**JMA/WMO Workshop on Quality Management in Surface, Climate and Upper-air Observations in RA II (Asia)**

Tokyo, Japan
27-30 July 2010

Doc.
Japan

(27.VII.2010)

# Siting Classification for Surface Observing Stations on Land

*(Submitted by Michel Leroy, Meteo-France)*

**Summary and Purpose of Document**

Several factors have an influence on the « quality » of a meteorological measurement: the intrinsic characteristics of sensors or measurement methods; the maintenance needed to maintain the system in nominal conditions; the site representiveness.

Environmental conditions on a site may generate measurement errors larger than the uncertainty of the instrument itself, whilst more attention is usually being given to the instrument itself. WMO/CIMO has clear recommendations about siting and exposure of instruments. But they are not always possible to follow and this is scarcely documented.
Several years ago, Météo-France defined a siting classification for wind, temperature, precipitation and solar radiation, ranging from 1 (WMO recommendations) to 5 (bad environment to be representative). It has been applied and proved to be efficient both to document the siting and to improve it, by rating it.
Recently, an expert meeting was organized by WMO, to cross experience on the subject and to define a siting classification for Surface Observation at Land. This classification will be proposed for validation by the next CIMO-XV in September 2010.

Considering also the various metrological characteristics of the equipment used in different surface networks, Météo-France defined also another classification, called "maintained performance classification", including the uncertainty of the instrument and the organization of preventive maintenance and calibration.
This complementary classification was also discussed within the expert team of WMO, but was not considered enough mature to be proposed to CIMO for validation.

The principles of these two classifications will be presented, along with the experience of Météo-France in applying them.

**WMO/JMA RA II (Asia) Workshop on Quality Management in Surface, Climate and Upper-air Observations**

Doc.
FRANCE

Tokyo, Japan
27-30 July 2010

# Siting Classification for Surface Observing Stations on Land

Michel Leroy, Météo-France
michel.leroy@meteo.fr

## Abstract

Several factors have an influence on the « quality » of a meteorological measurement: the intrinsic characteristics of sensors or measurement methods; the maintenance needed to maintain the system in nominal conditions; the site representiveness.

Environmental conditions on a site may generate measurement errors larger than the uncertainty of the instrument itself, whilst more attention is usually being given to the instrument itself. WMO/CIMO has clear recommendations about siting and exposure of instruments. But they are not always possible to follow and this is scarcely documented.

Several years ago, Météo-France defined a siting classification for wind, temperature, precipitation and solar radiation, ranging from 1 (WMO recommendations) to 5 (bad environment to be representative). It has been applied and proved to be efficient both to document the siting and to improve it, by rating it.

Recently, an expert meeting was organized by WMO, to cross experience on the subject and to define a siting classification for Surface Observation at Land. This classification will be proposed for validation by the next CIMO-XV in September 2010.

Considering also the various metrological characteristics of the equipment used in different surface networks, Météo-France defined also another classification, called "maintained performance classification", including the uncertainty of the instrument and the organization of preventive maintenance and calibration.

This complementary classification was also discussed within the expert team of WMO, but was not considered enough mature to be proposed to CIMO for validation.

The principles of these two classifications will be presented, along with the experience of Météo-France in applying them.

## 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. Meteorological services have 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 representativeness and therefore the measurement representativeness.

## SITE REPRESENTATIVENESS

This representativeness 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 topography, 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?

## THE GENESIS OF THE SITING CLASSIFICATION

In 1998, Météo-France defined a classification for some basic surface variables to document the nearby environment of a site. Class numbers are used, ranging from 1 (the best) to 5 (the worst). This classification was first applied to select the sites of 400 AWS of a new network, named RADOME. Obviously the objective was to select class 1 sites, but compromise were sometimes necessary and it was decided to accept sites with a maximum class number of 3.
This classification was presented is some international conferences (TECO, AMS). It is applied, with some modifications, by the USA, to document their climatic reference network. Some other countries (Canada, Switzerland, …) got also an interest in this approach.
Finally, this classification was considered and discussed within WMO (CBS, CIMO and as part of a pilot project for WIGOS). Group of experts amended it and it will be proposed for consideration and possible approval to the next CIMO XV in September 2010. Therefore, it could become a standard from WMO.

## SITING CLASSIFICATION

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 measured at a site has its own class, and is sometimes different from others. 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

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

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).

The example of the classification for precipitation is given below.

## CLASSIFICATION FOR PRECIPITATION

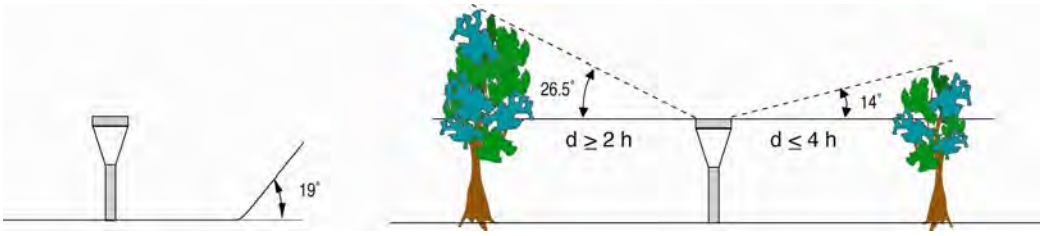
Wind is the greatest source of disturbance in precipitation measurements, due to the effect of the instrument on the airflow. Unless rain gauges are artificially protected against wind, for instance by a wind shield , the best sites are often found in clearings within forests or orchards, among trees, 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.

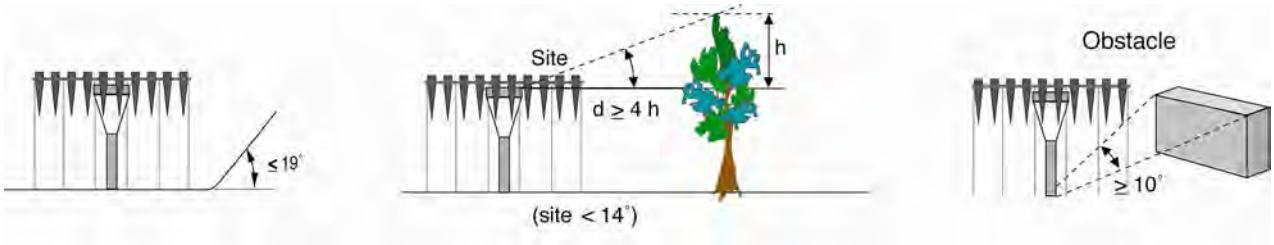
Reference for the heights of obstacles is the catchment’s height of the rain gauge.

### 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).



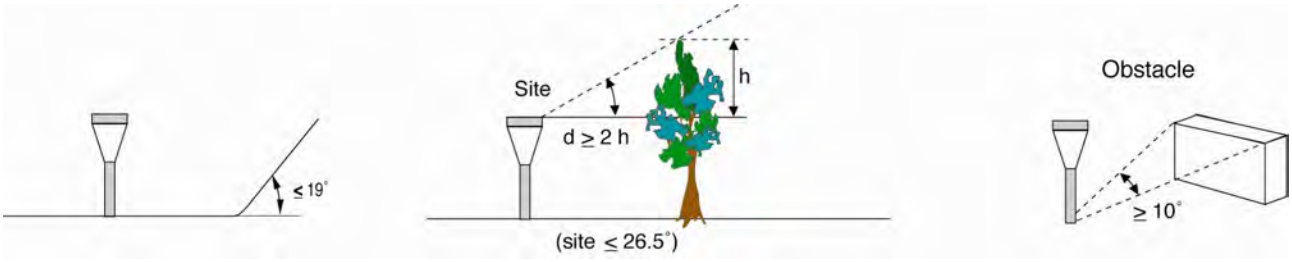

or




- 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 necessarily 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.

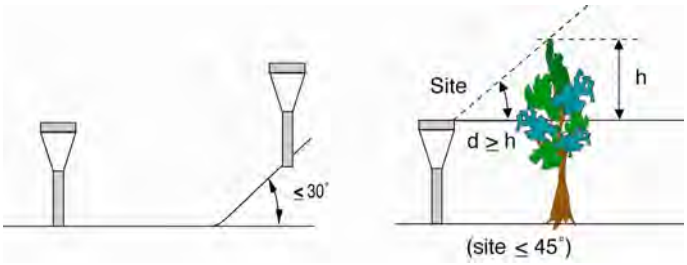
**Class 2 (additional estimated uncertainty added by siting up to 5 %)**

- 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).



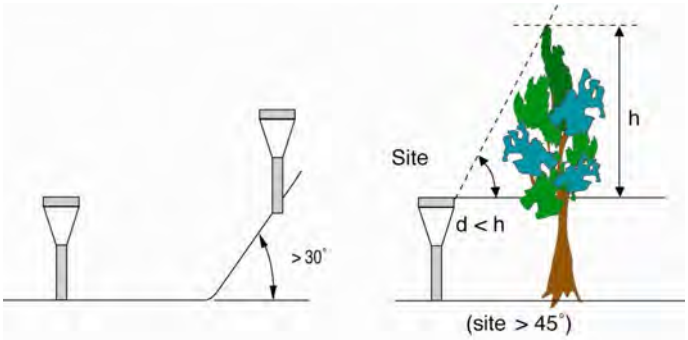

**Class 3 (additional estimated uncertainty added by siting up to 15 %)**

- 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°).
- 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.).

## MAINTAINED PERFORMANCE CLASSIFICATION

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.
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. But it is not always done, the observations may come from several networks with different characteristics and considering “by default” the “achievable measurement uncertainty” of WMO n°8, Annex 1B could be a mistake.
The required accuracy of the main surface-observing network of Météo-France, named Radome, has been stated, the instruments were selected and the maintenance and calibration are organized accordingly. 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, Météo-France also uses observations from other AWS networks (not belonging to Météo-France) and from manual climatologic sites (cooperative network). The instruments used in such networks are often not the same that the instruments specified and selected for Radome. Therefore, their performances are different, often lower. Nevertheless, their data have been used for climatological and forecasting applications, generally without considering the “quality” of the network. This may not be satisfactory and the “quality” of the observations has sometimes to be taken into account, mainly for the climatology.

In order to document the performance characteristics of the various surface observing networks used, Météo-France defined another classification, called "maintained performance classification", including the uncertainty of the instrument and the periodicity and the procedures of preventive maintenance and calibration. 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.

This classification is related to a network, considering the instruments used and the maintenance organization applied for this network. So, it is an "organization" classification. It doesn't give the information of what has been made on a particular day on a particular site.
This classification covers the quality factors a) and b) listed above.

An example for liquid precipitation is given below.

Class A
- The larger of **5%** and **0.1mm.** (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.

Class B
- 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.

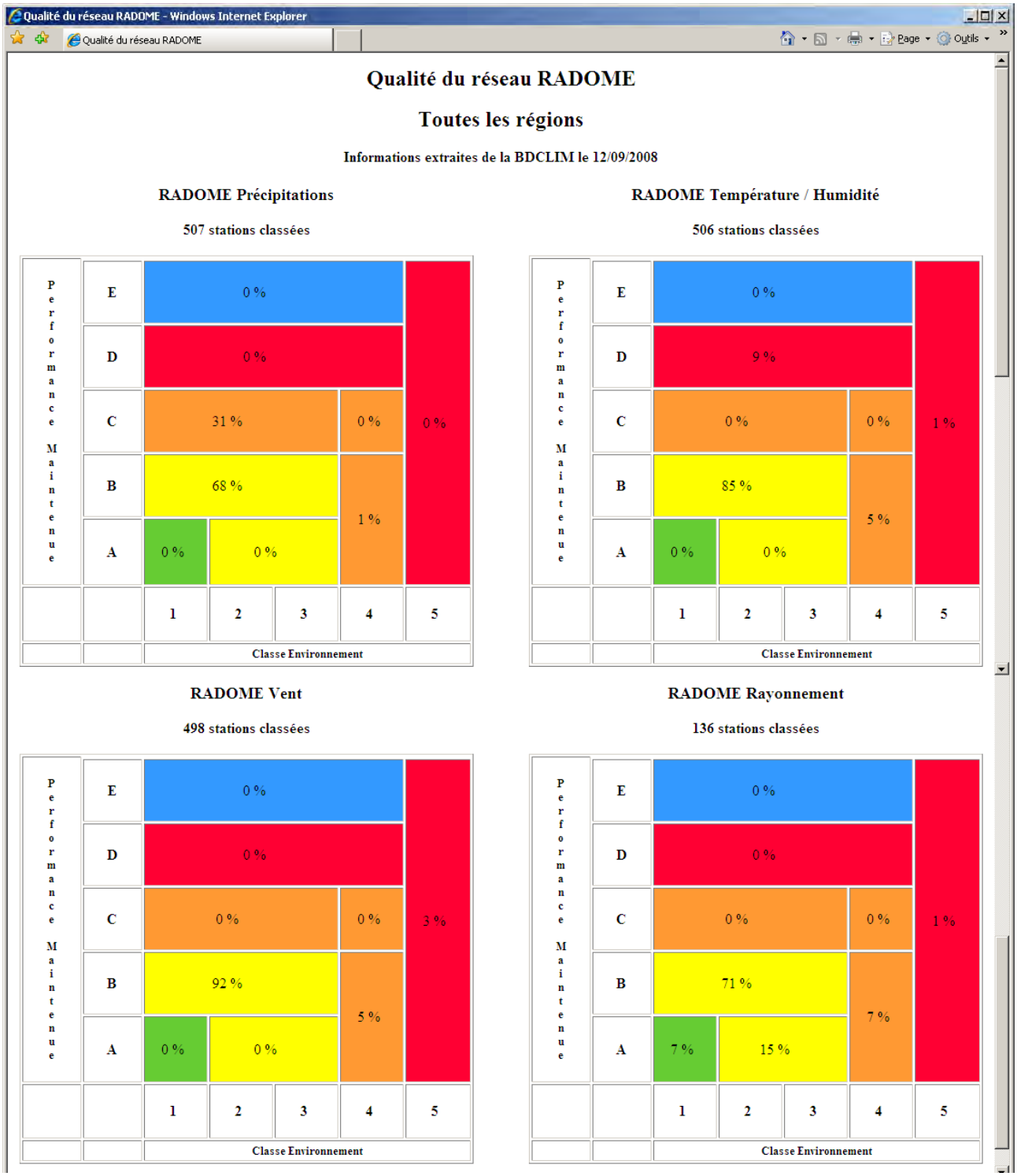
Class C
- The larger of **10%** and **0.5 mm.**
- Unknown error related to precipitation intensity.
- Calibration period of tipping bucket rain gauges lower than 18 months.
- A preventive maintenance is defined and applied.

Class D
- **> 10%**
- or no control and adjustment methods defined
- or no regular maintenance organized.

This classification was also discussed within the WIGOS project pilot, but was not considered as enough mature to be proposed as a WMO standard. More work is needed to reach a consensus.

## EXEMPLE: STATUS OF THE RADOME NETWORK IN FRANCE

With these two classifications, a letter and a number therefore describe a measurement on a given site. So, it is possible to have a general view of the classes of a network. The following graphs show the result of the classification of the Radome network.




For each diagram, the siting class is horizontal; the maintained performance class is vertical. The color is a little bit related to the "quality" of the combination of the two classes. A1 (green) is the best; the yellow zone is still a good compromise; the usefulness of a

measurement in the orange zone begins to be questionable; no points should be in the red zone; the blue one is for the unknown maintained performance class.
We have some values in the red zone:

- We currently have some electronic drifts with some acquisition modules for temperature, leading to an uncertainty that we have flagged with a class D. We are finishing to solve this problem.
- Some sites have a bad environment for some sensors, mainly wind sensors. For such sites, the installation was accepted with derogation, registered in our quality system.

The C class for precipitation is related to the use of a rain gauge model that exhibits quite large evaporation errors. These rain gauges will be replaced.

This objective presentation of our Radome network shows that it is not perfect. But it is an honest presentation, which may also brings arguments to improve it.

## CONCLUSION

The two classifications described have the advantage of being simple and therefore, easy to use as metadata. Unfortunately, the siting classification as it is defined, doesn't allow to correct the measurements. Correction methods remain possible, but independently of the siting classification. It is a clear limitation, but these classifications allow to easily document the "quality" of the design of a network. Another advantage is that it is also a didactic approach, both for network designers, financing authorities and final users. It gives a clear and honest view of a network status. The Météo-France experience is that the implementation of these classifications brought and still bring improvements in the networks' design, thus optimizing their value, not necessarily at an extra cost.

**Annex : definition of site classification for air temperature and humidity, surface wind, global and diffuse solar radiation, direct radiation and sunshine duration**

**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).

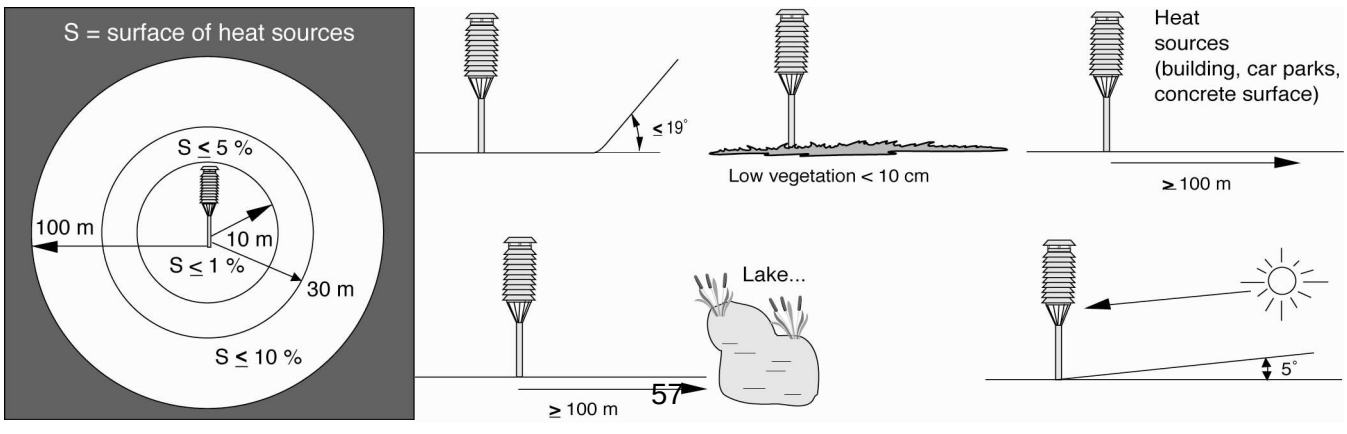
Shading by nearby obstacles should be avoided. Shading due to natural relief is not taken into account for the classification (see above).

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°.

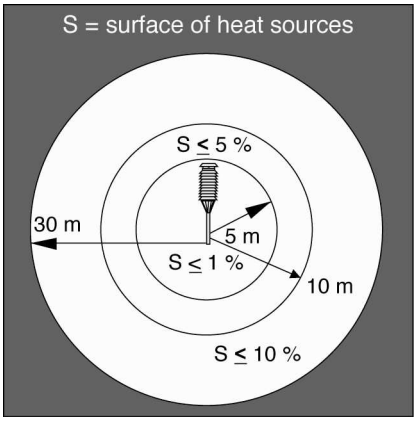
A source of heat (or expanse of water) is considered to have an impact if it occupies more than 10 % of the surface within a circular area of 100 m surrounding the screen, makes up 5% of an annulus of 10m-30m, or covers 1% of a 10 m circle.

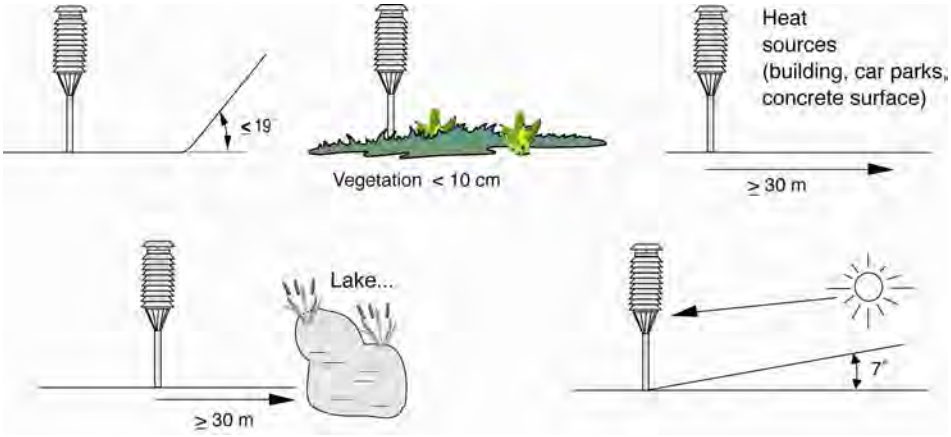


**Class 2**

- 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.

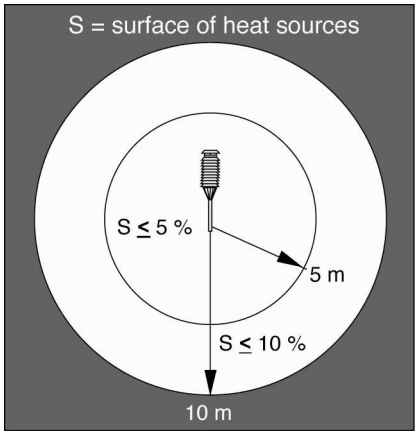


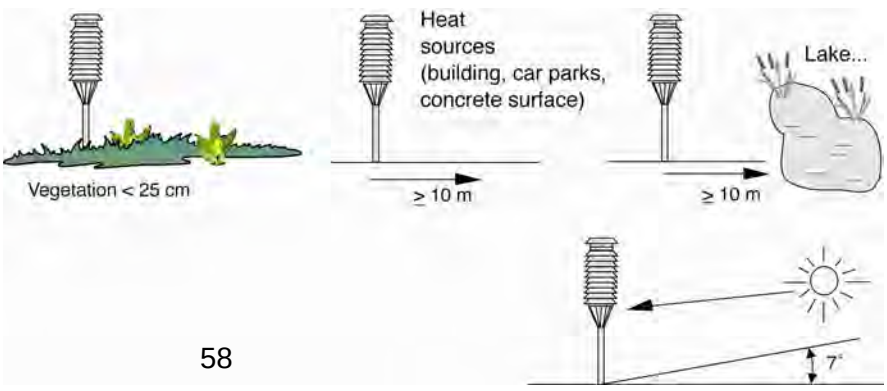




**Class 3 (additional estimated uncertainty added by siting up to 1 °C)**

- 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 °.

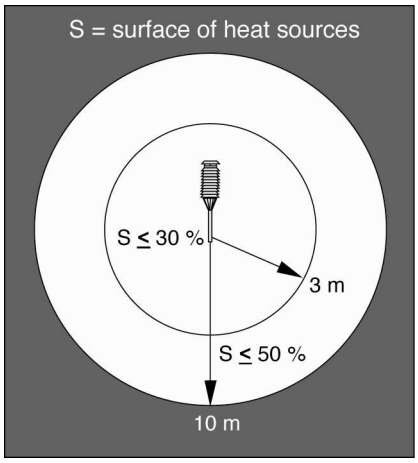
A source of heat (or expanse of water) is considered to have an impact if it occupies more than 10 % of the surface within a circular area of 10 m surrounding the screen or makes up 5% of an annulus of 5m.

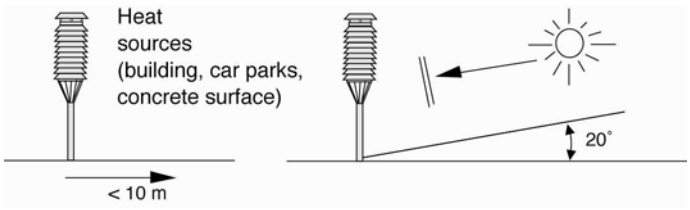


**Class 4 (additional estimated uncertainty added by siting up to 2 °C)**

- 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.

**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).

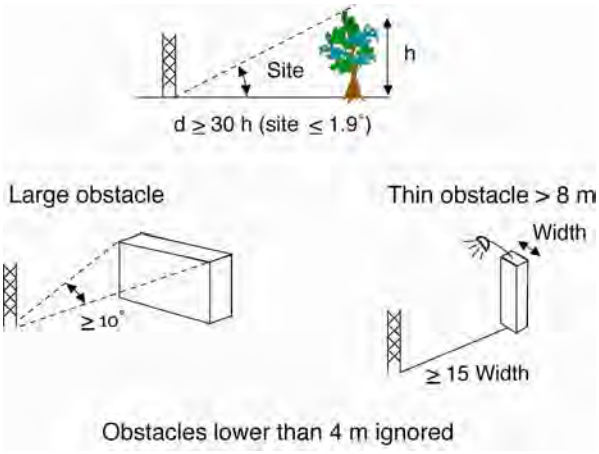
In the following, an object is considered to be an obstacle if its angular width is over 10°, except for tall thin obstacles, as mentioned below.

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.

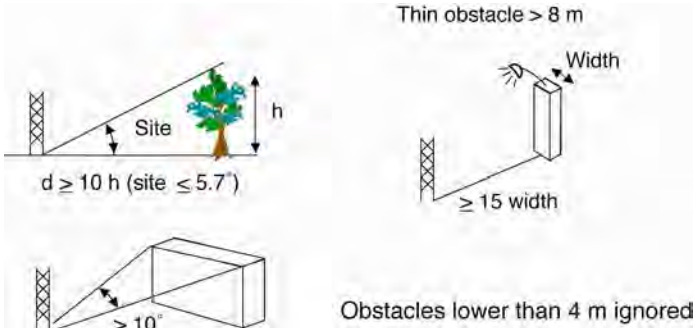



- Roughness class index is between 2 to 4 (roughness length ≤ 0.1 m).

**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.



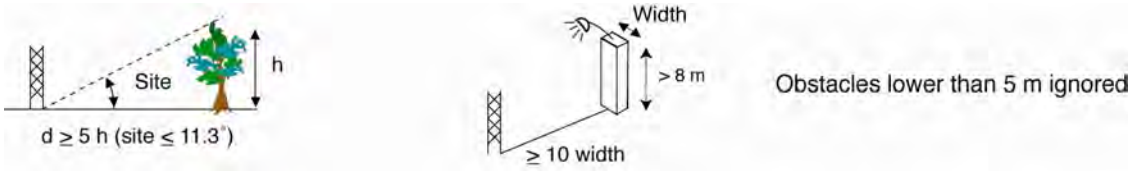

- Roughness class index is between 2 to 5 (roughness length ≤ 0.25 m).

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.

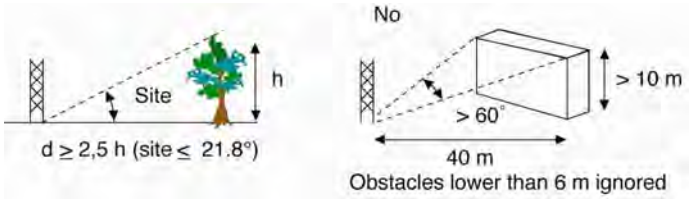
Single obstacles lower than 5 m can be ignored.



**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.

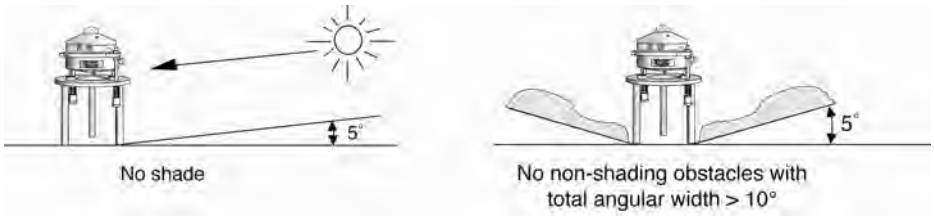
An obstacle is considered as reflecting if its albedo is greater than 0.5.

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°.

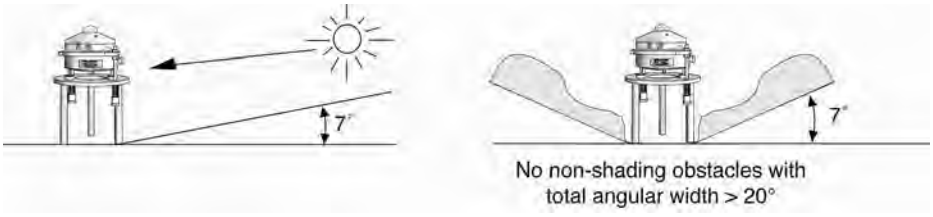



**Class 2**

- 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°.

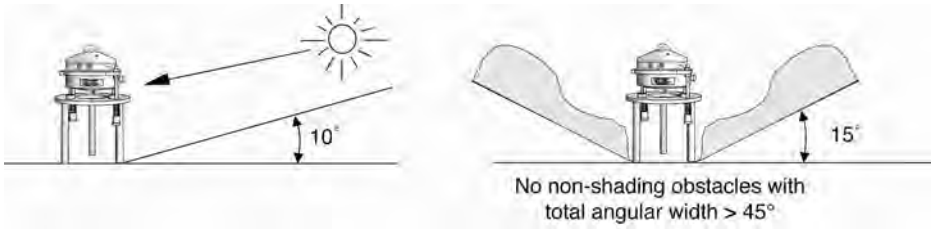



**Class 3**

- No shade projected onto the sensor when the Sun is at an angular height of over 10°.

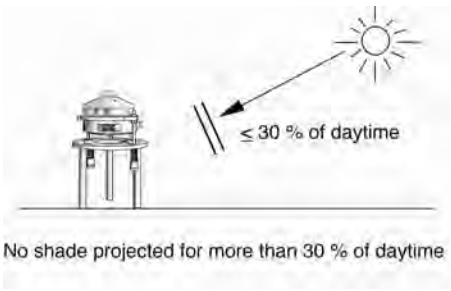
  For regions with latitude ≥ 60°, this limit is decreased to 7°.

- 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.

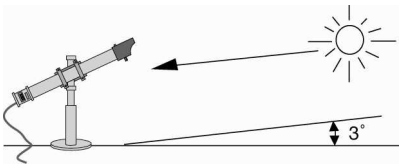
**Direct radiation and sunshine duration**

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.

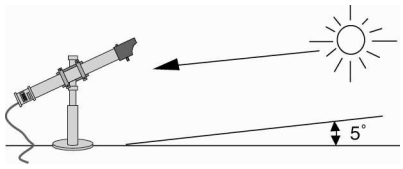
**Class 1**

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



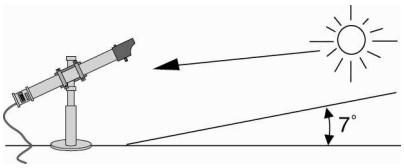

**Class 2**

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



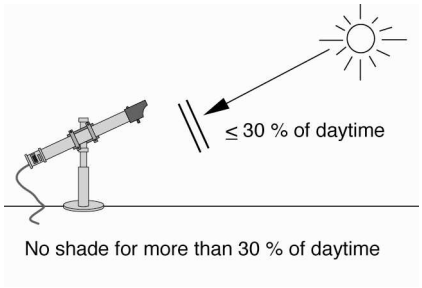

**Class 3**

- 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 $\alpha$ and an angular width of $\beta$ (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