\ UTC} – T_{18\ UTC}$), ($T_{12\ UTC} – T_{6\ UTC}$) are compared.

2) Against max and mintemp

3) Against presser tendency

4) Against maxwind

5) Monthly mean deviation

QC0 at DNMI:

Line (L)	Element	range check	Step check	missing value check	format / code check	consistency check	spatial check	statistical check	Updated automatic	Comments
1	Precipitation (12 h)	PIO		PIO		PIO				PIO: Observations received in real time from manual stations, using a PC to transmit data to DNMI (13 stations). Values are corrected immediately by the observer. Controls in the PIO-registration program
	(24 h)									
	(1 h)									
2	Temperature TN, TX, TT, TD	PIO		PIO		PIO				
3	Humidity RH	PIO		PIO						A Observations received in real time from automatic stations / instruments (1 h) Has to be specified by our Instrument-department.
4	Snow SS	PIO								
5	State of ground	PIO								
6	Pressure P0,P,a,PP	PIO		PIO						
7	Clouds N, Nh, $C_LC_MC_H$	PIO				PIO				
8	Wind FF,FG,FX,DD	PIO				PIO				
9	Visibility	PIO				PIO				
10	Weather ww, W1, W2	PIO		PIO		PIO				
11	Weather elements	PIO				PIO				
12	Surface temp.	PIO								
13	Soil temp.									
14	Sunshine dur.									
15	Solar rad.									

QC1 at DNMI:

Line (L)	Element	range check	Step check	missing value check	format / code check	consistency check	spatial check	statistical check	Updated automatic	Comments
1	Precipitation (12 h)	PIO		X PIO	X PIO					X: Synop observations received in real time All range checks according to check-constraints in database (TELE table). Missing value checks are performed when entering data into the database. Range checks and some consistency checks are performed on GTS data according to “Meteorological Bulletin, Basic functional design for ECMWF’s Meteorological Operational System, M1.4/3”, resulting in confidence values for each parameter. These confidence values are not used in further QC of the observations, and not documented in this table. PIO: Observations received in real time from manual stations, using a PC to transmit data to DNMI (13 stations). **KLIBAS 48/99** PC i observasjonstjenesten: PIO_INN v.2.5
	(24 h)									
	(1 h)									
2	Temperature TN, TX, TT, TD	X PIO		X PIO	X PIO					
3	Humidity RH	PIO		X PIO	X PIO					
4	Snow SS	X PIO		X PIO	X PIO					
5	State of ground	PIO		X PIO	X PIO					
6	Pressure P0,P,a,PP	PIO		X PIO	X PIO					
7	Clouds N, Nh, $C_LC_MC_H$	X PIO		X PIO	X PIO					
8	Wind FF,FG,FX,DD	X PIO		X PIO	X PIO					
9	Visibility	X PIO		X PIO	X PIO					
10	Weather ww, W1, W2	X PIO		X PIO	X PIO					
11	Weather elements	PIO								
12	Surface temp.	X PIO		X PIO	X PIO					
13	Soil temp.									
14	Sunshine dur.									
15	Solar rad.									

QC2 (ALA (A), HLA) at DNMI:

Line (L)	Element	range check	Step check	missing value check	format / code check	consistency check	spatial check	statistical check	Updated automatic	Comments
1	Precipitation (12 h)	A	A	A	A	A				A: AWS 1-hour data loaded into the database twice a day. **A: KLIMA 30/99** Quality control for the DNMI Automatic Weather Stations: The AWS routine (MND2ALA program) **HLA: KLIMA 95/99** Automatic quality control in XVIND by VINDDEK v.1.1 **HLA: KLIMA 57/99** Restructuring control design in VIND_REG v.1.4
	(24 h)	A	A	A	A	A				
	(1 h)	A	A	A	A	A				
2	Temperature TN, TX, TT, TG	A	A	A	A	A				
3	Humidity RH	A	A	A	A	A				
4	Snow SS	A	A	A	A					
5	State of ground		A							
6	Pressure P0,P,a,PP	A	A	A	A	A				
7	Clouds N, Nh, $C_LC_MC_H$									
8	Wind FF,FG,FX,DD	A HLA	A	A HLA	A	A			HLA	
9	Visibility									
10	Weather ww, W1, W2									
11	Weather elements									
12	Surface temp.	A	A	A	A	A				
13	Soil temp.	A	A	A	A					
14	Sunshine dur.	A	A	A	A					
15	Solar rad.	A	A	A	A					

QC2 (TELE) at DNMI:

Line (L)	Element	range check	Step check	missing value check	format / code check	consistency check	spatial check	statistical check	Updated automatic
1	Precipitation (12 h)	X 1) 3)	X 1)	X 1) 2) 3)		X 2) 3)	X 2)		X 2) 4) 5) 7)
	(24 h)								
	(1 h)								
2	Temperature TN, TX, TT, TG	X 1) 3)		X 1) 2) 3)		X 2) 3)	X 2)		X 2) 3) 4) 5) 7)
3	Humidity RH	X 1) 3)		X 2) 3)					X 3) 5) 7)
4	Snow SS	X 1) 3)		X 1)					X 4)
5	State of ground								
6	Pressure P0,P,a,PP	X 1) 3)	X 1)	X 1)		X 3)			X 4) 5) 6) 7)
7	Clouds N, Nh, $C_L C_M C_H$	X 1)		X 1) 2) 3)					X 5) 7)
8	Wind FF,FG,FX,DD	X 1)		X 1)					X 4)
9	Visibility	X 1)							
10	Weather ww, W1, W2	X 1) 3)				X 3)			
11	Weather elements			X 1)					
12	Surface temp.	X 1)							
13	Soil temp.								
14	Sunshine dur.								
15	Solar rad.								

Comments

X: Synop stations, and synops aggregated from AWS

1) KLIMA 30/99
Quality control for the DNMI Automatic Weather Stations: The AWS routine
KLIBAS 77/99
Correcting wind formula for update in ALA2TELE v.1.2
(ALA2TELE)

2) KLIBAS 62/97
Automatic correction of SYNOP weather observations: CONTROL1, CONTROL2, INTERPOL3
(Of the temperature parameters only TN, TX is interpolated)

3) KLIBAS 91/99
Adding new temperature checks to S-T-F v. 2.7
(S-T-F program)

4) KLIBAS79/99
Adding logical interpolation of SS in INTERPOL3 v.1.3

5) KLIBAS 64/99
Interpolation of temperature TT in TELE by INTERPOL2 v.1.1
(Interpolating TX,TN,P0,P,N,UU,RR as well)

6) KLIBAS 66/99
Interpolating air pressure in TELE with INTERPOL_P0

7) KLIBAS 65/99
HIRLAM v.1.3: Interpolating in TELE with forecast data.
(Filling in values when INTERPOL2 or INTERPOL_P0 are not able to do so by statistical techniques)

Some range checks implemented as table constraints.

QC2 (N) at DNMI:

Line (L)	Element	range check	Step check	missing value check	format / code check	consistency check	spatial check	statistical check	Updated automatic	Comments
1	Precipitation (12 h)									1) KLIBAS 03/96 Description of the precipitation routine – ORACLE constraints performed when registering data into the database (first time or updated) and application constraints / checks Checking whether the whole observation (primary key) is missing. Run on weekly basis. 2) KLIBAS 01/95 Consistency checks between all parameters in the (one) observation (RR, SS, SD, weather element) with use of daily characteristic.
	(24 h)	N 1)		N 1)	N 1)	N 1) 2)				
	(1 h)									
2	Temperature TN, TX, TT, TG									
3	Humidity RH									
4	Snow SS	N 1)		N 1)		N 1) 2)				
5	State of ground	N 1)		N 1)		N 1) 2)				
6	Pressure P0,P,a,PP									
7	Clouds N, Nh, $C_L C_M C_H$									
8	Wind FF,FG,FX,DD									
9	Visibility									
10	Weather ww, W1, W2									
11	Weather elements	N 1)		N 1)		N 1) 2)				
12	Surface temp.									
13	Soil temp.									
14	Sunshine dur.									
15	Solar rad.									

QC2 (ALV) at DNMI:

Line (L)	Element	range check	Step check	missing value check	format / code check	consistency check	spatial check	statistical check	Updated automatic	Comments
1	Precipitation (12 h)	X 1.2)		X 2)		X 1.3)	X 1.4)			X: Manual synop stations, SAWS and Climate stations. **1) KLIBAS 10/96** Rutine for kvalitetskontroll av klimadata v.1..1 (1.1 CONT1) (1.2 CONT2) (1.3 CONT3) (1.4 LISTER1,2,3 Listings used in the HQC, showing different observed parameters) (1.5 RELFUKT – Listing used in the HQC, showing statistics for UU) (1.6 KONTHUM – Listing used in the HQC, showing UU related values) (1.7 TGTN – Listing used in the HQC, showing TG – TN) **2) KLIBAS 69/98** Test for completeness in data series by CONTSYN1 v.3.0 **3) KLIBAS 07/99** CONTSYN2 v.2.0: Some additional checks for the ALV routine
	(24 h)									
	(1 h)									
2	Temperature TN, TX, TT, TG	X 1.2)	X 1.7)	X 1.1) 2)	X 1.3)	X 1.2)	X 1.4)			
3	Humidity RH	X 1.2)	X 1.6)	X 1.1) 2)		X 1.2) 1.3)	X 1.4) 1.5)			
4	Snow SS					X 1.2) 1.3)	X 1.4)			
5	State of ground			X 1.1) 2)		X 1.3)	X 1.4)			
6	Pressure P0,P,a,PP	X 1.2)		X 1.1) 2)		X 1.2) 1.3)	X 1.4)			
7	Clouds N, Nh, CCC	X 1.2)		X 1.1) 2)		X 1.2) 1.3)	X 1.4)			
8	Wind FF,FG,FX,DD	X 1.2)		X 1.1) 2)		X 1.2) 1.3)	X 1.4)			
9	Visibility	X 1.2)		X 2)		X 1.2) 1.3) 3)	X 1.4)			
10	Weather ww, W1, W2	X 1.2)		X 1.1) 2)		X 1.2) 3)	X 1.4)			
11	Weather elements					X 1.2) 3)	X 1.4)			
12	Surface temp.			X 2			X 1.4)			
13	Soil temp.									
14	Sunshine dur.									
15	Solar rad.									

HQC at DNMI:

<table>
<tr><th>Line (L)</th><th>Element</th><th>range check</th><th>Step check</th><th>missing value check</th><th>format / code check</th><th>consistency check</th><th>spatial check</th><th>statistical check</th><th>Comments</th></tr>
<tr><td>1</td><td>Precipitation (12 h)</td><td colspan="7" rowspan="17">All suspected / wrong / missing data reported from QC2 on paper lists (ALV routine) are manually inspected and corrected / interpolated due to knowledge of the topography, earlier/later observations and observations from other neighbouring stations (manually inspected). The user-interface is a table-based registration-form on PC.</td><td rowspan="17">Observations received once a week (24 h precipitation, snowdepth / cover, weather elements from Precipitation stations. Controlled when registered, on weekly and monthly basis

Observations received in real time and once a month from manual stations. Manually controlled when registered and on monthly basis. Special routine (TELE) where observations are manually controlled on daily basis.</td></tr>
<tr><td></td><td>(24 h)</td></tr>
<tr><td></td><td>(1 h)</td></tr>
<tr><td>2</td><td>Temperature TN, TX, TT, TG</td></tr>
<tr><td>3</td><td>Humidity RH</td></tr>
<tr><td>4</td><td>Snow SS</td></tr>
<tr><td>5</td><td>State of ground</td></tr>
<tr><td>6</td><td>Pressure P0,P,a,PP</td></tr>
<tr><td>7</td><td>Clouds N, Nh, CCC</td></tr>
<tr><td>8</td><td>Wind FF,FG,FX,DD</td></tr>
<tr><td>9</td><td>Visibility</td></tr>
<tr><td>10</td><td>Weather ww, W1, W2</td></tr>
<tr><td>11</td><td>Weather elements</td></tr>
<tr><td>12</td><td>Surface temp.</td></tr>
<tr><td>13</td><td>Soil temp.</td></tr>
<tr><td>14</td><td>Sunshine dur.</td></tr>
<tr><td>15</td><td>Solar rad.</td></tr>
<tr><td></td><td>All AWS parameters</td><td colspan="7">Not manually corrected</td><td>Observations received in real time from automatic stations / instruments (1 h)</td></tr>
</table>

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(24 h)</td><td colspan="6" rowspan="13">All suspected / wrong / missing data reported from QC2 on paper lists (ALV routine) are manually inspected and corrected / interpolated due to knowledge of the topography, earlier/later observations and observations from other neighbouring stations (manually inspected). The user-interface is a table-based registration-form on PC.</td><td rowspan="3">Observations received once a week. Controlled when registered, on weekly and monthly basis</td></tr>
<tr><td>2</td><td>Snow (24 h)</td></tr>
<tr><td>3</td><td>Weather element (24 h)</td></tr>
<tr><td>4</td><td>Precipitation
(12 h)</td><td rowspan="10">Observations received in real time and once a month from manual stations.</td></tr>
<tr><td></td><td>Temperature TN, TX, TT</td></tr>
<tr><td></td><td>Humidity RH</td></tr>
<tr><td></td><td>Snow SS, SD</td></tr>
<tr><td></td><td>Pressure P0,P,a,PP</td></tr>
<tr><td></td><td>Clouds N</td></tr>
<tr><td></td><td>Wind FF,FG,FX,DD</td></tr>
<tr><td></td><td>Visibility</td></tr>
<tr><td></td><td>Weather ww, W1, W2</td></tr>
<tr><td></td><td>Weather elements</td></tr>
<tr><td></td><td></td><td colspan="6"></td><td></td></tr>
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