DOCUMENTATION OF SURFACE OBSERVATION. CLASSIFICATION FOR SITING AND PERFORMANCE CHARACTERISTICS

Michel Leroy
Météo-France, BP202, 78195 Trappes Cedex, France
Tel : +33 130135405   Fax : +33 130136020   michel.leroy@meteo.fr

ABSTRACT

WMO/CIMO has clear recommendations about siting and exposure of instruments. But they are not always possible to follow. To take this aspect into account, at the occasion of the installation of the RADOME network, Meteo-France defined a site classification (for each parameter, such as wind, temperature, precipitation, solar radiation) ranging from 1 (WMO recommendations) to 5 (what should not be done at all).

Apart his automatic proprietary RADOME network, Meteo-France is also using data from many stations, ranging from automatic stations operated by other organisms to climatological stations operated by voluntary observers. The reality is that many of these stations are not following the WMO siting recommendations. Therefore, the site classification of these about 4000 stations is on going and should be finished at the end of 2008. An update of the classification is planned at least every 5 years.

Considering also the various metrological characteristics of the equipment used in these stations, Meteo-France defined another classification, called "maintained performance classification", including the uncertainty of the instrument and the periodicity of preventive maintenance and calibration. This classification ranges from A (instrument following the WMO/CIMO recommendations) to D (unknown characteristics and maintenance). This classification is related to a network, considering the instruments used and the maintenance organization applied for this network.

With these two classifications, a letter and a number therefore describe a measurement on a given site. For example : C3 for global solar radiation is for a class 2 pyranometers without ventilation, calibrated every 2 years, installed on a site with direct obstructions, but below 7°.

These classifications will be presented. They are intended to describe the real world of measuring networks, which is sometimes far from the WMO/CIMO recommendations. The interest of such classifications within CIMO could be considered.

INTRODUCTION

At the occasion of the installation of numerous automatic weather stations (AWS deployed for the RADOME network), Meteo-France defined and used a classification to document the nearby site environment.
Later, as a part of the work to get the Iso 9000-2000 certification, an additional documentation of the performance characteristics of various surface-observing networks has been defined.

QUALITY OF A MEASUREMENT

Quality is the ability to satisfy implicit or explicit needs. For meteorological measurements, this is often translated to a statement of operational accuracy requirements. Several factors have an influence on the « quality » of a measurement; one can quote:

a) The intrinsic characteristics of sensors or measurement methods.
   They are coming from technical specifications, emitted by technical services, users or manufacturers. These characteristics are commonly described by the manufacturers, sometimes controlled during intercomparisons and are generally well known and mastered, at least for the classic measurements which we are dealing with. Météo-France has been traditionally dealing with this aspect.
b) The maintenance tasks (including calibration) needed to maintain the system in nominal conditions.
   These operations are often expensive and necessitate a continuous effort. Preventive maintenance is the best guaranty to maintain a system close to its nominal performance, allowing final measurements to be close to the « intrinsic » performances of the sensor. Our experience shows that this maintenance is not always well mastered in case of a dense network.
c) The site representativity and therefore the measurement representativity.

SITE REPRESENTATIVITY

This representativity is sometimes neglected, especially when the density of a network is increasing. The people selecting a site know the exposure rules, but numerous logistic constraints exist. For cost and availability considerations, the measurement system is often (at least in France) hosted on a site not belonging to the owner (or the administrator) of the network. The access to the site, its supervision, and the availability of telephone and power lines are important elements. These logistic aspects, and also the orography, may surpass the strict application of exposure rules, quite restricting, especially for wind measurements (at least 10 times the height of nearby obstacles, which exclude nearby trees or buildings). A compromise is often selected. But when the rules are not applied, there may be no limits. Who have not ever seen anemometers close to high trees?

In 1998, Meteo-France defined a classification for some basic surface variables to document the nearby environment of a site. This classification ranges from 1 to 5. By convention, a class 1 site follows the WMO recommendations. A class 5 site is a site where nearby obstacles create an inappropriate environment for a meteorological measurement and where measurements must be avoided.
For some classes, an estimation of the possible associated errors or perturbations has been indicated. This estimation is coming from bibliographic studies and/or some comparative tests.
A classification is defined for air temperature measurement, relative humidity, wind, precipitation, and solar radiation.
This classification has been presented during TECO1998 and is not presented here in details.

Between 2000 and 2006, Meteo-France installed 400 AWS in the framework of the RADOME program. The basic set of measurements includes air temperature, relative humidity, wind at 10 m,

and quantity of precipitation. Additional measurements of soil temperature and/or global solar radiation sometimes exist. The selection of the sites made a systematic use of our site classification. The objective was to set up the AWS in site with a class 1 for all the parameters, but up to class 3 was accepted when a better class was not possible. In extreme cases, few derogations were accepted, for class 4 or even class 5, or for not installing a sensor with an inadequate exposition.
These decisions were not ideal, but they were realistic, considering the field reality. Nevertheless, applying this classification allowed the setup of the network with a rather good compromise.

Apart this Radome network, Meteo-France also uses observations from other AWS networks (not belonging to Meteo-France) and from basic climatologic sites, with daily human readings. The classification of these about 3500 sites is on going and must be conducted before the end of 2008. It was also decided to update each site classification every 5 years or earlier, if a routine visit shows a change in the environment. The results are included in the climatological data base (as metadata), with their historical changes. Pictures of the site are also archived.
The classification is mainly based on the angles under which the nearby obstacles are seen from each sensor. Their distance or height is also necessary for wind measurements. Therefore precise measurement of site angles may be necessary, which may require optical instruments. Binoculars, with laser telemetry and magnetic compass, allow the measurement of distance, site and azimuth, for each target (obstacle). But the number of such instruments used by Meteo-France is limited, due to their cost (about 10 000 €). In many cases, especially when no wind measurements are made, a single visual inspection is enough to classify a site. Wood triangles, with angles of 14, 26.6 and 45°, corresponding to the angle of sight of obstacles located at a distance of 4, 2 and 1 times their height, are used as a help. When there is a doubt, the binoculars (or an optical theodolite) are used.
Knowing this classification increases the value of the data. Users may consider the use of data, according to their needs and the "representativeness" of each site. This is now used if France for climatological studies, not (yet?) for weather forecasts.

MAINTAINED PERFORMANCE

Another primary quality factor of a measurement is the set of "intrinsic" characteristics of the equipment used. They are the characteristics related to the design of the instrument. They are known from the manufacturer documentation and/or from laboratory or field tests. The actual performances are sometimes worst that the announced performances, depending on the "objectivity" of the manufacturer. The statement of achievable measurement uncertainty included in Chapter 1 of doc WMO n° 8 (Guide to Meteorological Instruments and Methods of Observation) should be used to check the possible validity of uncertainty announced by a manufacturer. When writing technical specifications to buy equipment, it is necessary to have in mind the achievable measurement uncertainty, recognizing also that even requesting (only) the state of the art achievable uncertainty may result in high costs and/or some exaggeration of their instrument performances from some manufacturers. Therefore, it is highly recommended to be aware of the possible performances (with associated costs) before issuing technical specifications. A value analysis may conduct to look for performances lower than the "required measurement uncertainty" and the "achievable measurement uncertainty" found in Annex 1B of WMO n° 8.
Test reports and intercomparison reports of instruments are very valuable tools to specify and select an instrument with objective information.

Once an instrument is selected and its performance characteristics known, it is necessary to maintain the level of performance during its operational period. Preventive maintenance and calibration are therefore necessary and must be identified to maintain the desired measurement uncertainty.
When delivering observations for various applications (mainly forecasts and climatology), it should be possible to state the "guaranteed" (for example with a 95% level of confidence) accuracy of a

measurement. It is not always done and using "by default" the "achievable measurement uncertainty" of WMO n°8, Annex 1B could be a mistake.
The required accuracy of the Radome network has been stated, the instruments selected accordingly and the maintenance and calibration organized. Doing this, the performances are known and documented. They are generally less stringent than the WMO operational measurement uncertainty requirements.

In addition to his proprietary Radome network, Meteo-France also uses observations from other AWS networks (not belonging to Meteo-France) and from basic climatologic sites. The instruments used in such networks are often different that the instruments specified and selected for Radome. Therefore, their performances are often lower. Nevertheless, their data was used for climatological and forecasting applications, generally without considering the "quality" of the network. This is not satisfactory and the "quality" of the observations has to be taken into account, when in an ISO9000 process.

In order to document the performance characteristics of the various surface observing networks used, Meteo-France defined another classification, called "maintained performance classification", including the uncertainty of the instrument and the periodicity of preventive maintenance and calibration. This classification ranges from A (instrument following the WMO/CIMO recommendations) to D (unknown characteristics and maintenance). This classification is related to a network, considering the instruments used and the maintenance organization applied for this network.
This classification covers the factors a) and b) listed above.

The four levels are:

- Class A: WMO/CIMO recommendations.
- Class B: Specifications lower than WMO recommendations. Specifications followed by Radome, when the Radome spec. are lower than the WMO recommendations. Maintenance and calibration applied for the Radome network.
- Class C: Specifications and/or maintenance and calibration procedures lower than class B, but known and applied.
- Class D: Unknown performances and/or maintenance and calibration not organized.

It is easier to understand with the more detailed definitions, for some parameters.

<u>Air temperature</u>

- Class A: Overall uncertainty of 0.1°C. Therefore, the uncertainty of the temperature probe lower than 0.1°C and use of a "perfect" artificially ventilated screen.
- Class B: Pt100 (or Pt1000) temperature probe of class A (± 0.25°C). Acquisition uncertainty < 0.15°C. Radiation screen with known characteristics and over-estimation of Tx (daily max. temperature) < 0.15°C in 95% of cases. Laboratory calibration of the temperature probe every 5 years.
- Class C: Temperature probe with uncertainty < 0.4°C. Acquisition uncertainty < 0.3°C. Radiation screen with known characteristics and over-estimation of Tx < 0.3°C in 95% of cases.
- Class D: Temperature probe and/or acquisition system uncertainty lower than for class C or unknown. Unknown radiation screen or with "unacceptable" characteristics (for example, over-estimation of Tx > 0.7°C in 5% of cases).

<u>Relative humidity</u>

- Class A: Overall uncertainty of 1%!

- Class B: Sensor specified for ± 6%, over a temperature range of –20°C to +40°C. Acquisition uncertainty < 1%. Calibration every year, in an accredited laboratory.
- Class C: Sensor specified for ± 10%, over a temperature range of –20°C to +40°C. Acquisition uncertainty < 1%. Calibration every two years in an accredited laboratory, or calibration every year in a non-accredited laboratory.
- Class D: Sensor with unknown performances or specifications worst than ± 10% over the common temperature conditions. Unknown calibration or calibration not organized.

Solar global radiation

- Class A: Pyranometer of ISO class 1. Uncertainty of 5% for daily total. Ventilated sensor. Calibration every two years. Regular cleaning of the sensor (at least weekly).
- Class B: Pyranometer of ISO class 1. No ventilation. Calibration every two years. No regular cleaning of the sensor.
- Class C: Pyranometer of ISO class 2. No ventilation. Calibration every five years. No regular cleaning of the sensor.
- Class D: Sensor with unknown performances or sensor not using a thermopile. Unknown calibration or calibration not organized.

Classes are also defined for pressure, precipitation (accumulation), wind, visibility, and temperature above or under ground.
The classes for the Radome network are class B for air temperature, relative humidity, precipitation amount, pressure, wind, visibility. Global solar radiation is of class A or B, depending on the sites.

CONCLUSION

With these two classifications, a letter and a number therefore describe a measurement on a given site. For example: C3 for global solar radiation is for a class 2 pyranometer without ventilation, calibrated every 2 years, installed on a site with direct obstructions, but below 7°.

These classifications are intended to describe the real world of measuring networks, which is sometimes far from the WMO/CIMO recommendations. The interest of such classifications within CIMO could be considered.