EXTRACT FROM ABRIDGED FINAL REPORT OF THE COMMISSION FOR INSTRUMENTS AND METHODS OF OBSERVATION

ANNEX IV
Annex to paragraph paragraph 4.36 of the general summary

SITING CLASSIFICATIONS FOR SURFACE OBSERVING STATIONS ON LAND

Environmental conditions of a site[1] may generate measurement errors exceeding the tolerances envisaged for instruments. More attention is usually given to the characteristics of the instrument than to the environmental conditions in which the measurement is made and it is often environmental conditions that distort results, influencing their representativeness, particularly when a site is supposed to be representative of a large area (i.e. 100 to 1 000 km^2).

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

There are sites that 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 km^2) and where meteorological measurements should be avoided. The smaller the siting class, the higher the representativeness of the measurement for a wide area. A site with a poor class number (large number) can still be 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 in 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.

Judging from the experience of Météo-France, the classification process helps the actors and managers of a network to better take in to consideration the exposure rules, and thus it 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.

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

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 the 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 to 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 areas generally lead to high class numbers. 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).

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 infrared (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).

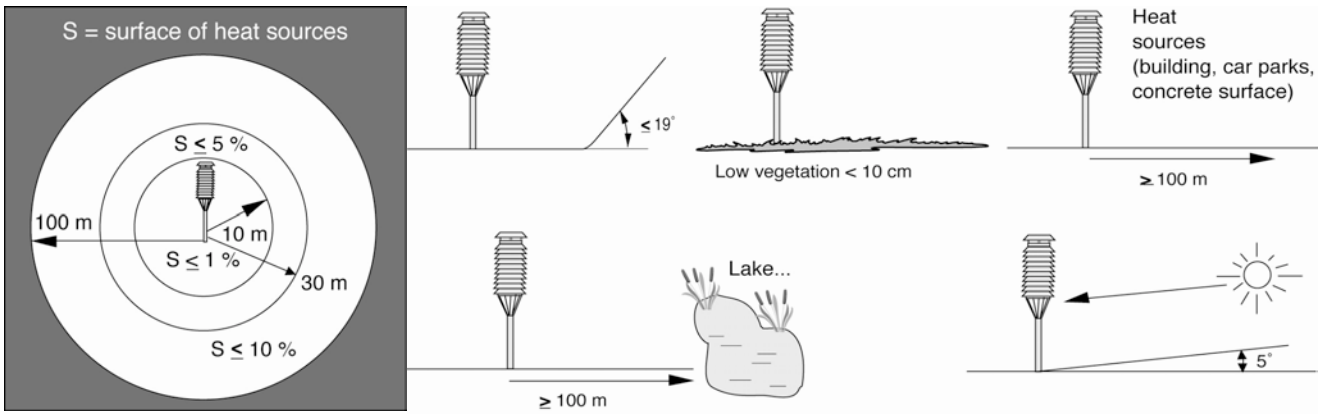
Shading by nearby obstacles should be avoided. Shading due to natural relief is not taken into account for the classification (see above).

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°.

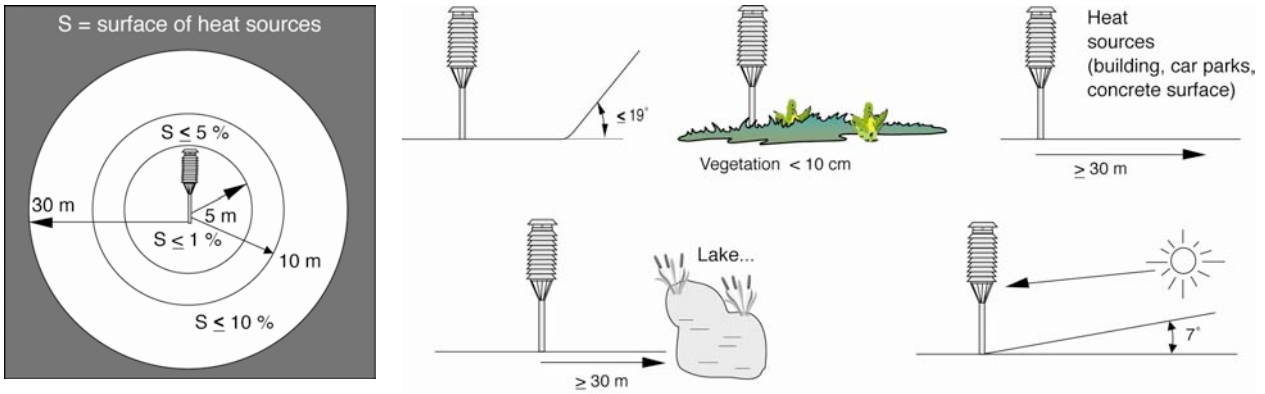
A source of heat (or expanse of water) is considered to have an impact if it occupies more than 10% of the surface within a circular area of 100 m surrounding the screen, makes up 5% of an annulus of 10m–30m, or covers 1% of a 10 m circle.



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°.

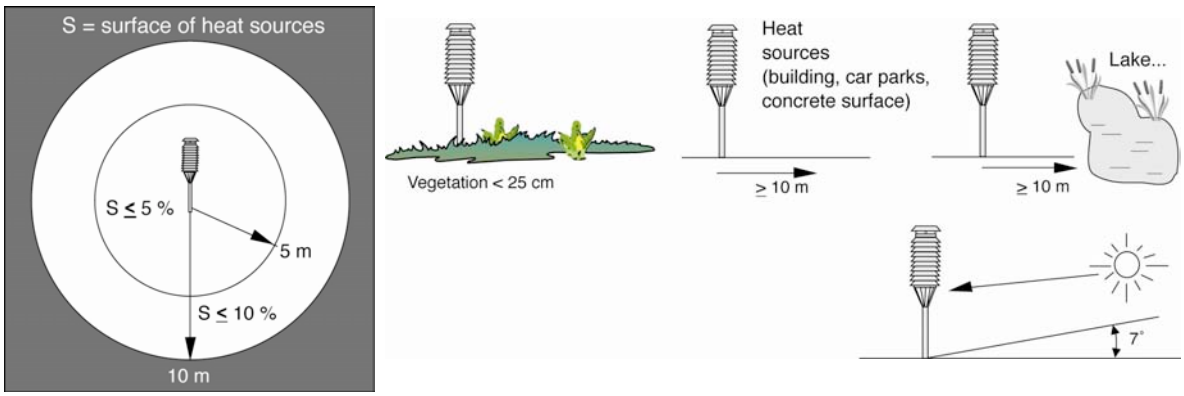
A source of heat (or expanse of water) is considered to have an impact if it occupies more than 10% of the surface within a circular area of 30 m surrounding the screen, makes up 5% of an annulus of 5m–10m, or covers 1% of a 5 m circle.



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

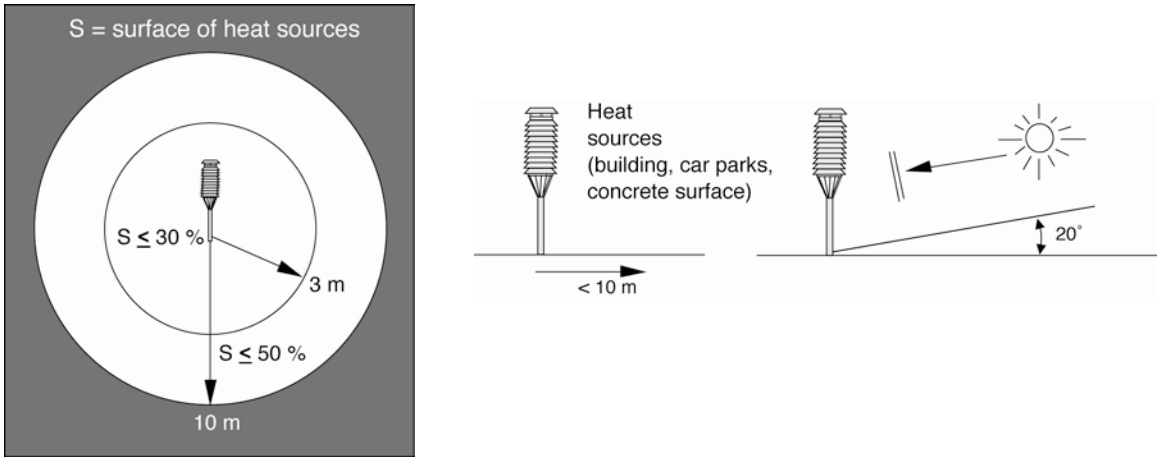
- Ground covered with natural and low vegetation (<25 cm) representative of the region;
- Measurement point situated:
  - at more than 10 m from artificial heat sources and reflective surfaces (buildings, concrete surfaces, car parks, etc.)
  - at more than 10 m from an expanse of water (unless significant 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 5 m.



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

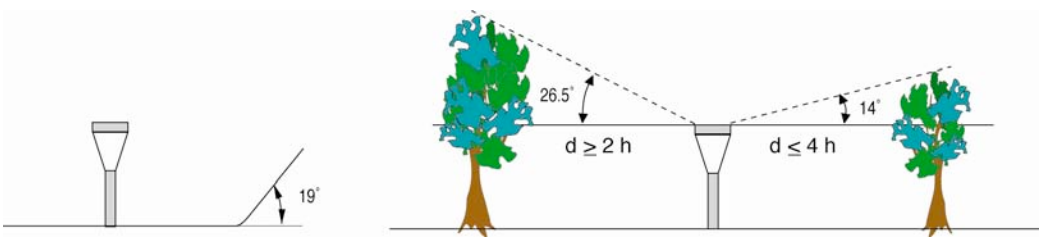
Wind is the greatest source of disturbance in precipitation measurements, due to the effect of the instrument on the airflow. Unless raingauges are artificially protected against wind, for instance by a wind shield, the best sites are often found in clearings within forests or orchards, among trees, in scrub or shrub forests, or where other objects act as an effective windbreak 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.

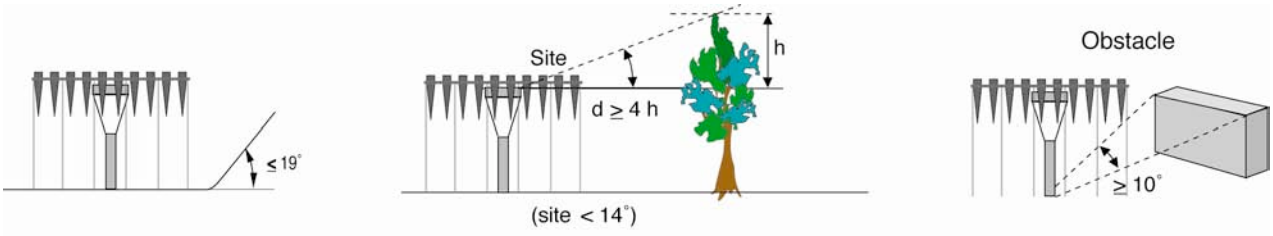
Reference for the heights of obstacles is the catchment's height of the rain gauge.

Class 1

- Flat, horizontal land, surrounded by an open area, slope less than 1/3 (19°). Raingauge 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

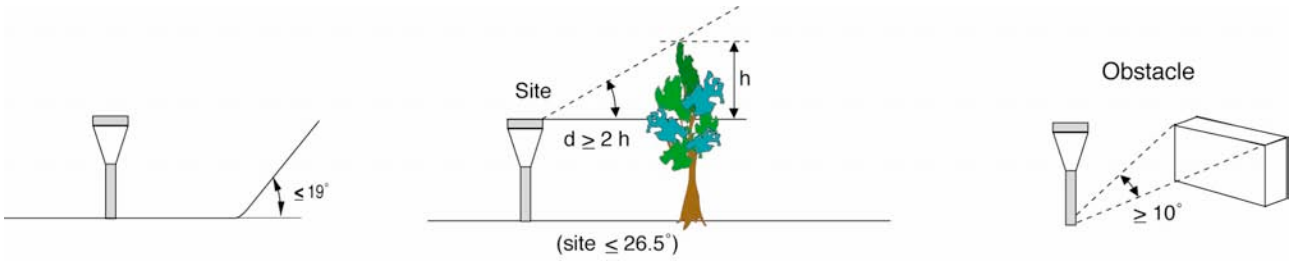


- Flat, horizontal land, surrounded by an open area, slope less than 1/3 (19°). For a raingauge artificially protected against wind, the instrument does not necessarily need to be protected by obstacles of uniform height. In this case, any other obstacles must be situated at a distance of at least 4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

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

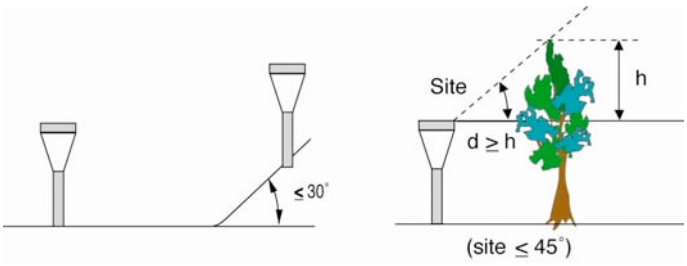
- Flat, horizontal land, surrounded by an open area, slope less than 1/3 (19°);

- 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 raingauge).



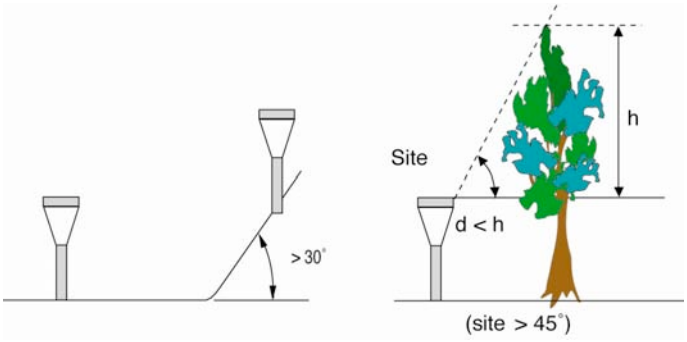
Class 3 (additional estimated uncertainty added by siting up to 15%)

- 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.).

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 disturbed not only by surrounding obstacles; terrain roughness also plays a role. 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_0		
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: $x/H \sim 10$	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 measurements are carried out at lower height (such as measurements 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 be placed 10 meters above the average height of the obstacles. This method allows the influence of the adjacent obstacles to be minimized. This method represents a permanent solution for partly eliminating the influence of certain obstacles. It inconveniently imposes the necessity for higher

masts that are not standard and consequently are 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).

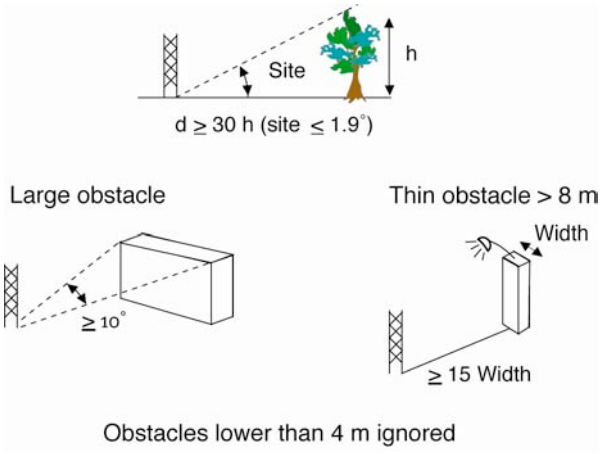
In the following, an object is considered to be an obstacle if its angular width is over 10°, except for tall thin obstacles, as mentioned below.

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.

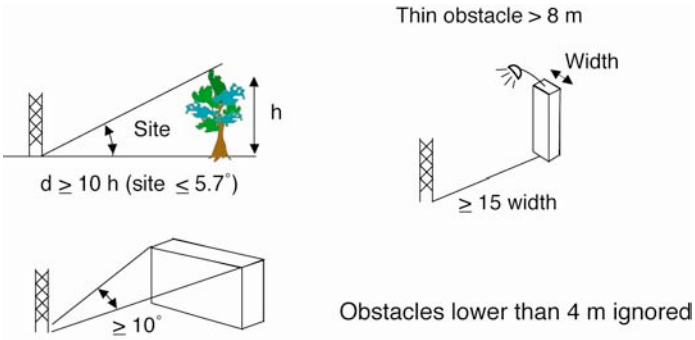


- Roughness class index is between 2 to 4 (roughness length ≤ 0.1 m).

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.



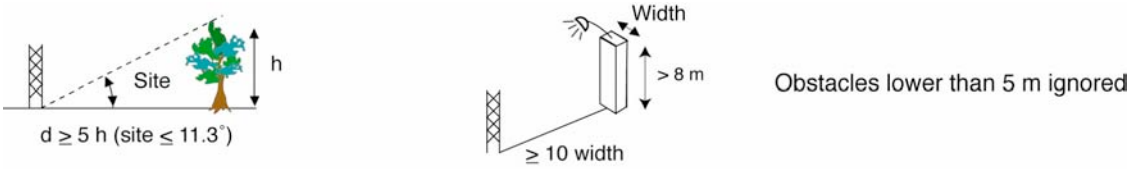
- Roughness class index is between 2 to 5 (roughness length ≤ 0.25 m).

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.

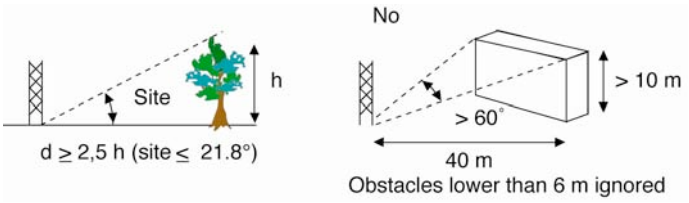
Single obstacles lower than 5 m can be ignored.



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

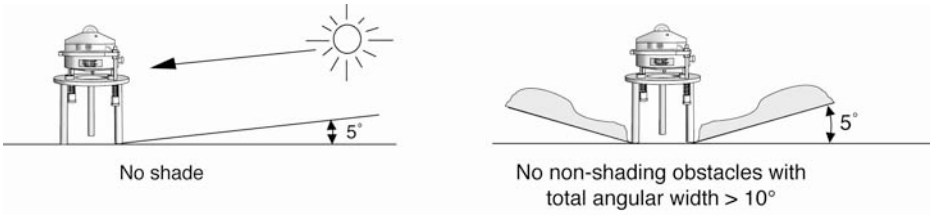
Close obstacles have to be avoided. Shading due to the natural relief is not taken into account for the classification. Non-reflecting obstacles below the visible horizon can be neglected.

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.

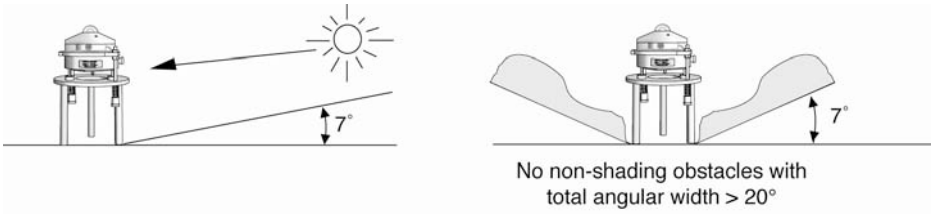
Class 1

- 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°.



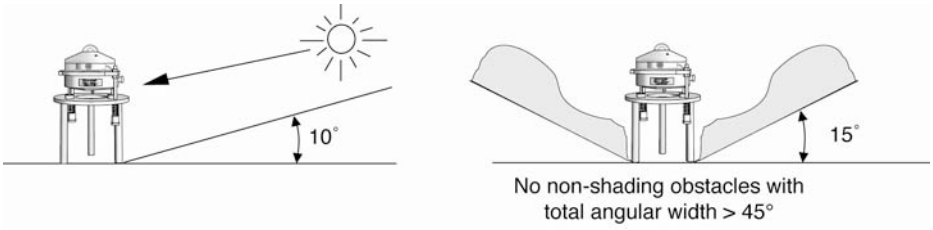
Class 2

- 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°.



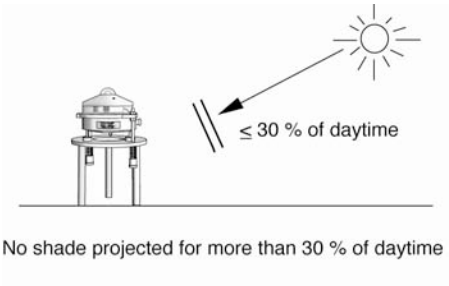
Class 3

- 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.

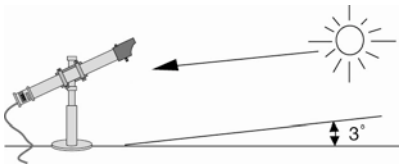
DIRECT RADIATION AND SUNSHINE DURATION

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.

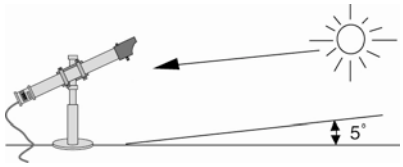
Class 1

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



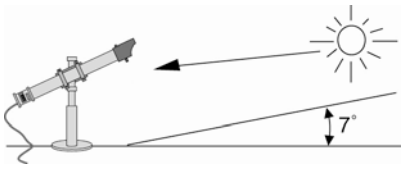
Class 2

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



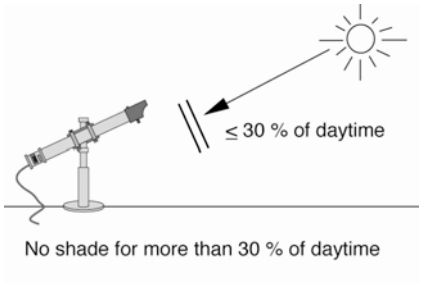
Class 3

- 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.