W O R L D   M E T E O R O L O G I C A L   O R G A N I Z A T I O N

COMMISSION FOR INSTRUMENTS AND METHODS OF OBSERVATION

AD-HOC WORKING GROUP ON WIGOS PILOT PROJECT
Third Session

Geneva, Switzerland

8 – 9 October 2009

FINAL REPORT

WMO General Regulations 42 and 43

Regulation 42

Recommendations of working groups shall have no status within the Organization until they have been approved by the responsible constituent body. In the case of joint working groups, the recommendations must be concurred with by the presidents of the constituent bodies concerned before being submitted to the designated constituent body.

Regulation 43

In the case of a recommendation made by a working group between sessions of the responsible constituent body, either in a session of a working group or by correspondence, the president of the body may, as an exceptional measure, approve the recommendation on behalf of the constituent body when the matter is, in his opinion, urgent, and does not appear to imply new obligations for Members. He may then submit this recommendation for adoption by the Executive Council or to the President of the Organization for action in accordance with Regulation 9(5).

EXECUTIVE SUMMARY

The CIMO Ad-Hoc Working Group on the CIMO WIGOS Pilot Project (CIMO-WIGOS-PP-3) held its third session at the WMO Headquarters, in Geneva, Switzerland, from 8 to 9 October 2009.

The aim of the meeting was to review and agree on two proposed classifications for land surface observing stations for use within WIGOS. The first classification addresses the siting of stations and the second their maintained performance. These classifications are needed because quality observations cannot be ensured only by the use of high-quality instrumentation, but rely at least as much on the proper siting of the instruments and on their maintenance.

These classifications are the first step towards providing a measure of the data quality to users of meteorological observations to allow them to assess whether specific observations meet the quality needed for their applications, which is of crucial importance for example for all climate applications and in particular for climate change monitoring. The meeting strongly supported the development of both classifications.

The meeting agreed that the siting classification was mature and should be submitted for approval to CIMO members and possibly proposed for further development as a common ISO-WMO standard if supported by Members.

The meeting also welcomed the proposal of the maintained performance classification and recognized that it needed some further development before it could be submitted for approval by CIMO. The meeting also noted the need to develop guidance documents on the application of these classifications.

AGENDA

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Annex III Classification for Performance Characteristics of Surface Observing Stations on Land

GENERAL SUMMARY

1. ORGANIZATION OF THE SESSION

1.1 Opening of the meeting

1.1.1 The third session of the Commission for Instruments and Methods of Observations (CIMO) Ad-Hoc Working Group on the CIMO WIGOS Pilot Project (CIMO-PP-3) was held at the WMO Headquarters in Geneva, Switzerland from 8 to 9 October 2009. The Chair of the meeting, Mr Michel Leroy, opened the meeting and welcomed the participants.

1.1.2 Mr Miroslav Ondras welcomed the participants to the WMO Headquarters. He stressed that the WMO Integrated Global Observing System (WIGOS) was aiming at improving the management as well as the standardization of observing systems and products. However, he noted that the aims of the different systems were not the same, neither the capabilities of the Members. It is to be expected that some of the observations carried out under WIGOS will not meet all the WMO requirements. Therefore, a siting classification would help users to identify the quality of the data and for which applications they can be used. He recalled that both CIMO and the Commission for Basic Systems (CBS) had approved the concept of the siting classification that will be discussed during this meeting. It is now be up to the meeting to agree on the details of the classification that could subsequently be submitted to relevant WMO constituent bodies for approval.

1.2 Adoption of the agenda

1.2.1 The meeting adopted the agenda as reproduced at the beginning of this report.

1.3 Working arrangements

1.3.1 The working hours and tentative timetable for the meeting were agreed upon.

2. BACKGROUND ON WIGOS AND ON THE CIMO PILOT PROJECT ON WIGOS

2.1 The meeting was informed about the development of the WIGOS, which will build on and add value to WMO's existing observing systems by coordinating their efforts, addressing shortcomings and supporting their interoperability, while meeting user requirements. It was stressed that within the WIGOS concept, the ownership and data-sharing policies of all observing components and partner organizations of these networks would be respected and ensured.

2.2 Three main areas of standardization had been identified as key requirements for the development of WIGOS and were presented to the meeting. It was mentioned that numerous standardization activities would be expected to be carried out in this context. As the same standards should ultimately apply to all observing systems, a strong collaboration between WMO and its partners will be required. Also, the aims of WIGOS can only be achieved if the observing systems owners accept the full responsibility for implementing the standards and document their systems appropriately.

2.3 The meeting recognized that numerous standards were already existing, like the CIMO Guide (WMO-No. 8), but that they were not always implemented because the observing system owners were not aware of their existence or because they had their own ideas about how to carry out meteorological observations for their specific purpose (e.g.. road meteorology) that do not necessarily corresponds to the needs and requirements of the meteorological community.

2.4 Mr Alain Heimo presented a draft concept of a framework for the standardization of the WIGOS surface-based component. He recognized that WMO has a lot of technical documents which are relevant for WIGOS, but that they are insufficiently harmonized, sometimes even overlapping and difficult to find. Network managers could strongly benefit from a well designed web interface that would provide an easy access to all these documents. This concept would consist of a web-interface from which all the standards would be accessible and also provide guidance to the network managers on the metadata to be documented for each type of information. In turn, the users would have access to the observation metadata and could assess the suitability of the observations for their applications.

2.5 Mr Heimo advised that in a first step, an IT system should be developed and linked to all existing standards. In a second step, the compatibility of the standards would need to be looked at. It would ultimately lead to a unique way to create the observations metadata according to a prescribed format/standard.

2.6 The meeting recognized that clearly defined metadata were crucial for the users and that a classification of the data quality would also help improve their quality as it provides a tool to the network manager to assess the stations. However, the meeting agreed that the production of the metadata had to be simple so that it could be implemented operationally and easily understood by users. Furthermore, data quality classes could be used to provide information as to their suitability for specific applications.

2.7 The present tendency is to merge data from official and private networks. In such a context, it is of highest relevance to have information on the respective data quality. Therefore, it would be beneficial to reach out outside of WMO to other network managers, to encourage them to use the proposed classification. In this context, the meeting recognized that proposing this classification as an ISO-WMO standard would help reaching out to a much wider community and ensuring and improving data quality.

3. CLASSIFICATION OF SURFACE OBSERVING STATIONS WITHIN WIGOS

3.1 Mr Leroy presented the classifications of siting and maintained performance of surface observing stations located on land that he had developed and presented in a number of conferences and forums. The background to the first classification, the siting classification, originates in the recognition that improper siting of an instrument can jeopardize the quality of the data, even of the best instruments. A lot of work is being done on the quality of the instruments (like conducting instrument intercomparisons) but, in general, only very limited information on the instrument siting is available. Also, the siting conditions, which are frequently neglected by network managers, could have a much stronger effect on the data than the precise manner in which the observation is carried out (e.g. sampling time). The background for the second classification, the maintained performance classification, was identified in the context of data exchange originating from stations that were maintained by other entities. The goal is to offer a tool to the users' community to complement the siting classification by giving information on the quality of the data from the maintenance point of view (e.g. the best instrument will deliver dubious data when not properly maintained). These classifications were developed using available scientific work, evaluating the magnitude of the errors that can be expected in each class.

3.2 These classifications are based on the three following principles affecting the quality of a measurement: 1) the intrinsic characteristics of sensors or measurement methods, 2) the maintenance tasks (including calibration) needed to maintain the system in nominal conditions and 3) the site, its surroundings and its representativeness. In spite of the known exposure rules for meteorological stations, it is frequent that the site selected for their installation does not fully meet the requirements because of the numerous constraints influencing the site selection procedures.

3.1 Siting Classification of Surface Observing Stations

3.1.1 Mr Leroy presented the siting classifications for surface observing stations on land that he had developed and presented in a number of conferences and forums.

3.1.2 The classification is providing one value for each measured element (temperature, wind, precipitation,…), but does not combine all the elements of one site into a single value that would be of only limited interest and often contra productive. The meeting agreed that the classification should not only cover the site itself, but also its surrounding and the representativeness of the site. It was noted that some stations are very representative of an area, even if that area is of limited size, like for example a mountain valley.

3.1.3 The meeting thoroughly reviewed the classification, examining each of the criteria used for assessing the station's site. Extensive discussions were needed and an additional teleconference was needed. The meeting finally agreed on the final version available in Annex II. A summary of some of the main points of the discussion is provided below.

3.1.4 The meeting discussed whether the classification should also include information that would allow for the data correction, as can be done in the case of wind measurements. The meeting agreed that the siting classification should be easy to implement and to maintain and decided not to include such information in it. However, the classification could provide information on whether the data could principally be corrected or not.

3.1.5 The meeting was informed that China had conducted an evaluation of its stations with respect to their environment. Several parameters were considered and graded and finally combined to provide a final grading for the station. This information was used to improve the quality of the stations and led to an improvement of almost all the lower-grade stations. Other participants also informed that the classification of stations in their NMHSs had lead to station improvements.

3.1.6 The meeting agreed that the successful implementation of such a classification requires more than the development of the classification itself. Indeed, guidance on how to apply the classification would be needed. Such documentation, with a variety of examples on how to characterize the station, would need to be provided to Members and relevant capacity-building activities would have to be organized, possibly by Regional Instrument Centres.

3.1.7 The meeting recommended that some guidance be also developed that would provide advice on how to use the ratings obtained, indicating for which purposes stations of a specific class are appropriate. The meeting recommended that CIMO includes such activities in its future work programme. Class 1 should be considered as reference and appropriate in particular for climate applications. Although Class 5 does not follow all WMO requirements, class 5-stations can have an interest for special applications, but users should know about it. Therefore, the meeting agreed that class 4 and 5 could be flagged with an "S" (special) to indicate such situation, like urban area, complex terrain, etc. The meeting also recalled that there is a difference between climate and weather stations, the weather stations being sometimes placed in non-ideal - but relevant - locations, but still yielding the required observations for forecasting purposes.

3.1.8 Several methods could be used to effectively determine the class of a site. The meeting considered that they did not need to be standardized. It was also stressed that the evaluation/rating of any site needed to be repeated on a regular basis by the network managers, ideally by personal independent from the maintenance personal. In case an environmental change would be noticed during the yearly check, then the instrument's siting would need to be fully reclassified.

3.1.9 For wind measurements, the CIMO Guide presently recommends an open area where the distance between the anemometer and any obstruction is at least 10 times the height of the obstructions. The criteria used in the proposed classification are more stringent than those presently provided in the CIMO Guide, because they also provide some information on whether the data can principally be corrected or not:

- Obstacles distant by more than 30 times their heights: no correction need to be applied to the wind data
- Obstacles distant by more than 20 times their heights: correction can be applied.
- Obstacles distant by more than 10 times their heights: correction may be applied taking special care, in some situations.

It should be noted that by distances below 20 times the height of the obstacle, the measured value before correction can be erroneous by up to 25%; by distance around 10 times the height of obstacles, the measured value can in some cases even be of opposite direction. Therefore, the meeting requested that the CIMO Guide be amended accordingly, explaining the background for this modification. The meeting welcomed the offer of Mr van der Meulen to prepare this update of the CIMO Guide for consideration by CIMO-XV as well as a background paper that could be presented during TECO-2010 or published as an IOM report and provide additional background information.

3.1.10 In finalizing the wind classification, the meeting recalled that it was generally difficult to find a good or even acceptable location for a wind sensor. Precise wind measurements are not only important for climate applications, but also for synoptic stations, in particular for aviation.

3.1.11 For the classification relevant to temperature measurements, the meeting considered whether the classification should take into account the statistical wind situation at the site of the temperature measurement. Wind increases the air mixture and minimizes the effect of close artificial surfaces and shading and could in principle be taken into account. But, as low wind speeds may occur at the time of occurrence of extreme temperatures (i.e. daily minimum and maximum), the wind climatology of the site is not taken into account in the proposed classification criteria. Taking into consideration the present state of knowledge and the fact that the classification should remain as simple as possible to use, the meeting decided not to include the effect of wind on temperature measurements in the final version of the classification.

3.1.12 The proposed classification also includes parts for radiation measurements: global and diffuse radiation, direct radiation and sunshine duration and a tentative part on long-wave radiation. The latter part is considered tentative as, in contrary to the other parts, it has only occasionally been tested in a network yet: only very few countries have stations operationally measuring long-wave radiation. The meeting therefore recommended that this part should not be submitted to the approval of CIMO before it would have been tested operationally by a NMHS. The meeting encouraged Meteoswiss, which is presently operating long-wave radiation stations, to test the tentative classification and to report on its experience to relevant CIMO expert teams.

3.1.13 The meeting recommended that, in future developments, a code letter be part of the station metadata, which would describe the general environmental location of the station (valley, mountain top, …).

3.2 Maintained Performance Classification of Surface Observing Stations

3.2.1 Mr Leroy presented the maintained performance classification for surface observing stations on land that he had developed recognizing the importance of maintenance and calibration information in data exchange. The classes of this classification are marked with letters to avoid confusion with the siting classification and range from A (best) to D (worst). Each class corresponds to an uncertainty, Class A corresponding to the achievable measurement uncertainty. (It should be noted that in some cases the required measurement uncertainty stated in WMO-No. 8, Part I, Chapter 1, Annex 1B, is lower than that value, which is unfortunately not readily achievable in normal operational conditions to date).

3.2.2 This classification provides information on how networks are maintained for each parameter. Therefore, generally, the rating of a kind of a station in the network would be the same for a given parameter, if the maintenance of all the stations of this kind within the network is the same.

3.2.3 The meeting reviewed and improved the proposed classification. The status of the classification as available at the end of the discussions is reproduced in Annex III. The meeting recognized that the text of this classification was very concise and that an accompanying document would be needed to explain the scientific background of the numbers appearing in it.

3.2.4 The meeting recognized that assessing the quality of a station taking into account its maintenance was difficult to perform, but strongly needed. As the classification provided in Annex III is already well-developed, but would need more work to be acceptable as a world standard, the meeting recommended that it be further developed and tested before being submitted for approval to CIMO. The participants in the meeting agreed to provide information to Mr Leroy on how to further improve the classification and possibly finalize its development prior to CIMO XV. The meeting also agreed that the Class A should correspond to reference stations.

3.2.5 Some applications making use of measurements of meteorological parameters may have requirements that are different and possibly more stringent than those of the meteorological community. The meeting therefore suggested that in the case of known such cases, a note be added to the relevant parameters of the classification, specifying that the figures given in it were for meteorological applications, but that other users might have more stringent requirements. The meeting also felt, that in such cases, CIMO should consider reviewing the published achievable measurement uncertainties. The meeting finally noted that precisely in the case of wind measurements, most instruments meet the specified requirements upon fabrication, but that their maintenance is crucial to ensure they continue to meet those values on the long-term.

4. ANY OTHER BUSINESS

4.1 The meeting was of the opinion that it would be extremely beneficial if those two classifications could ultimately be submitted to ISO as common ISO/WMO standards. However, in view of the novelty of the approach, the meeting recommended that the concurrence of CIMO members be considered first on the principle of those classifications before proceeding further and collaborating with ISO on their further development and finalization.

5. CLOSURE OF THE SESSION

The session closed on Friday, 9 October 2009, late afternoon.

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Siting Classification for Surface Observing Stations on Land

Environmental conditions of a site[1] may generate measurement errors exceeding the tolerances envisaged for instruments. More attention being usually given to the characteristics of the instrument than to the environmental conditions in which the measurement was made; it is often environmental conditions that distort results, influencing their representativeness, particularly where a site is supposed to be representative of a large area (i.e. 100 to 1 000 km2).

WMO-No. 8 indicates exposure rules for various sensors. But what should be done when these conditions are not fulfilled?

There are sites which do not respect the recommended exposure rules. Consequently a classification has been established to help determine the given site's representativeness on a small scale (impact of the surrounding environment). Hence, a class 1 site , can be considered as a reference site. A class 5 site is a site where nearby obstacles create an inappropriate environment for a meteorological measurement that is intended to be representative of a wide area (at least tenths of km2) and where meteorological measurements should be avoided. The smaller is the siting class, the higher is the representativeness of the measurement for a wide area. A site with a poor class number (large number) can stay valuable for a specific application needing a measurement in this particular site including its local obstacles.

Each type of measurements on a site is subject to a separate classification.

By linking measurements to their associated uncertainty levels, this classification may be used to define the maximum class number of a station, in order to be included in a given network, or to be used for a given application. In a perfect world, all sites would be of class 1, but the real world is not perfect and some compromises are necessary. It is more valuable to accept this situation and to document it by means of this siting classification.

By experience of Météo-France, the classification process helps the actors and managers of a network to better take in consideration the exposure rules and thus often improves the siting. At least, the siting environment is known and documented in the metadata. It is obviously possible and recommended to fully document the site, but the risk is that a fully documented site may increase the complexity of the metadata, which would often restrict their operational use. That is why this siting classification is defined to condense the information and facilitate the operational use of this metadata information.

A site as a whole has no single classification number. Each parameter being measurer at a site has its own class, and are sometimes different. If a global classification of a site is required, the maximum value of the parameters' classes can be used.

The rating of each site should be reviewed periodically as environmental circumstances can change over a period of time. A systematic yearly visual check is recommended: if some aspects of the environment have changed, a new classification process is necessary.

A complete update of the site classes should be done at least every 5 years.

In the following text, the classification is (occasionally) completed with an estimated uncertainty due to siting, which has to be added in the uncertainty budget of the measurement. This estimation is coming from bibliographic studies and/or some comparative tests.

The primary objective of this classification is to document the presence of obstacles close to the measurement site. Therefore, natural relief of the landscape may not be taken into account, if far away (i.e. >1 km). A method to judge if the relief is representative of the surrounding area is the following: does a move of the station by 500 m change the class obtained ? If the answer is no, the relief is a natural characteristic of the area and is not taken into account.

Complex terrain or urban area generally leads to high class number. In such cases, an additional flag "S" can be added to class numbers 4 or 5 to indicate Specific environment or application (i.e 4S).

[1] A "site" is defined as the place where the instrument is installed.

Air temperature and humidity

Sensors situated inside a screen should be mounted at a height determined by the meteorological service (within 1.25 m to 2 m as indicated in the CIMO Guide). The height should never be less than 1.25 m. The respect of the higher limit is less stringent, as the temperature gradient vs. height is decreasing with height. For example, the difference in temperature for sensors located between 1.5 and 2 m is less than 0.2 °C.

The main discrepancies are caused by unnatural surfaces and shading.

- Obstacles around the screen influence the irradiative balance of the screen. A screen close to a vertical obstacle may be shaded from the solar radiation or "protected" against the night radiative cooling of the air, by receiving the warmer infra red (IR) radiation from this obstacle or influenced by reflected radiation.
- Neighbouring artificial surfaces may heat the air and should be avoided. The extent of their influence depends on the wind conditions, as wind affects the extent of air exchange. Unnatural or artificial surfaces to take into account are heat sources, reflective surfaces (e.g. buildings, concrete surfaces, car parks) and water sources (e.g. ponds, lakes, irrigated areas).

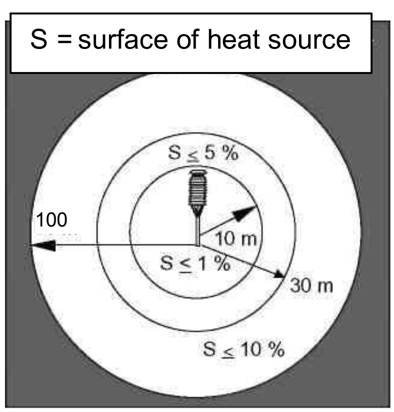
Shading by nearby obstacles should be avoided. Shading due to natural relief is not taken into account for the classification (see above).

The indicated vegetation growth height represents the height of the vegetation maintained in a 'routine' manner. A distinction is made between structural vegetation height (per type of vegetation present on the site) and height resulting from poor maintenance. Classification of the given site is therefore made on the assumption of regular maintenance (unless such maintenance is not practicable).

Class 1

- Flat, horizontal land, surrounded by an open space, slope less than 1/3 (19°).
- Ground covered with natural and low vegetation (< 10 cm) representative of the region.
- Measurement point situated:
  - at more than 100 m from heat sources or reflective surfaces (buildings, concrete surfaces, car parks etc.)
  - at more than 100 m from an expanse of water (unless significant of the region)
  - away from all projected shade when the Sun is higher than 5°.

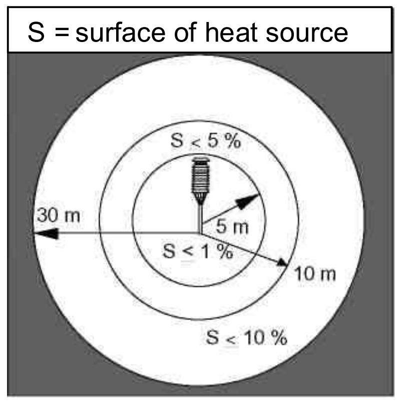
A source of heat (or expanse of water) is considered to have an impact if it occupies more than 10 % of the surface within a circular area of 100 m surrounding the screen, makes up 5% of an annulus of 10m-30m, or covers 1% of a 10 m circle.



Class 2

- Flat, horizontal land, surrounded by an open space, slope inclination less than 1/3 (19°).
- Ground covered with natural and low vegetation (< 10 cm) representative of the region.
- Measurement point situated :
  - At more than 30 m from artificial heat sources or reflective surfaces (buildings, concrete surfaces, car parks etc.)
  - At more than 30 m from an expanse of water (unless significant of the region)
  - Away from all projected shade when the Sun is higher than 7 °.

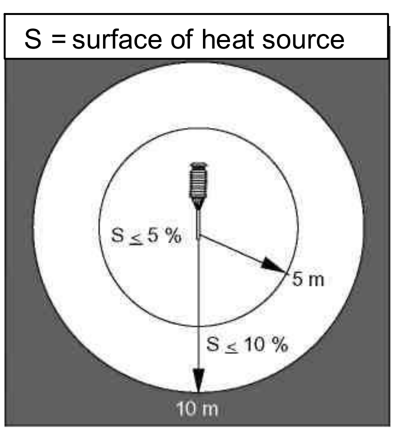
A source of heat (or expanse of water) is considered to have an impact if it occupies more than 10 % of the surface within a circular area of 30 m surrounding the screen, makes up 5% of an annulus of 5m-10m, or covers 1% of a 5 m circle.



Class 3 (additional estimated uncertainty added by siting up to 1 °C)

- Ground covered with natural and low vegetation (< 25 cm) representative of the region.
- Measurement point situated:
  - at more than 10 m from artificial heat sources and reflective surfaces (buildings, concrete surfaces, car parks etc.)
  - at more than 10 m from an expanse of water (unless significant of the region)
  - away from all projected shade when the Sun is higher than 7 °.

A source of heat (or expanse of water) is considered to have an impact if it occupies more than 10 % of the surface within a circular area of 10 m surrounding the screen or makes up 5% of an annulus of 5m.



Class 4 (additional estimated uncertainty added by siting up to 2 °C)

- Close artificial heat sources and reflective surfaces (buildings, concrete surfaces, car parks etc.) or expanse of water (unless significant of the region, occupying:
  - Less than 50% of the surface within a circular area of 10 m around the screen
  - Less than 30% of the surface within a circular area of 3 m around the screen
- Away from all projected shade when the Sun is higher than 20 °.

Class 5 (additional estimated uncertainty added by siting up to 5 °C)

Site not meeting the requirements of class 4.

Precipitation

Wind is the greatest source of disturbance in precipitation measurements, due to the effect of the instrument on the airflow. Unless rain gauges are artificially protected against wind, for instance by a wind shield , the best sites are often found in clearings within forests or orchards, among trees, in scrub or shrub forests, or where other objects act as an effective wind-break for winds from all directions. Ideal conditions for the installation are those where equipment is set up in an area surrounded uniformly, by obstacles of uniform height. An obstacle represents an object with an angular width of 10° or more.

The choice of such a site is not compatible with constraints in respect of the height of other measuring equipment. Such conditions are practically unrealistic. If obstacles are not uniform, they are prone to generate turbulence which distorts measurements; this effect is more pronounced for solid precipitation. This is the reason why more realistic rules of elevation impose a certain distance from any obstacles. The orientation of such obstacles with respect to prevailing wind direction is deliberately not taken into account. Indeed, heavy precipitation is often associated with convective factors, whereby the wind direction is not necessarily that of the prevailing wind. Obstacles are considered of uniform height if the ratio between the highest and lowest height is lower than 2.

Reference for the heights of obstacles is the catchment's height of the rain gauge.

Class 1

- Flat, horizontal land, surrounded by an open area, slope less than 1/3 (19°). Rain gauge surrounded by obstacles of uniform height, seen under an elevation angle between 14 to 26° (obstacles at a distance between 2 to 4 times their height).

or

- Flat, horizontal land, surrounded by an open area, slope less than 1/3 (19°). For a rain gauge artificially protected against wind, the instrument does not necessarilyy need to be protected by obstacles of uniform height. In this case, any other obstacles must be situated at a distance of at least 4 times their height.

Class 2 (additional estimated uncertainty added by siting up to 5 %)

- Flat, horizontal land, surrounded by an open area, slope less than 1/3 (19°).
- Possible obstacles must be situated at a distance at least twice the height of the obstacle (with respect to the catchment's height of the rain gauge).

Class 3 (additional estimated uncertainty added by siting up to 15 %)

- Land is surrounded by an open area, slope less than 1/2 (≤ 30°).
- Possible obstacles must be situated at a distance greater than the height of the obstacle.

Class 4 (additional estimated uncertainty added by siting up to 25 %)

- Steeply sloping land (> 30°).

or

- Possible obstacles must be situated at a distance greater than one half (1/2) the height of the obstacle.

Class 5 (additional estimated uncertainty added by siting up to 100 % !)

- Obstacles situated closer than one half (1/2) their height (tree, roof, wall, etc.).

Surface wind

Conventional elevation rules stipulate that sensors should be placed 10 m above ground surface level and on open ground. Open ground here represents a surface where obstacles are situated at a minimum distance equal to at least ten times their height.

Roughness

Wind measurements are not only disturbed by surrounding obstacles; terrain roughness also plays a role. The WMO defines wind blowing at a geometrical height of 10 m and with a roughness length of 0.03 m as the surface wind for land stations.

This is regarded as a reference wind for which exact conditions are known (10 m height and roughness length of 0.03 m).

Therefore, roughness around the measuring site has to be documented. Roughness should be used to convert the measuring wind to the reference wind, but this procedure can be applied only when the obstacles are not too close. Roughness related matters and correction procedure are described in chapter 5 of the CIMO Guide.

The roughness classification, reproduced from the CIMO Guide, is recalled here:

Terrain classification by Davenport (1960), adapted by Wieringa (1980) in terms of aerodynamic roughness length z_o		
Class index	Short terrain description	Z_0 (m)
2	Mud flats, snow; no vegetation, no obstacles	0.005
3	Open flat terrain; grass, few isolated obstacles	0.03
4	Low crops; occasional, large obstacles : x/H > 20	0.10
5	High crops; scattered obstacles : 15 < x/H < 20	0.25
6	Parkland, bushes; numerous obstacles : x/H ~ 10	0.5
7	Regular large obstacle coverage (suburb, forest)	1.0
8	City centre with high- and low- rise buildings	2

Here x is a typical upwind obstacle distance and H is the height of the corresponding major obstacles. For more detailed and updated terrain class index descriptions see Davenport, et al. (2000).

Environment classification

The presence of obstacles (almost invariably) means a reduction in average wind readings, but less significantly affects wind gusts.

The following classification assumes measurement at 10 m which is the standard elevation for meteorological measurement.

When measurement are carried out at lower height (such as measurement carried out at 2 m, as is sometimes the case for agro-climatological purposes), a class 4 or 5 (see below) is to be used, with flag S (Specific situation).

Where numerous obstacles higher than 2 m are present, it is recommended that sensors should be placed 10 meters above the average height of the obstacles. This method allows the influence of the adjacent obstacles to be minimised. This method represents a permanent solution for partly eliminating the influence of certain obstacles. It inconveniently imposes the necessity for higher masts which are not standard and consequently more expensive. It must be considered for certain sites and where used, the height of obstacles to be taken into account is that above the level situated 10 m below the sensors (e.g. for an anemometer installed at a 13 m height, the reference "ground" level of the obstacles is at a 3 m height; an obstacle of 7 m is considered to have an effective height of 4 m).

In the following, an object is considered to be an obstacle if its angular width is over 10°, except for tall thin obstacles, as mentioned below.

Changes of altitude (positive or negative) in the landscape which are not representative of the landscape, are considered as obstacles.

Class 1

- The mast should be located at a distance equal to a least 30 times the height of surrounding obstacles.
- Sensors should be situated at a minimum distance of 15 times the width of narrow obstacles (mast, thin tree) higher than 8 m.

Single obstacles lower than 4 m can be ignored.

- Roughness class index is between 2 to 4 (roughness length ≤ 0.1 m).

Class 2 (additional estimated uncertainty added by siting up to 30 % , possibility to apply correction)

- The mast should be located at a distance of at least 10 times the height of the surrounding obstacles.
- Sensors should be situated at a minimum distance of 15 times the width of narrow obstacles (mast, thin tree) over 8 m high.

Single obstacles lower than 4 m can be ignored.

- Roughness class index is between 2 to 5 (roughness length ≤ 0.25 m).

  Note: when the mast is located at a distance of at least 20 times the height of the surrounding obstacles, a correction (see CIMO Guide, wind chapter) can be applied. In case of nearer obstacles, a correction may be applied is some situations.

Class 3 (additional estimated uncertainty added by siting up to 50 %, correction cannot be applied)

- The mast should be located at a distance of at least 5 times the height of surrounding obstacles.
- Sensors should be situated at a minimum distance of 10 times the width of narrow obstacles (mast, thin tree) higher than 8 m.

Single obstacles lower than 5 m can be ignored.

Class 4 (additional estimated uncertainty added by siting greater than 50 %)

- The mast should be located at a distance of at least 2.5 times the height of surrounding obstacles.
- No obstacle with an angular width larger than 60° and a height greater than 10 m, within a 40 m distance.

Single obstacles lower than 6 m can be ignored, only for measurements at 10 m or above.

Class 5 (additional estimated uncertainty cannot be defined)

Site not meeting the requirements of class 4.

Global and diffuse radiation

Close obstacles have to be avoided. Shading due to the natural relief is not taken into account for the classification. Non-reflecting obstacles below the visible horizon can be neglected.

An obstacle is considered as reflecting if its albedo is greater than 0.5.

The reference position for elevation angles is the sensitive element of the instrument.

Class 1

- No shade projected onto the sensor when the Sun is at an angular height of over 5°. For regions with latitude ≥ 60°, this limit is decreased to 3°.
- No non-shading reflecting obstacles with an angular height above 5° and a total angular width above 10°.

Class 2

- No shade projected onto the sensor when the Sun is at an angular height of over 7°. For regions with latitude ≥ 60°, this limit is decreased to 5°.
- No non-shading reflecting obstacles with an angular height above 7° and a total angular width above 20°.

Class 3

- No shade projected onto the sensor when the Sun is at an angular height of over 10°. For regions with latitude ≥ 60°, this limit is decreased to 7°.
- No non-shading reflecting obstacles with an angular height above 15° and a total angular width above 45°.

Class 4

- No shade projected during more than 30% of the daytime, for any day of the year.

Class 5

- Shade projected during more than 30% of the daytime, for at least one day of the year.

Direct radiation and sunshine duration

Close obstacles have to be avoided. Shading due to the natural relief is not taken into account for the classification. Obstacles below the visible horizon can be neglected.

The reference position for angles is the sensitive element of the instrument.

Class 1

- No shade projected onto the sensor when the Sun is at an angular height of over 3°.

Class 2

- No shade projected onto the sensor when the Sun is at an angular height of over 5°.

Class 3

- No shade projected onto the sensor when the Sun is at an angular height of over 7°.

Class 4

- No shade projected during more than 30% of the daytime, for any day of the year.

Class 5

- Shade projected during more than 30% of the daytime, for at least one day of the year.

Long-wave Radiation (tentative)

Close obstacles have to be avoided, because the long-wave radiation emitted by these obstacles replaces the IR radiation emitted by the sky in their direction. The influence of these obstacles is taken into account by estimating the portion of the sky hemisphere occupied by these obstacles, as viewed by the sensitive element of the pyrgeometer. An obstacle seen with an angular height of α and an angular width of β (in °), has an influence on the measurement, with a weight of $100*\sin^2(\alpha)*\beta/360$ in %. This weight is hereafter called “shading weight”. For example, a “ring” of obstacles seen under an elevation angle of 10°, gives a shading weight of only 3%.

Shading due to the natural relief is not taken into account for the classification. Obstacles below the visible horizon can be neglected.

The reference position for elevation angles is the sensitive element of the instrument.

Class 1

- No obstacles with shading weight more than 2%.

Class 2

- No obstacles with shading weight more than 5%.

Class 3

- No obstacles with shading weight more than 10%.

Class 4

- No obstacles with shading weight more than 20%.

Class 5

- Site not meeting the requirements of class 4.

Classification for Performance Characteristics of Surface Observing Stations on Land

DRAFT Classification

A 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 worse than the announced performances, depending on the “objectivity” of the manufacturer. The statement of achievable measurement uncertainty included in Part I, Chapter 1 of doc WMO-No. 8 (Guide to Meteorological Instruments and Methods of Observation) should be used to check the possible validity of the uncertainty announced by the manufacturer. When writing technical specifications to buy equipment, it is necessary to have in mind the achievable measurement uncertainty: even requesting only the state-of-the-art achievable uncertainty may result in high costs and/or some exaggeration of their instrument’s performances by 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 lead to specify lower performances than the “required measurement uncertainty” and the “achievable measurement uncertainty” found in Part I, Chapter 1, Annex 1B of WMO-No. 8.
Test 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 operation. Preventive maintenance and calibration are therefore necessary and must be performed 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-No. 8, Annex 1B is not recommended.

In order to document the performance characteristics of the various surface observing networks, this document defines a classification, called "performance classification" including the uncertainty of the instrument and the periodicity of preventive maintenance and calibration. This classification ranges from A (instrument well maintained following the WMO/CIMO required measurement uncertainty and stated achievable measurement uncertainty, in particular table in chapter 1 of the CIMO Guide) to D (no maintenance and calibration organized), with an additional class E for unknown characteristics and maintenance.
This classification is related to a network, considering the instruments used and the maintenance organization applied for this network. So, it is a “structural” classification. It doesn’t mention the information of what has been made on a particular day on a particular site.

The five levels are:

- Class A: WMO/CIMO required measurement uncertainty or achievable measurement uncertainty when higher. Maintenance and calibration are organized to keep this uncertainty in the field and over time. When the required measurement uncertainty is smaller than the achievable accuracy, the latter is indicated.
- Class B: Lower specifications, but still considered as quite “good”, often having a good value to money ratio and more affordable in practice. Maintenance and calibration are organized to keep this uncertainty in the field and over time.
- Class C: Specifications and/or maintenance and calibration procedures lower than class B, but known and applied. Maintenance and calibration are still organized.
- Class D: Specifications lower than class C or no maintenance and calibration organized.
- Class E: Unknown performances and/or unknown maintenance procedures.

Typical conditions to get and maintain the stated accuracy are indicated.

Parameter	Class A	Class B	Class C	Class D
Air temperature	**0.2°C** (achievable measurement uncertainty). Temperature probe with uncertainty below or equal 0.05 °C (in laboratory conditions, over the measuring range). Uncertainty of the acquisition system < 0.02 °C. High performance artificially ventilated screen. Laboratory calibration of the temperature probe every year.	**0.5 °C** Temperature probe with uncertainty below 0.25°C (corresponds of class A of IEC 751 standard). Acquisition uncertainty < 0.1°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.	**1.0°C** Temperature probe with uncertainty < 0.4°C. Acquisition uncertainty < 0.2°C. Radiation screen with known characteristics and over-estimation of Tx < 0.3°C in 95% of cases.	> **1°C** Temperature probe and/or acquisition system uncertainty lower than for class C. Unknown radiation screen or with "unacceptable" characteristics (for example, over-estimation of Tx > 0.7°C in 5% of cases).
Relative humidity	**3%** (achievable measurement uncertainty). Performance verified over the full range of humidity and a temperature range typical for the location of the station. Acquisition uncertainty < 0.2%. Calibration every 6 months, in an accredited laboratory.	**6%** Sensor specified for ± 6%, over a temperature range typical for the location of the station. Acquisition uncertainty < 1%. Calibration every year, in an accredited laboratory.	**10%** Sensor specified for ± 10%, over a temperature range typical for the location of the station. Acquisition uncertainty < 1%. Calibration every two years in an accredited laboratory.	**> 10%** Sensor with performances or specifications worst than ± 10% over the common temperature conditions. Calibration not organized.
Atmospheric pressure	**0.3 hPa** (achievable measurement uncertainty). Sensor with a numeric output. Influence of dynamic pressure due to wind reduced by a static head. Yearly calibration in an accredited laboratory.	**0.5 hPa** Sensor with a numeric output. Sensor specified for ± 0.5 hPa, including possible drift between calibrations. Influence of dynamic pressure due to wind reduced by a static head. Two-year calibration in an accredited laboratory.	**1 hPa** Sensor specified for ± 1 hPa, including possible drift between calibrations. Calibration organized for this uncertainty.	**> 1 hPa** Specifications lower than for class C or no regular calibration organized.

Wind	Wind speed: **10% (or 0.5 m/s)** Starting threshold (for wind speed) ≤ **0.5 m/s** wind direction: **5°** Calculation of wind parameters following WMO recommendations: 4 Hz samples, gust over a 3 seconds period. Yearly control of bearings, for rotating anemometers. Yearly calibration. Note : wind speed uncertainty could be reduced to 5% for wind energy. To be changed if 5% is introduced in the CIMO guide.	Wind speed: **10% (or 0.5 m/s)** Starting threshold (for wind speed) ≤ **1 m/s** wind direction: **10°** Calculation of wind parameters following WMO recommendations, with the possible difference concerning gust calculation: min. 1 Hz sampling, gust calculated over a period < 3 s. Yearly control of bearings, for rotating anemometers.	Wind speed: **15% (or 0.5 m/s)** Starting threshold (for wind speed) ≤ **2 m/s** wind direction: **10°** Two-year control/maintenance of the mechanical status of sensors.	Wind speed: > **15%** (or **1 m/s**) Wind Direction: > **20°** Starting threshold (for wind speed) > **2 m/s**. Or no regular maintenance organized.
Precipitation (liquid). Classification still to be defined for solid precipitation	The larger of **5%** and **0.1 mm.** (achievable measurement uncertainty). Reported resolution better than or equal to 0.1 mm. If any, error related to precipitation intensity corrected. Use of a wind shield. Daily control of the collecting cone for rain gauges using a cone. 6 months calibration for tipping bucket rain gauges.	The larger of **5%** and **0.2 mm.** Reported resolution better than or equal to 0.2 mm. If any, error related to precipitation intensity corrected or at least known. 6 months calibration for tipping bucket rain gauges. Weekly control of the collecting cone for tipping bucket rain gauges.	The larger of **10%** and **0.5 mm.** Unknown error related to precipitation intensity. Calibration period of tipping bucket rain gauges lower than 18 months. A preventive maintenance is defined and applied.	> **10%** or no control and adjustment methods defined or no regular maintenance organized.

Global solar radiation	Pyranometer of ISO class 1. **5%** for daily total. Ventilated sensor. Calibration every two years. Regular cleaning of the sensor (at least weekly and daily in case of lithometeor deposition).	Pyranometer of ISO class 1. No ventilation. Calibration every two years. Regular cleaning of the sensor (at least weekly).	Pyranometer of ISO class 2. No ventilation. Calibration every five years. No regular cleaning of the sensor.	Uncertainty > 10% for daily total or sensor not using a thermopile. Or Calibration not organized
Visibility (MOR)	**50 m** below 600 m, **10%** between 600 and 1500 m, **20%** above 1500 m. All, in 95% of cases in homogenous visibility conditions (ratio of standard deviation to mean value over 10 minutes < 0.1). 3 months calibration (or periodicity recommended by the manufacturer, if lower). At least, weekly cleaning of the optics.	The larger of **20%** and **50 m**, up to 10000 m. In 90% of cases in homogenous visibility conditions. 6-months calibration (or periodicity recommended by the manufacturer). For forward scatter meters, full control of the calibration chain: reference transmissometer, transfer control forward scatter meter, calibration plates. Use of internal warning from the sensor to clean the optics.	The larger of 40% and 100 m, up to 10000 m. Yearly calibration. Defined calibration chain (and applied !).	Specifications lower than for class C or No control and adjustment methods defined or No regular maintenance organized.
Temperature above or below ground level.	Not specified by WMO. **0.5°C**	**1°C** Temperature probe with uncertainty < 0.25°C (corresponds to class A of IEC 751 standard). Acquisition uncertainty < 0.1°C. Laboratory calibration of the temperature probe every 5 years.	**1.5°C** Temperature probe with uncertainty < 0.4°C. Acquisition uncertainty < 0.2°C.	Specifications lower than for class C or Height (or depth) of measurement unknown.