QUALITY MANAGEMENT, CALIBRATION, TESTING AND COMPARISON OF INSTRUMENTS AND OBSERVING SYSTEMS

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Introduction

The Direction of Observing Systems (DSO) of Météo-France and Météo-France have been recently quality certified in reference to ISO 9001-2000 standard. Some aspects in relation with quality management of surface observation will be presented.

An explicit identification of the uncertainty objectives related to users requirements has been done. Then, indicators have been defined, calculated and analyzed.
Considering instrumentation, the control of calibration is necessary to guarantee the required performances. And to set the required performances, it is necessary to know the characteristics of the instruments available on the market. Testing and intercomparisons are a very objective tools to know these performances and the state of the art of various instruments.
Several intercomparisons are planned within CIMO and will be presented.

Identification of uncertainty objectives

The quality certification forces us to explicitly define the uncertainty objectives of an observing network. Thus, the users know the uncertainty associated with the various measurements.
First, an explicit identification of the users was necessary. The most common users of observation are the forecasters and the climatologists. Apart these internal users (internal to a Met. Service), we found that there are few other direct users of observation data (numerical models are considered to be covered by the forecasters' category). A special case is the aeronautic users, thru METAR/SPECI and local reports. These needs are clearly defined by Annex 3 of ICAO.
To get an answer about their needs from forecasters and climatologists is not so easy, when the subject is the uncertainty of measurement. These categories of meteorologists are not always aware of the uncertainty of measurements. Therefore, a common answer is to apply the WMO/CIMO (doc n°8, chapter 1) required measurement uncertainties, which are a synthesis of the users requirement, obtained thru discussions of different group of users, within WMO. These requirements are not always achievable and annex 1B of the CIMO guide indicates the achievable measurement uncertainty. This achievable measurement uncertainty is the best that can be obtained. It may not be the case for a given network, if the instruments are not the "best" instruments possible, with the "best" calibration procedures.
It may also be the choice of a Met. Service to look for reduced performances, for a question of cost and as a result of a value analysis.
Once the uncertainty objectives are set, the achievement of this uncertainty in an operational network must be demonstrated, both thru the procedures applied and specific indicators. In fact, the analysis of error sources to demonstrate the achievement can lead to change the objectives, in order to be able to respect them, in limited conditions of budget and staff.
For example, for his proprietary Radome network, Météo-France has set the following objectives, some are less ambitious that the achievable measurement uncertainty stated by the CIMO Guide:
Uncertainty of 0.5 hPa for pressure, 6% for relative humidity, 0.5°C for air temperature, 10% for wind speed, 5 to 10% for quantity of precipitation, 5% for daily amount of solar radiation.

Quality indicators

Once the objectives are known, it is necessary to define indicators to measure the effective status of the observing systems. To define an indicator is not always easy, especially when quality management is new for a Met. Service. Indicators must be simple and easy to interpret. They are here to measure the reach of the objectives and to help to identify and to solve the problems.
The final measurement uncertainty in the field is difficult to measure. It depends on the known characteristics of the instrument and the maintenance and calibration procedures. Therefore indicators selected by Météo-France are:

- Percentage of sensors calibrated in the stated delay. Our objective in France is 90%. The periodicity is defined for each sensor. For example, the nominal period for hygrometers is 12 months, with a maximum tolerance of 3 months (so, the hygrometers must be calibrated before 15 months since the last calibration).
- Percentage of sensors found outside stated limit, during the calibration process. These limits are larger than the limits used to adjust a sensor. For example, a hygrometer is adjusted in laboratory, when a control point differs more than 2.5% from the reference. A hygrometer is considered has being outside an Acceptable User Limit, when a control point differs more than 5% from the reference. The climatological service is then informed that the hygrometer was found outside these limits during the last calibration. It is considered that no correction can be applied on past-recorded data, but the data can be flagged. With a 5% limit, about 10% of hygrometers of the Météo-France network are flagged! And we don't think to be so bad in managing our network.
- Percentage of sensors for which the periodicity of preventive maintenance are respected. This periodicity is defined so that the objective for uncertainty is theoretically respected.

Another aspect important for the users is the availability of data. Météo-France has defined two indicators, one for forecasters interested with real time data and one for climatologists interested by the completeness of the database. For the Radome network, our objectives are:

- 95% of expected (hourly) data available for the end user in less than 10 minutes. This objective is hard to reach, mainly for transmissions' delays. The messages from the observing stations are available in one minute or few minutes, but there are many steps between the station itself and the final central database. Establishing the indicator counting the % of data available in less than 10 minutes has illustrated some delays and bottlenecks in the global process, which have been solved. It was just necessary to calculate the indicator to discover some solvable problems.
- 98% of expected (hourly) data available in the climatological database, in a delay of 24 hours. Here the delays that may occur in the transmission process are not taken into account. This indicator mainly represents the level of good running of the network, taking into account the failure and time of repair.

These indicators are just some examples for quality management.
Quality management is also concerned by validation procedures and software at different levels: the acquisition system itself, temporal consistency of data, spatial consistency of data, comparison with climatological values, etc. Will Wauben, KNMI, will present some of these techniques.

Testing and comparison of instruments

The analysis process leading to the definition of the uncertainty objectives of a network is greatly made easier by knowledge of the instruments on the market and their characteristics. Test reports are a great help for this, but testing instruments requires staff, skill and time. The current tendency in several Met. Services is to reduce such activities, which are not always considered as essential for a Met. Service, when compared to forecast. Test reports from other Met. Services are not always made available. WMO/CIMO has an interesting Web Portal on Development, Maintenance and Operation of Instruments, Observing Methods and AWS, available from the CIMO Web page.

WMO intercomparisons are very useful tools to know more about the instruments on the market, with a knowledge about the limitations and the characteristics of the instruments. Few intercomparisons are organized because they are time consuming and rely on the willingness of some WMO state members to organize them. The workload is quite high.
In the framework of the Upper Air Working group, several Radiosonde Intercomparisons have been held, the last one in Mauritius.
WMO/CIMO has set up an Expert Team on Surface-based Instrument Intercomparisons and Calibration Methods (ET on SBII&CM) to organize intercomparisons required or suggested by CIMO.
Recently, a laboratory Intercomparison of RI (Rainfall Intensity) gauges has been held in 2004-2005, in three laboratories: University of Genoa, Italy; DeBilt, KNMI; Trappes Météo-France. This intercomparison and the results obtain will be presented by Prof. Lanza. The final report is available on the WMO/CIMO web site.
Following this laboratory intercomparison, a WMO field Intercomparison of RI Measuring Instruments will be held in 2007-2008, in Vigna di Valle, close to Roma, Italy. Participating instruments have been selected: Tipping bucket rain gauges, weighing rain gauges, siphon rain gauges, optical disdrometers, optical present weather sensor, acoustic detector, Doppler radar.
Another intercomparison is in preparation: a WMO Intercomparison of Thermometer Screens/Shields in conjunction with Humidity Measurements will be held in 2007, in Ghardaïa, Algeria. This site offers desert conditions, where screen intercomparisons have not yet be held and documented. Participating instruments have been selected: naturally ventilated screens of different types (multiplates, Stevenson types), several designs of artificially ventilated screens, capacitive hygrometers, several dew point hygrometers of different design.

Conclusion

Quality management and ISO 9001-2000 certification force us to explicit the uncertainty targeted and reached by the observing networks. The organization of maintenance and calibration must demonstrate the control of the network, thru the procedures applied and various indicators.