KVALOBS

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Kvalobs is the quality assurance system for observations at The Norwegian Meteorological Institute (met.no). See overview figure 1. The first runtime version was set in operation on 4 January 2005 after a five year specification and development process. The system will be updated and improved upon in the years to come.
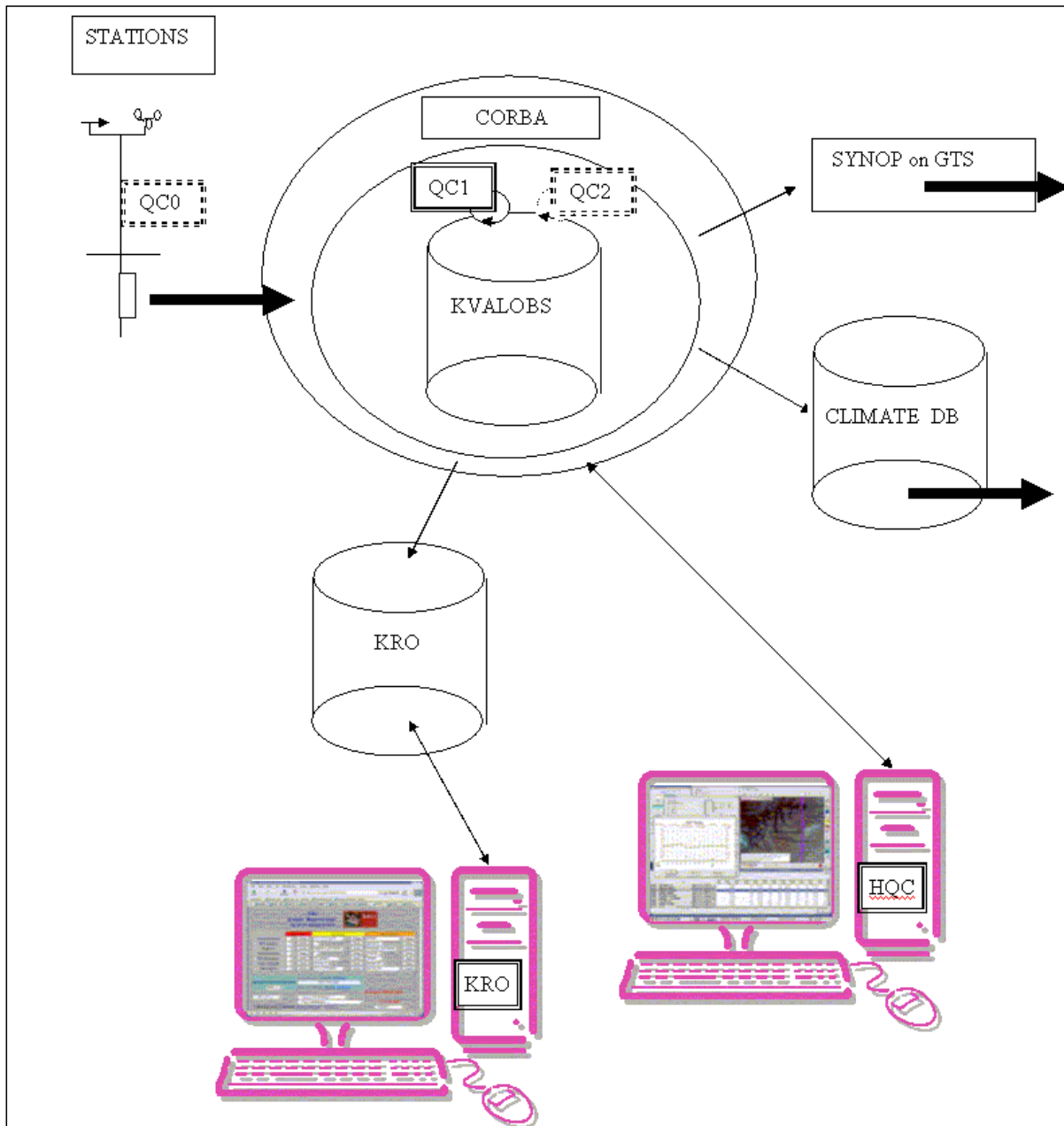

Figure 1. Kvalobs design overview. The arrows represent the data flow. The main input and output of observations in bold.

The institute is in the process of modernising the observation network. Development of an automated quality control system was necessary to enable rapid delivery of high quality data to users. The system was also designed to minimise human intervention and ensure mitigating activities taking effect as early as possible in the data flow process.

Central to the system is the automatic control system using the Kvalobs database. Messages from the stations are routed directly to the Kvalobs decoders. The message is parsed and controlled. Each observation or weather element contained within the message is separately stored in the database. While the observations is controlled, deficiencies as well as apparent or suspected errors are flagged accordingly. The expected messages that fail to arrive are detected 30 minutes past observation time. Before the first time use of the observation, only unphysical values are removed. When an expected message fails to arrive, the observation is marked as blank in the database for further substitution later, every entry pertinently flagged. All results are signalled to the subsequent user systems of which there are three: The SYNOP generator for direct distribution onto the GTS; The Climate Database for permanent storage; And the quality assurance message system KRO. The observations are subject to further control when additional reference material is available. After six months the data are automatically deleted from the Kvalobs database.

In parallel with the Kvalobs development new standard message formats have been introduced mainly to fit with the public GSM format restrictions [See TECO poster P1(17)].

Decoding

The formats decoded during the first version of Kvalobs are SYNOP/SHIP; Internal formats on messages from dial-up modems; Internal formats on the GSM net; Internal format on manual registrations or on batch file registrations. Other formats considered but not yet implemented are METAR messages, BUFR, and the DF22 file format in use by the offshore industry. Messages with syntactic errors are rejected for manual inspection and eventual correction by reentry in a corrected version.

Quality control

In the Nordic cooperation a nomenclature on quality control aspects has been discussed [1]. The term QC0 is applied to quality control at the station. QC1 is quality control at a central location before the first use of the observations. QC2 is quality control after the first use of the observations. HQC is human quality control which in Kvalobs is restricted to the period subsequent to the first use of the observations.

QC0 is the fixed set of procedures applied at each station. A feature of automatic feedback to the observers on errors received were discussed within the Kvalobs project, but was found undesirable. The errors will often be beyond the observer's control and feedback on these will only be demotivating. Rather than the automatic and direct feedback, routines on regular reports output from the automatic QC1 system manually edited will be developed.

All observations received are in Kvalobs subject to the automatic QC1. The result from the control is fed into the feedback system KRO.

The quality control system design

The quality control is fully database oriented. The control algorithms and their various attributes are parameterized in database tables. The framework software is compiled from C++ code and runs on Linux servers. The database engine is PostgreSQL [2]. PostgreSQL has shown high reliability, is an open source product and as such free of charge. A perl script interpreter is integrated in the system with the possibility to include other interpreters later. The four programs kvDataInputd, kvManagerd, kvQabased and kvServiced are run. The interface between these programs is arranged in CORBA. Also the systems outside are interfaced with CORBA allowing different priorities to different clients.
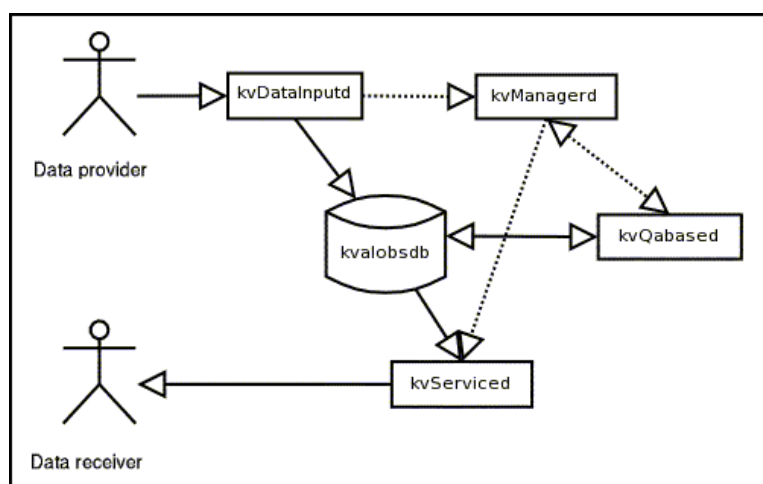

Figure 2. Schematic overview of control and data flow in Kvalobs. Fully drawn
       arrows show the data flow. Dotted arrows show control intervention.

Sequence of the quality control

Once the parameter identification is clear all checks relevant to the actual time and station are retrieved from the database. For every check firstly the basic script algorithm is retrieved from the database, then the specified observation data and model data are retrieved including reference observations, then all the check, station and parameter specific metadata are retrieved. From the different information elements a script is constructed and run. When the script terminates, flags and values are updated for one or more parameter and/or station.

In the first version of Kvalobs only QC1 is operational with

- range check on 94 parameters;
- step/freeze/drift check on 44 parameters;
- 181 formal consistency checks on 36 parameters;
- 97 climatological consistency checks on 19 parameters;
- comparison with numerical prognosis on 7 parameters;
- 2 checks on ship's position.

Details on the checks are available in a separate report [3].

Planned QC2 extensions will include

- dip check with automatic correction;
- statistical control, i.e. significant deviation from monthly frequency distribution relative to neighbouring stations';
- automated distribution of collected measurements, for example distribution of 72 hours precipitation measurements onto three 24 hours equivalents.

Additional checks are easily implemented. A testing environment was developed as an integral part of the system to enable easy verification of new checks.

Interpolation

There are always two observation values available for the end user: The observation as received from the station ("original") and an observation value considered best measuring the actual condition ("corrected"). In most instances the two values are identical. Otherwise the corrected values may be one of

- A short term HIRLAM prediction value;
- An interpolated value using the Akima algorithm [4];
- A missing value when the original is missing or rejected, and interpolation is inappropriate;
- A value manually entered using the HQC application.

During QC1 the HIRLAM values are available. Later when sufficient time has elapsed to enable interpolation the Akima algorithm is applied. Lastly during the HQC phase manual intervention may overrule the automatic substitution. Whenever a check or a manual operation has changed either values or flags the new information is transferred to the Climate Database for permanent storage. The end users will normally obtain their observation data from the Climate Database.

Human quality control (HQC)

An application with graphical user interface to the observations under scrutiny was developed. Data are displayed in a table and the interactive dialogue helps to filter out non essential information. From the table the observation data can be further displayed on a map using the GIS application module DIANA[5] in combination with model generated fields, satellite images, radar images and the subjective analysis. Independently from Kvalobs, DIANA is also the main tool used by the met.no forecasters to display all synoptic information available. A time series display is also available.
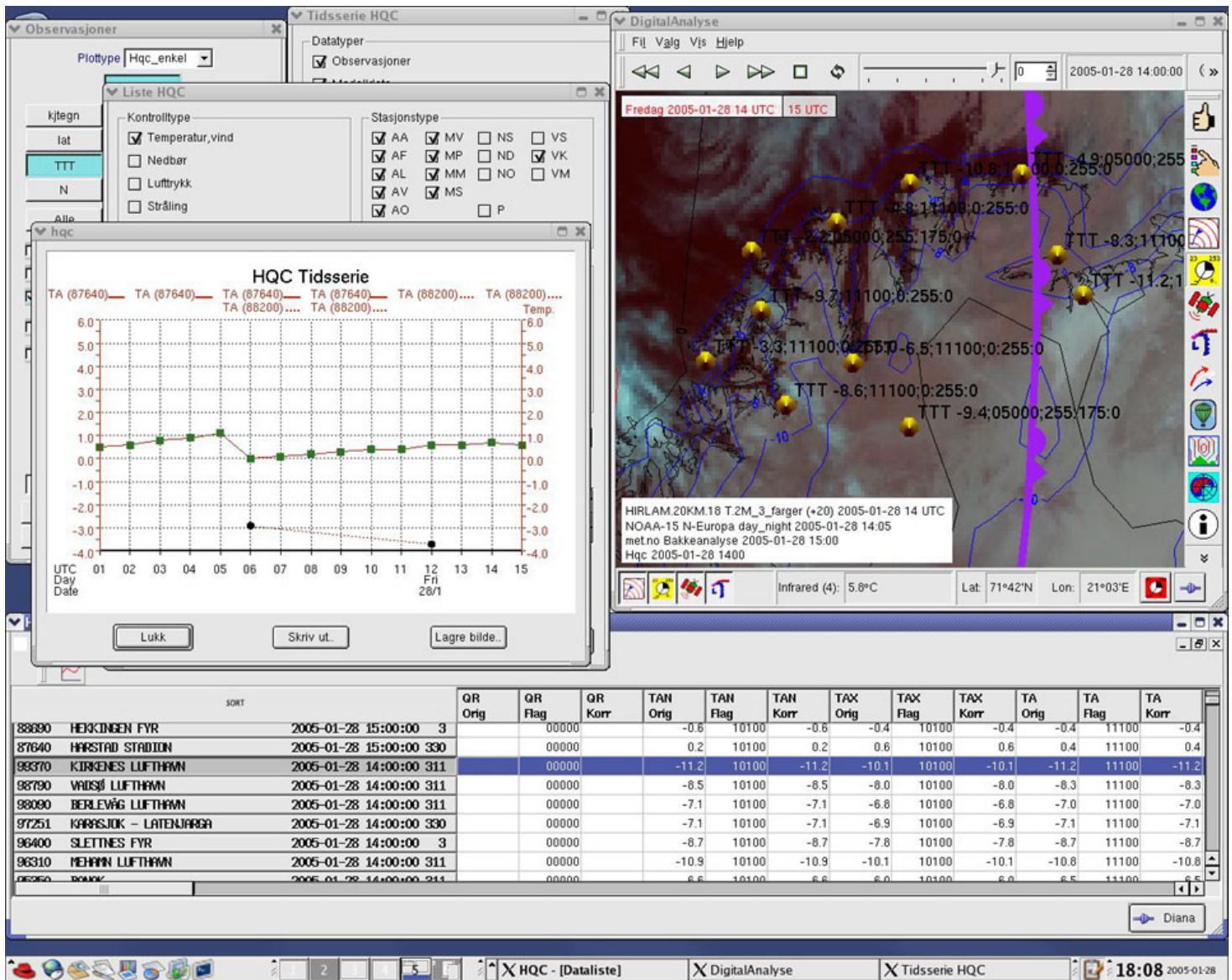

Figure 3. Sample screen capture of the HQC application with data table at the bottom. Map with observations and their flags displayed with HIRLAM isolines, NOAA satellite image and a front from the subjective analysis on upper right. Time series presentation is on the left. Part of the dialogue is also visible in the upper left.

Flags

Each control within the automatic control application has available a set of detailed control flags to indicate further action on suspected errors. Some of these are summarised to flags pertinent to end users' needs. The useflags implemented are in agreement with the NORKLIM recommendations [6].

Surveillance and service information

The feedback system KRO was developed in the Kvalobs project as a separate application. KRO has a separate database and a web interface as main features (figure 4). Firstly KRO is available to everybody connected to the internal net of met.no. The users can manually enter a message to the database on suspected errors with stations. Secondly the observers can send messages into KRO by using the GSM connection. Thirdly the automatic quality control system provides information that is aggregated into KRO messages on specific events of concern. In the first version of Kvalobs three events are dealt with:

- Messages failing to arrive; A text summarising the situation is generated when three or more subsequent messages fail to arrive;
- The precipitation gauge in need of being emptied; Repeated exceedance of a fixed alarm level;
- Sensor malfunction; Repeated errors in a number of connected parameters.

When a new KRO message is entered the station shows status "red" in the web interface. The station net service staff has authority on KRO to acknowledge the error and describe the action taken. When an action on error is described the status changes from "red" to "yellow". Another two options are available to the service staff. If the operator decides that no action is required the error message can be dismissed and the station status turned to "green". If the message is considered by the operator as information only it will remain visible additional to and separate from the error messages (figure 5).
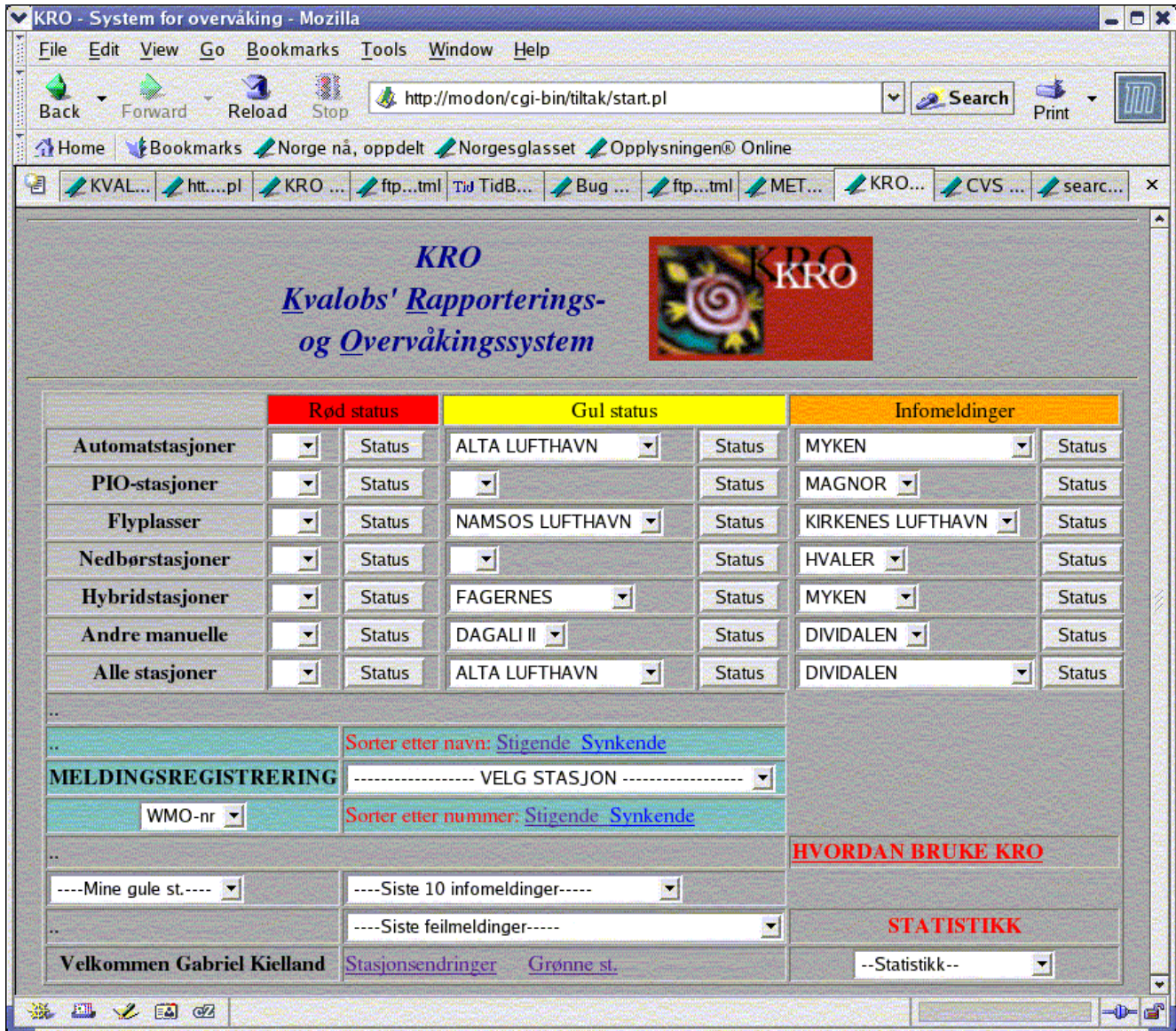

Figure 4. The KRO web interface available to all met.no staff.

Figure 5. Example of KRO station status screen with options available to the station net service staff. In the example there are four error messages. Three buttons are available: "Edit action description", "Error corrected" and "Move error message to information message".

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References:

[1] P. Rissanen et al. : "Nordic Methods for Quality Control of Climate Data". KLIMA Report 10/2000. The Norwegian Meteorological Institute.

[2] http://www.postgresql.org

[3] L. Andresen and G. Kielland : "Detailed specification of the Kvalobs control checks" The Norwegian Meteorological Institute 2005 (in preparation).

[4] H. Akima : "A New Method of Interpolation and Smooth Curve Fitting Based on Local Procedures". Journal of the ACM Vol. 17 #4 (October 1970).

[5] A. Christoffersen and E. Martinsen in Proceedings from ECMWF Ninth Workshop on Meteorological Operational Systems 10-14 November 2003 : "Operational visualisation systems at met.no"
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[6] L. Andresen et al. : "Quality Information of Meteorological Observations. Recommendations for a common Nordic end-user flagging system". KLIMA Report 11/2003. The Norwegian Meteorological Institute.