OPERATIONAL QUALITY CONTROL ON RAW DATA OF THE NEW SWISS GROUND-BASED MEASUREMENT NETWORK

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ABSTRACT

Among its duties, MeteoSwiss is responsible for the operation and maintenance of a meteorological and climatological network guaranteeing regular measurements on the entire Swiss territory. The ground-based network is currently being renewed by MeteoSwiss, under the project SwissMetNet. With this project, MeteoSwiss will have a state-of-the-art unified and secured network, composed of 130 automatic weather stations measuring ca. 20 meteorological parameters and 20 housekeeping values.

Instrumental quality control performed on the raw data (meteorological and housekeeping parameters) is assured at two levels. The first level performs plausibility tests online (real-time control), and delivers instantaneous alarms. The second level is a quality control performed operationally on a daily basis over the entire network, using the measured raw data from the past 90 days.

The aim of this second level control is to detect drifting time series due to instrumental problems, which are not seen by the first level control. The benefits of such a quality control are firstly to reduce the detection time for instrumental problems and to improve measurements' accuracy. This in turn avoids gaps in time series (and thus guarantees high data availability), improves know-how on measurements' techniques, and helps determining the operational MTBF for each sensor (optimizing spare parts inventory and on-site interventions). The presentation focuses on the development and operational implementation of this second quality control on raw data within SwissMetNet.

1   Introduction

MeteoSwiss, the Swiss Federal Office of Meteorology and Climatology, is currently building a new ground-based network of automatic weather stations, that will merge and replace all existing different networks over the Swiss territory. By the end of the project, 130 automatic weather stations will be connected, covering the entire country. This paper focuses on the quality control of the raw data measured by this new network [1]. The data flow within SMN is presented in chapter 2. An extensive description of the SMN project concept can be found in [2], [3] and [4]. Chapter 3 contains the description of the QC technique applied on the data, and chapter 4 some conclusions and future views.

2   SMN data flow

The raw data measured at the automatic stations (cf. Figure 1) are collected via an ADAS (Automatic Data Acquisition System) and transferred via a secured network of the Swiss

Confederation (BV-NET) to a Central Data Acquisition System (CDAS/NIMDAS). A firewall separates the BV-NET from the MeteoSwiss LAN, where the data are stored in the central data base of MeteoSwiss (DWH). An extract of the data base, containing all raw data collected by this network during the past 90 days (actualised once a day), is used to perform QC tests of Time series (QCT).
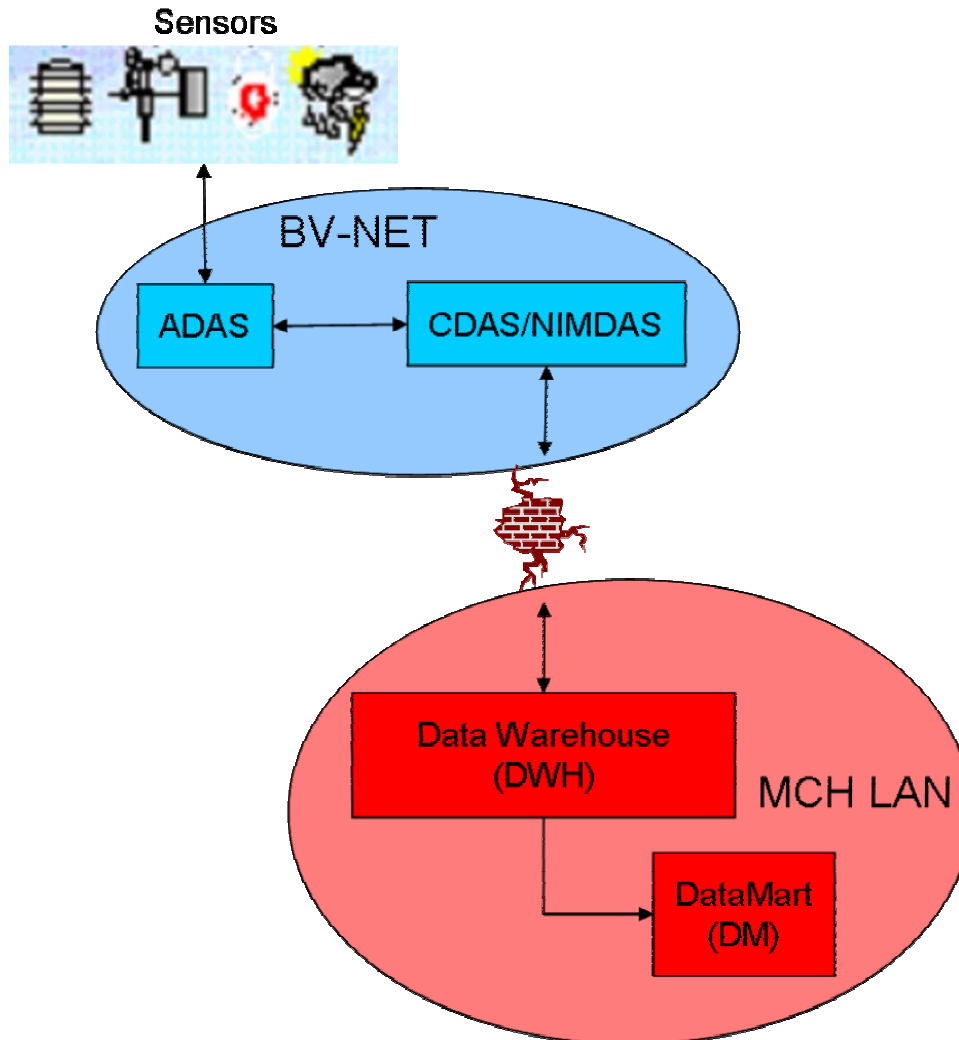

Figure 1 The SMN data flow architecture. Raw data are transferred via a secured network of the Swiss Confederation (BV-NET) through a firewall to the MeteoSwiss LAN, and stored in a central data base (DWH). The DataMart contains all raw data of the past 90 days from all stations of the SMN network, and is used to perform QC tests.

The sampling rate of most sensors used in SMN is 1 sec. Data are transferred on a 10 min average basis. A fully equipped SMN station delivers up to 20 meteorological and 20 housekeeping parameters including, for most of the parameters, minimum and maximum values during the 10 min interval, standard deviation and number of valid samples used for the average calculation (ideally 600).

3   QCT – Quality Control vs. Time

The first QC level of SMN measurements is performed in real time, and works mostly with predefined tolerance intervals. It is implemented in the MetConsole, which is the graphical device that allows visualisation of the entire network and measurements (cf. Figure 2).
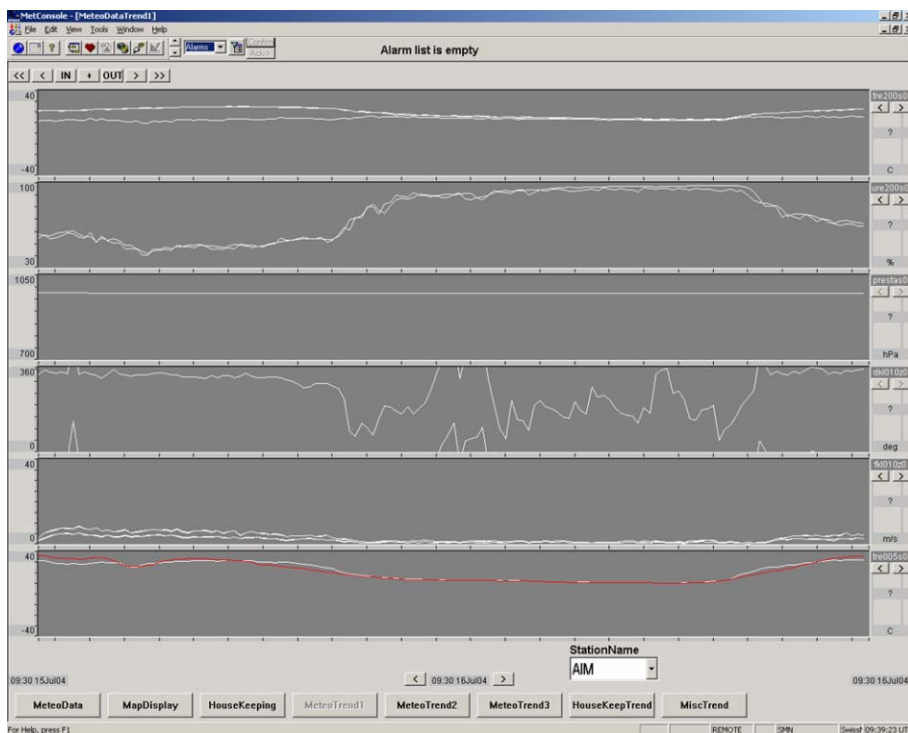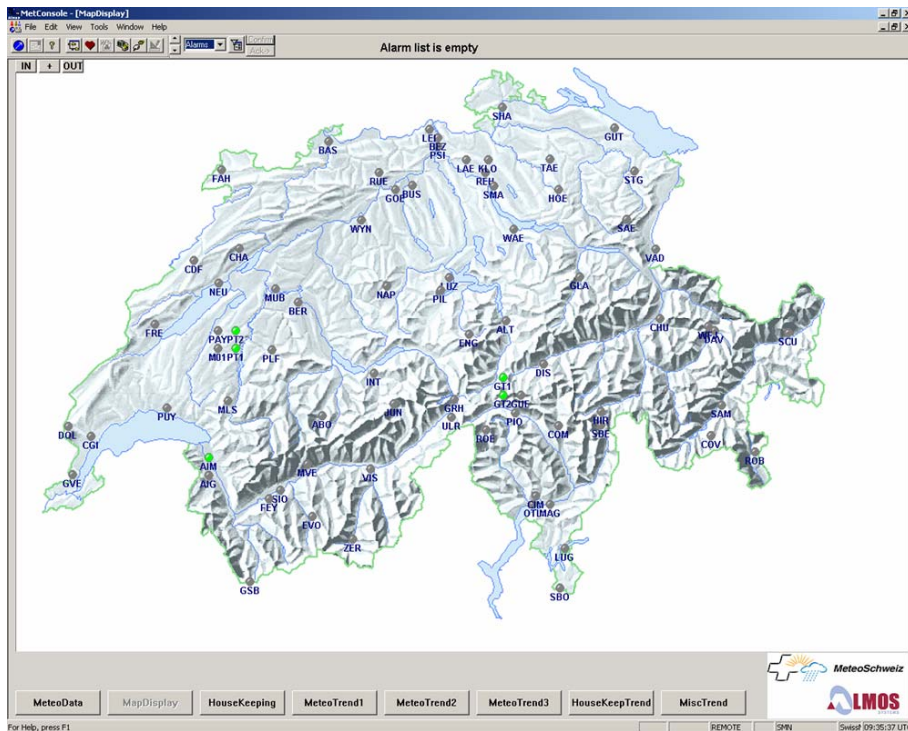
Figure 2 The MetConsole tool, which allows monitoring of the entire network by a first QC level in real time, and access on data series for the last 28 days (bottom).

The aim of applying QC procedures on time series (the second QC level for SMN) is to detect as quickly as possible drifts or trends in the measurements or the housekeeping data that are due to instrumental problems, and which can not be detected by the first level on-line QC (working only with the last measured value). The operational QCT tool runs on the principle of rules associating a QC procedure with an extract of the DM (cf. Figure 3). A rule is defined by a QC procedure and e.g. by a sensor and/or a parameter to which the procedure must be applied. Each rule defines search criteria (station type, instrument,

etc.). These criteria are applied to a meta-database describing the network configuration (position of each station, list of instruments mounted on each station, etc.), in order to extract data from the DM that fulfil the criteria.
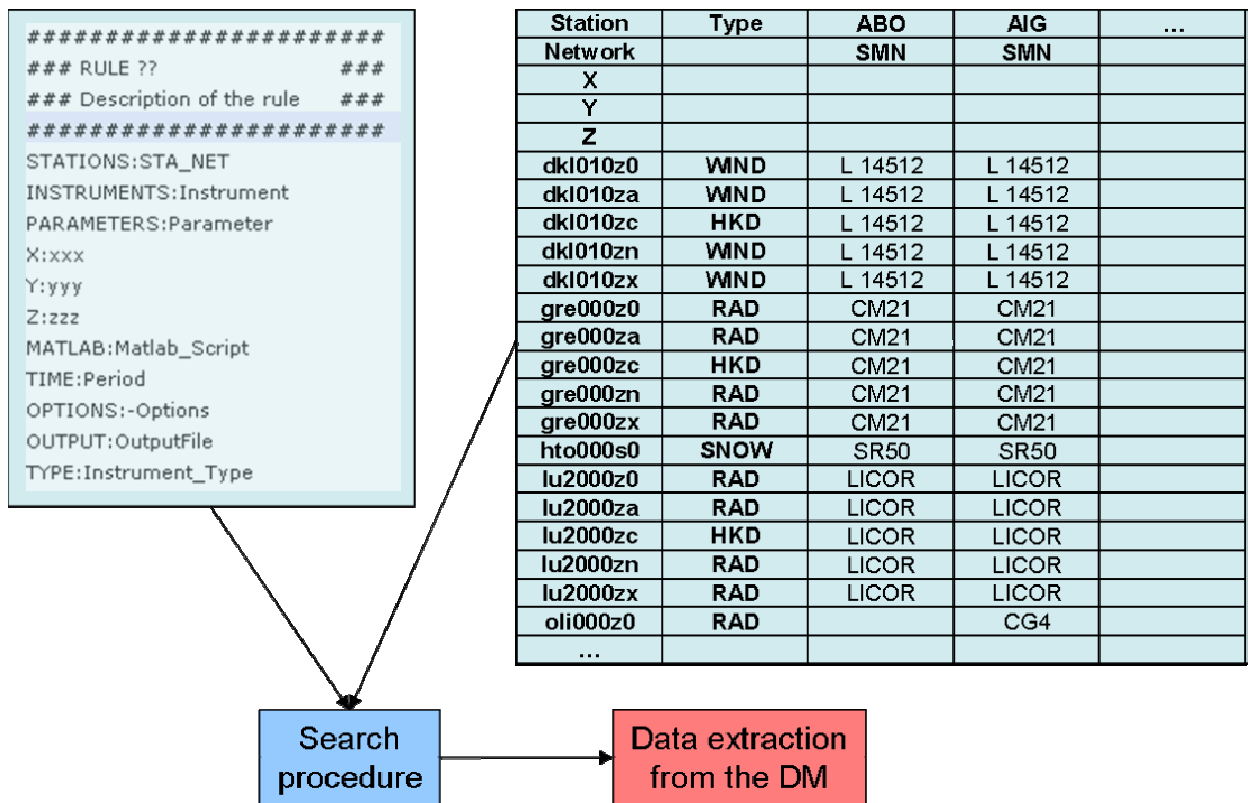
```
############################
### RULE ??              ###
### Description of the rule  ###
############################
STATIONS:STA_NET
INSTRUMENTS:Instrument
PARAMETERS:Parameter
X:xxx
Y:yyy
Z:zzz
MATLAB:Matlab_Script
TIME:Period
OPTIONS:-Options
OUTPUT:OutputFile
TYPE:Instrument_Type
```

Station	Type	ABO	AIG	...
Network		SMN	SMN	
X				
Y				
Z				
dkl010z0	WIND	L 14512	L 14512	
dkl010za	WIND	L 14512	L 14512	
dkl010zc	HKD	L 14512	L 14512	
dkl010zn	WIND	L 14512	L 14512	
dkl010zx	WIND	L 14512	L 14512	
gre000z0	RAD	CM21	CM21	
gre000za	RAD	CM21	CM21	
gre000zc	HKD	CM21	CM21	
gre000zn	RAD	CM21	CM21	
gre000zx	RAD	CM21	CM21	
hto000s0	SNOW	SR50	SR50	
lu2000z0	RAD	LICOR	LICOR	
lu2000za	RAD	LICOR	LICOR	
lu2000zc	HKD	LICOR	LICOR	
lu2000zn	RAD	LICOR	LICOR	
lu2000zx	RAD	LICOR	LICOR	
oli000z0	RAD		CG4	
...				

Search procedure → Data extraction from the DM

Figure 3 Procedure for data extraction: the search procedure (lower left box) is defined by a rule (upper left box) and the meta-database of the network configuration (upper right box). The latter lists sensor types (e.g. CM21), associated with a parameter name (e.g. gre000z0 for global radiation), that are mounted in each station (e.g. AIG)

This selection and extraction process, coupled with a test procedure, is repeated for each measured parameter of a station. In turn, a loop is implemented over all stations of the network (cf. Figure 4). At the end, all parameters of all stations have been quality checked. Each parameter which does not fulfil the defined QC criteria is listed in an Alarm Database, containing information on the parameter, the station and the observed value of the criteria. This list of alarms is generated once a day, after QC on the entire network has been performed. It is transmitted via email to the network monitoring team for further intervention. This Alarm Database allows firstly to initiate the necessary maintenance and repair of the problematic sensors, and secondly to perform statistics on failure and breakdown of each network component.

This QCT system runs automatically on an operational basis every night. The core program which drives the selection and extraction of the data, the calls to QC procedures and the Alarm Database is written in Perl. All QC procedures are written in Matlab.

The tests performed in QCT are applied on 90 days time series. Several tests categories are applied, among them statistics on available data (tolerance interval for number of missing values in the past 7 days, comparison against the rest of the period), time evolution of the correlation of two parameters (e.g. global radiation and luminosity) or of two different measurements of one parameter (e.g. redundant measurement for

temperature), tolerance interval for housekeeping data, such as battery voltage or power alimentation.
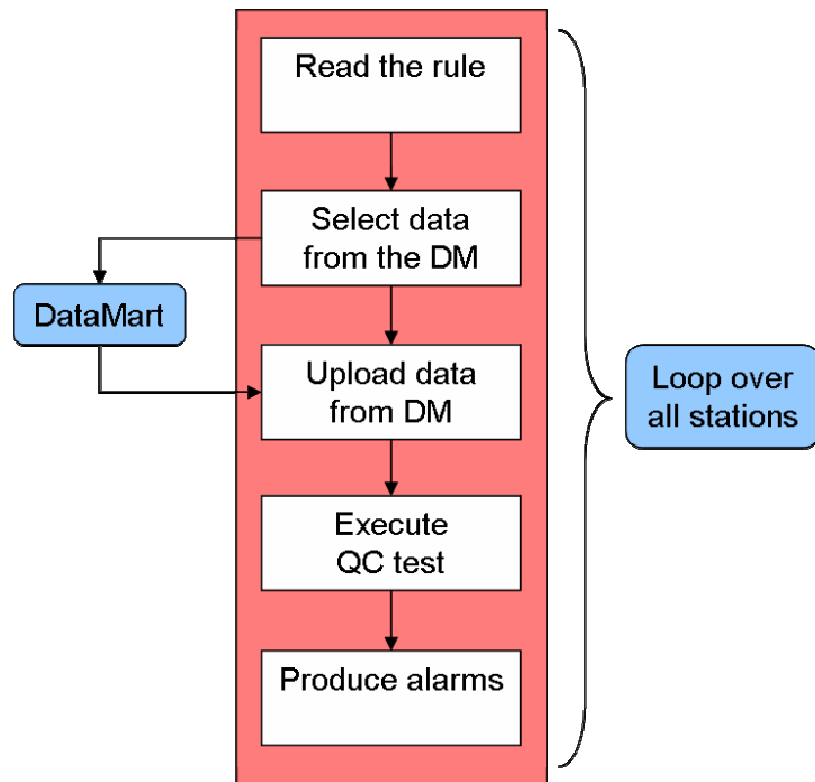

Figure 4 Loop over all stations of the network of all QC procedures, and production of alarms.

4   Conclusions and perspectives

The QCT tool has proven to be extremely useful for network monitoring. It is an appropriate complement to the first level on-line QC, which improves reaction time for network maintenance.

Future developments on QCT include a graphical visualisation of the alarms, in the form of an interactive map with all stations in colour codes, as it is already in operation for the MetConsole (cf. Figure 2), green dot meaning "no problem detected" and red dot meaning "problem on one or more instruments", and the possibility to see the QCT results for each station by clicking on the dot.
The network configuration database will allow to refine search criteria, and to apply very specific QCT procedures on a specific part of the network (e.g. develop a test for wind measurements performed by a Lambrecht at stations located above 1500 m asl).

The development of a third QC level will include the spatial dimension (QCS), and check one station by comparing its measurements with neighbour stations.

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