

WORLD METEOROLOGICAL ORGANIZATION

**COMMISSION FOR INSTRUMENT AND
METHODS OF OBSERVATION
*OPAG-SURFACE***

**EXPERT TEAM ON SURFACE TECHNOLOGY AND
MEASUREMENT TECHNIQUES
*First Session***

Geneva, Switzerland, 13-16 October 2004

CIMO/OPAG-SURFACE/
ET ST&MT-1/Doc. 4.3(2)

(6.X.2004)

ITEM: 4.3

Original: ENGLISH ONLY

THE STATE-OF-THE-ART OF INSTRUMENTS AND AUTOMATED SURFACE OBSERVING SYSTEMS (ASOS)

Development of Siting Criteria and Metadata Standards

Submitted by Chairman

Summary and Purpose of Document

The document contains an introduction on the activities so far to develop guidance material on siting criteria and metadata.

ACTION PROPOSED

The meeting is invited to take notice of the document and to supply suggestions or recommendations on how to provide new documentation and guidelines on siting criteria and metadata standards.

References:

1. CIMO-XIII, abridged final report (WMO-No. 947)
2. CIMO MG (2003) final report
3. Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8, next ed.)
4. Guide on the Global Observing System (WMO-No. 488)
5. Guide to Climatological Practices (WMO-No. 100)
6. Guide to Agricultural Meteorological Practices (WMO-No. 134)

Background

1.1. Introduction

It's a trivial statement that siting of instruments is relevant when observations should be representative for any surrounding area. Many Members follow their own policy on selecting sites and the design of a weather station. In particular for the design and siting of AWS it is not always clear what observation policy is followed. Sites, which are easy to access, but located in the neighborhood of roads, building and forests are chosen. Moreover the design of the weather observing equipment (sensors or systems) is sometimes clustered in a way that without any doubt the measurements will influence each other. Sometimes it is obvious that the designer has not considered any sensing technological precautions and just placed the sensor on a way, which is easy to be connected to the data acquisition system of the AWOS.

Nevertheless, design and siting are well described in a number of WMO Manuals and Guides and IOM's. A point of discussion is sometimes that an *ideal* site cannot be found because of natural and artificial limitations. However in those cases any clarification for the location chosen is not always based on what is recommended or on *common sense*, as suggested in many documents.

The measure of representativity of a station is of outmost relevance for the user of observational data, because these data can easily be misinterpreted due to the lack of knowledge on these siting aspects. And not only the location of a station, but also the placements of the sensors and further constructions, which might influence the measurements has to be considered by the user. Moreover knowledge of the state of maintenance of instruments, other equipment and the terrain itself is extremely relevant for further data interpretation and validation. All those issues (location choice, installation, up-to-date knowledge of the state-of-the-art) have to be well documented. In general such information is mentioned *metadata*, *i.e.* data-of-data.

Because the amount of data that can be transmitted today has increased significantly, it is possible nowadays to transmit these metadata easily together with the observational data itself. As a consequence, Congress has adopted the recommendations from CBS to further develop this *metadata* policy. In particular Cg-XIV has stated to following:

3.1.2.13 Congress noted with appreciation that CBS developed a core metadata standard, based on the ISO standard for geographic metadata, with a view to describing sata exchanged by all WMO Programmes in an unambiguous way. Noting the crucial importance of metadata for the FWIS, Congress requested all WMO Programmes to join their efforts in the further development of detailed WMO metadata standards.

Res. 2 (Cg-XIV), World Weather Watch Programme for 2004-2007:

The Congress expresses:

...

- (e) An improved GTS capacity and further implementation of advanced telecommunication techniques and services including data communications network services, improved MTN project, the coordinated data communications protocols and the file transfer practices, a file naming convention and a WMO metadata standard, recommended practices on the use of XML.

...

These statements are based on previous discussion during CBS-Ext(02):

METADATA STANDARDS

6.2.43 The Commission emphasized that technical data exchange was the key to the success of the WMO Programmes. As the variety and volume of data increased, the need for describing those data

in an unambiguous way became essential if best use was to be made of data within and between different Programmes. A standard approach to describing data was central to the concepts behind the proposals for the future WMO information system. "Metadata" was the technical term used for the information that described data. There were three stages in making use of data; a different level of detail was required for metadata at each stage: (a) "Discovery level." The first step in using data was to find out ("discover") where the data of interest might be obtained; (b) "Request level." Once potential sources of data had been identified, the user could approach one of the data providers with a more specific request; (c) "Usage and management level." The third level of metadata was more detailed, describing not only the general aspects of the data but also specific details (such as the precision and units).

6.2.44 The Commission endorsed the conclusions of the report of the Expert Team on Integrated Data Management that the ISO standard for geographic metadata was suitable for use within WMO (ISO DIS 19115). Using an existing standard as the basis for metadata within WMO permitted to have access to skills and tools from communities outside WMO. The Commission noted the WMO core minimum set of information that was considered to be essential for exchanging data for WMO purposes. That was intended to be adequate for the "discovery" level.

6.2.45 The Commission recognized that the information in the WMO core metadata would not itself meet all the requirements for describing data for all WMO Programmes. A far more comprehensive standard would be required for that. The Commission recommended that each WMO Programme use the WMO core metadata as a starting point to develop more detailed metadata standards in response to its own requirements. Those more-detailed programme-specific standards should, to the extent possible, be based on the ISO standard with any necessary extensions. Reliance on the ISO standard as a common starting point would reduce the effort required by the Programmes and would greatly enhance the compatibility between the various Programme-specific standards and with the WMO core metadata standard.

6.2.46 Noting that there were many possible ways of representing WMO metadata, the Commission endorsed the recommendation that XML be adopted as the common language (or format) for exchange. It noted that a framework for mapping the proposed metadata standard into XML was developed as an XML schema to ensure interoperability. The Commission recognized that several further actions were required before WMO could adopt the metadata standard for operational use. Key among those was to apply the draft standard to data held by several Programmes, so that practical problems with using the standard could be identified and corrected before the standard was finalized. The second action needed was to publicize the standard, both within WMO technical commissions and elsewhere (for example, registering the interpretation of the standard with ISO). The third major action was to work with other expert teams to implement the detailed metadata required to provide the "management and usage" layer and also the technical mechanisms to transfer metadata with the data they described.

6.2.47 The Commission requested its OPAG on ISS to pursue the development of the WMO metadata standard, and tasked its chairperson to involve, to the largest extent possible, members of other technical commissions in assessing the proposal and in testing the standard by applying it to their data. It also invited its president to address that important matter at a future meeting of presidents of technical commissions.

MODIFICATIONS TO THE *MANUAL ON CODES (WMO-NO. 306)*

6.2.57 Noting the stated requirements for improving the transmission of data from AWS, XBT/XCTD and subsurface floats, and CLIMAT stations as well as the resulting proposals developed by expert groups and CBS teams, ***the Commission recommended additions related to metadata and capability of sensors*** to FM 94 BUFR and FM 95 CREX tables (see Annex 2 to Recommendation 4 (CBS-Ext.(02))).

In line with this policy (CBS-Ext.(02) also agreed that "Maintenance of accurate metadata for all AWS" installations should be implemented as a matter of urgency, a task for the Expert Team on Requirements for Data from Automatic Weather Stations (ET-AWS).

1.2. Available Documentation

Guidance material on *siting* and *metadata* is provided in several Guides like the Guide to Meteorological Instruments and Methods of Observation (WMO-No.8, new revision), The Guide on the Global Observing System (WMO-No. 488), the Guide to Climatological Practices (WMO-No. 100) and the Guide to Agricultural Meteorological Practices (WMO-No. 134). Relevant text copied from those Guides are given in Annex I.

Guidance material on *siting* is issued by WMO/CIMO in 1993 as IOM-report: IOM 55 (WMO/TD 589), J. Ehinger, *Instruments Siting and Exposure of Meteorological Instruments* (available at WMO HQ). At present this CIMO publication is the most detailed document. Nevertheless this document does not contain typical "recommendations for standardization of siting criteria", which will be helpful in particular for the design of a network of AWSs.

Recently WMO/CCI has issued a report in the WCDMP "Guidelines" Series, Entitled *Guidelines On Climate Metadata And Homogenization*, by Aguilar *et al.* (WCDMP-53 (WMO/TD No. 1186)). This document contains much recommendation on both *siting* and *metadata*.

Activity plan

2.1. Planned activities

In line with CIMO XIII, the CIMO management group has decided to continue the work on further developing guidelines on siting and on metadata standards, and to recommend WMO regulations on this matter.

To realize this request, further review of existing and newly available publications on this topic will be carried out. As a result, recommendations for standards will be developed and proposed at the next CIMO. Furthermore, recommended practices have to be published in an IOM report.

2.2. Time Table

	<i>Deliverable</i>	<i>deadline</i>
a.	Update relevant IOM Reports	September 2005
b.	Update of relevant chapters of the CIMO Guide	September 2005
c.	Monitoring reports of activities ensuring consistency of CIMO Guide with Guide of CCI, CHy and AgM, and with Manual on GOS and Technical Regulations	February 2005

Relevant text on *siting* and *metadata* copied from:

- ?? Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8, next ed.)
- ?? Guide on the Global Observing System (WMO-No. 488)
- ?? Guide to Climatological Practices (WMO-No. 100)
- ?? Guide to Agricultural Meteorological Practices (WMO-No. 134)

?? *Reference:* Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8, next ed.)

1.1.3 **Metadata**

The purpose of this Guide and of related WMO publications is to ensure reliability of observations by standardization. However, local resources and circumstances may cause deviations from the agreed standards of instrumentation and exposure. A typical example is that in regions with much snowfall the instruments are mounted higher than usual so that they may be useful in winter as well as in summer.

Users of meteorological observations often need to know the actual exposure, type and condition of the equipment and its operation; and perhaps the circumstances of the observations. This is now particularly significant in the study of climate, in which detailed station histories have to be examined. Metadata (data about data) should be kept concerning all the station establishment and maintenance matters described in section 1.3, and concerning the changes which occur, including calibration and maintenance history and the changes in exposure and staff (WMO, 2004). Metadata are especially important for the elements that are particularly sensitive to exposure, such as precipitation, wind and temperature. One very basic form of metadata is information on the existence, availability and quality of meteorological data and of the metadata about them.

1.3.3 **Siting and exposure**

1.3.3.1 **SITE SELECTION**

Meteorological observing stations are designed to enable representative measurements (or observations) to be made according to the type of station involved. Thus, a station in the synoptic network should make observations to meet synoptic-scale requirements whereas an aviation meteorological observing station should make observations that describe the conditions specific to the local (aerodrome) site. Where stations are used for several purposes, e.g. aviation, synoptic and climatology, the most stringent requirement will dictate the precise location of an observing site and its associated sensors. A detailed study on siting and exposure is published by WMO (1993a).

As an example, the following considerations apply to the selection of site and instrument exposure requirements for a typical synoptic or climatological station in a regional or national network:

- (a) outdoor instruments should be installed on a level piece of ground, approximately 10 metres by 7 metres (the enclosure), covered with short grass or a surface representative of the locality, and surrounded by open fencing or palings to exclude unauthorized persons. Within the enclosure, a bare patch of ground about 2 metres by 2 metres is reserved for observations of the state of the ground and of soil temperature at depths of less than 30 centimetres;
- (b) there should be no steeply sloping ground in the vicinity and the site should not be in a hollow. If these conditions are not complied with, the observations may show peculiarities of entirely local significance;
- (c) the site should be well away from trees, buildings, walls or other obstructions. The distance of any such obstacle (including fencing) from the raingauge should not be less than twice the height of the object above the rim of the gauge, and preferably four times the height;
- (d) the sunshine recorder, raingauge, and anemometer must have exposures to satisfy their requirements, preferably on the same site as the other instruments;
- (e) it should be noted that the enclosure may not be the best place from which to estimate the wind speed and direction; another observation point, more exposed to the wind, may be desirable;

- (f) very open sites which are satisfactory for most instruments are unsuitable for raingauges. For such sites, the rainfall catch is reduced in other than light winds and some degree of shelter is needed;
- (g) if in the surroundings of the instrument enclosure, maybe at some distance, objects like trees or buildings obstruct the horizon significantly, then for observations of sunshine or radiation alternative viewpoints should be selected;
- (h) the position used for observing cloud and visibility should be as open as possible and command the widest possible view of the sky and the surrounding country;
- (i) at coastal stations, it is desirable that the station should command a view of the open sea, but it should not be too near the edge of a cliff because the wind eddies created by the cliff will affect the measurements of wind and the amount of precipitation;
- (j) night observations of cloud and visibility are best made from a site unaffected by extraneous lighting.

It is obvious that some of the above considerations are somewhat contradictory and require compromise solutions. Detailed information appropriate to specific instruments and measurements is given in the succeeding chapters.

ANNEX 1.D

STATION EXPOSURE DESCRIPTION

The accuracy with which an observation describes the state of a selected part of the atmosphere is not the same as the accuracy of the instrument, because the value of the observation also depends on the instrument's exposure to the atmosphere. This is not a technical matter, so its description is the responsibility of the station observer or attendant. In practice, an ideal site with perfect exposure is seldom available, and unless the actual exposure is adequately documented the reliability of observations cannot be determined (Wieringa and Rudel, 2002).


Station metadata should contain the following aspects of instrument exposure:

- (a) height of the instruments above the surface (or below it, for soil temperature);
- (b) type of sheltering and degree of ventilation for temperature and humidity;
- (c) degree of interference from other instruments or objects (masts, ventilators);
- (d) microscale and toposcale surroundings of the instrument, in particular—
 - (i) the state of the enclosure's surface, influencing temperature and humidity; nearby major obstacles (buildings, fences, trees) and their size;
 - (ii) the degree of horizon obstruction for sunshine and radiation observation;
 - (iii) surrounding terrain roughness and major vegetation, influencing the wind;
 - (iv) all toposcale terrain features such as small slopes, pavement, water surfaces;
 - (v) major mesoscale terrain features, such as coasts, mountains or urbanization.

Most of these matters will be semi-permanent, but any significant changes (growth of vegetation, new building) should be recorded in the station logbook, and dated.

For documenting the toposcale exposure, a map of scale not larger than 1 : 25,000 showing contours of ~ 1 m elevation differences is desirable. On this map the locations of buildings and trees (with height), surface cover, and of installed instruments should be marked. At map edges, major distant terrain features (built-up areas, woods, open water, hills etc.) should be indicated. Photographs are useful if they are not merely close-ups of the instrument or the shelter, but are taken at sufficient distance to show the instrument and also its terrain background. Such photos should be taken from all cardinal directions.

The necessary minimum metadata for instrument exposure can be provided by filling in the template given below for every station in a network. The classes used here for describing terrain roughness are given in chapter 5 (Wind) of this Guide. More extensive description of metadata matters is given in WMO (2004).

Station	Update													
Elevation	Latitude	Longitude												
<div style="display: flex; justify-content: space-between;"> <div style="width: 30%;"> <p>0 100 m</p>  <p>□ enclosure</p> <p>▨ building</p> <p>/// road</p> <p>X X trees, bush</p> <p>(12) height (m) of obstacle</p> <p>+3 elevation contour</p> </div> <div style="width: 65%; border: 1px solid black; padding: 10px; position: relative;"> <div style="position: absolute; top: 5px; left: 5px;">↑ N</div> <div style="position: absolute; top: 50px; left: 50px; width: 20px; height: 20px; border: 1px solid black; text-align: center; line-height: 20px;">□</div> </div> </div>														
<p><u>Radiation horizon</u></p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 10%; text-align: right;">1 : 6</td> <td style="width: 80%; border-bottom: 1px solid black;"></td> <td style="width: 10%; text-align: right;">8°</td> </tr> <tr> <td style="text-align: right;">1 : 10</td> <td style="border-bottom: 1px solid black;"></td> <td style="text-align: right;">4°</td> </tr> <tr> <td style="text-align: right;">1 : 20</td> <td style="border-bottom: 1px solid black;"></td> <td style="text-align: right;">0°</td> </tr> <tr> <td></td> <td style="text-align: center;">N E S W N</td> <td></td> </tr> </table>			1 : 6		8°	1 : 10		4°	1 : 20		0°		N E S W N	
1 : 6		8°												
1 : 10		4°												
1 : 20		0°												
	N E S W N													
<p><u>Temperature and humidity</u> : sensor height</p> <p style="padding-left: 150px;">artificial ventilation ? yes / no</p> <p>Surface cover under screen</p> <p>Soil under screen</p> <p><u>Precipitation</u> : gauge rim height</p> <p><u>Wind</u> : anemometer height free-standing ? yes /no</p> <p>(If not: above building of height ,width ,length</p> <p>Terrain roughness class: to N ,to E ,to S ,to W</p> <p><u>Remarks</u> :</p>														

General template for station exposure metadata

Reference: *Guide on the Global Observing System* (WMO No. 488; 1988; Suppl. No. 1 (VI.1994))

3.2.1.2 Land stations*

3.2.1.2.1 Siting (location) of stations

Each station making surface synoptic observations should be located at a site where the meteorological data obtained are representative of the state of the atmosphere over a large region. The dimensions of this region, or area of representativity, may range from 2 000 km² to 10 000 km² (for a plane or homogeneous relief).

The station should have a plot of land specially assigned to it. The optimum area is approximately 1 ha.

The location of the observing posts (meteorological instrument area) should be typical of the physico-geographical conditions of the surrounding area and protected from the influence of industry. It is therefore necessary to locate a meteorological instrument area in an open site far from any constructions or woods. The minimum distances from constructions and groups of trees should be greater than 10 times and 20 times their heights respectively. The site should also be farther than 100 m from bodies of water, except where coastal measurements are required.

3.2.1.2.2 Meteorological observing area

The meteorological observing area is where most of the instruments and devices are situated. The observing area should preferably be no smaller than 25 m x 25 m where there are many installations, but in cases where there are relatively few installations (as in Figure III.1) the area may be considerably smaller. The sides of the observing area should be oriented north-south and east-west. An adequate north-south dimension is very important for measurements, which can be strongly influenced by shadow (e.g. radiation, sunshine duration, temperature gradients just below and above the ground).

The instruments and equipment should be set out in a definite order, in several rows or lines. In the northern hemisphere the sensors are arranged as follows: wind-measuring equipment on the north side, along with temperature and humidity equipment, then a row of precipitation gauges with soil temperature measurement taking place in the southern part of the observing area. Figure III.1 provides an example of the layout of an observing station in the northern hemisphere showing minimum distances between installations.

The meteorological observing area should be fenced, but not with solid fencing material; large-mesh wire netting is the most suitable while palings, picket fences, hedges, clay enclosures, etc. are unsuitable. In the Arctic, desert and certain other regions, the observing area may not need to be fenced and may simply be marked out.

The surface of the observing area must be left in its natural state (grass should be kept down to 20 cm). The area should not be walked on except along paths or tracks. Paths should not be of asphalt or concrete. In the interest of safety, the electrical voltage supplied to the equipment shall not exceed 24 or 36 volts. Installations should preferably be painted white (any other colour may be used for masts and fencing).

* The requirements for the siting of stations and instrument exposure given in this section apply to an 'ideal' situation, which should be attained where possible. It is understood that these requirements cannot always be fully met for one reason or another

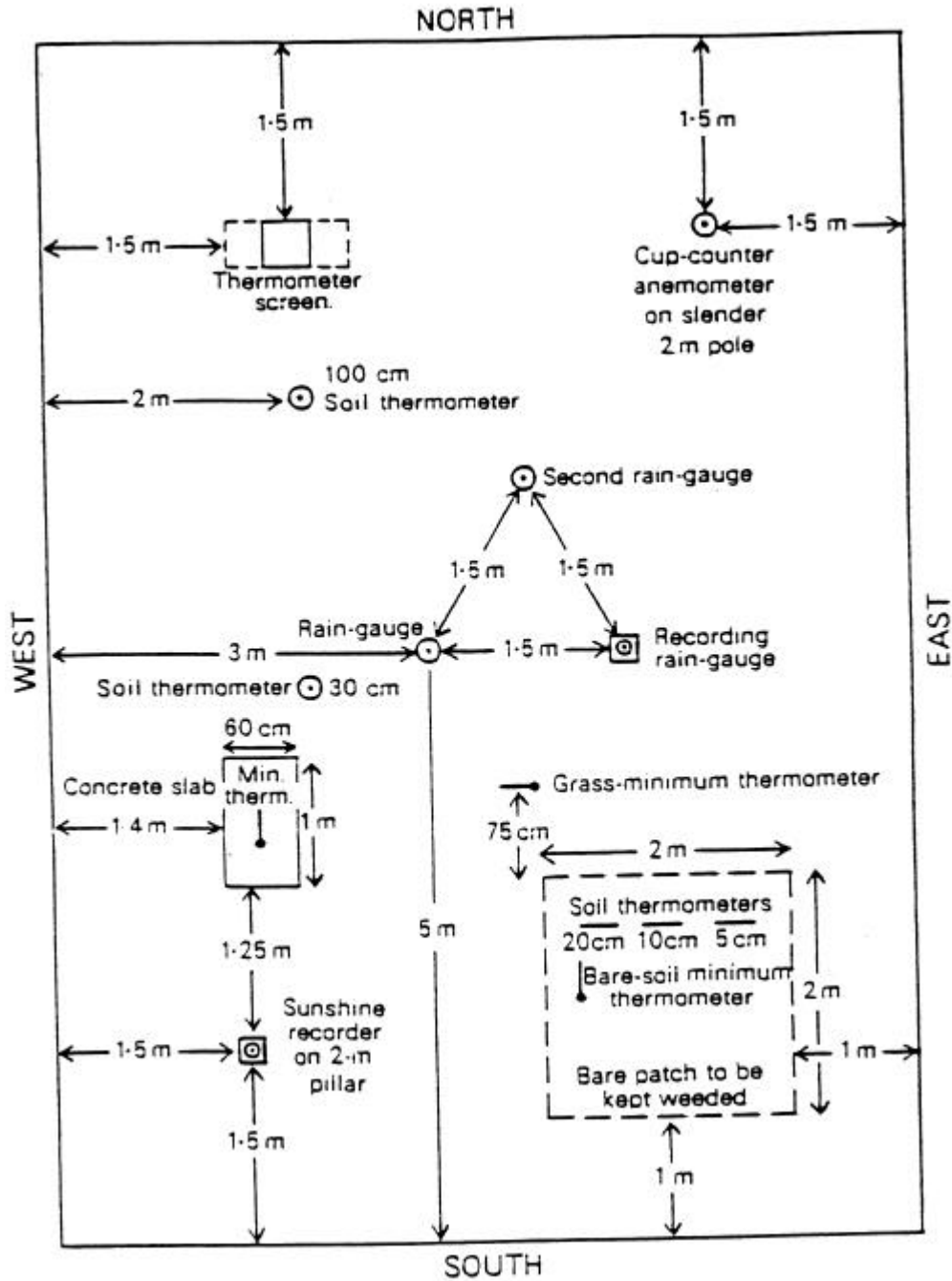


Figure III.1- Layout of an observing station in the northern hemisphere showing minimum distances between installations

(Source: UK Meteorological Office, Observer's Handbook, 4th edition, 1982)

Reference: Guide to Climatological Practices (WMO No. 100; 2001 edition)

The Siting of Climatological Stations

The precise exposure requirements for specific instruments used at climatological stations, aimed at optimizing the accuracy of the instrumental measurements, are discussed in the Manual on the Global Observing System, Part III (WMO No. 544), and in the Guide to Meteorological Instruments and Methods of Observation (WMO No. 8). However, the representativeness and/or homogeneity of the climatological record are closely related to the choice of location of the observing site. A station sited on, or near a steep slope, ridge, cliff, hollow, building, wall or other obstruction, is likely to provide data which are representative of only the site. A station which is or will be affected by the growth of vegetation, including even limited tree growth near the sensor, growth of tall crops or woodland nearby, by the erection of buildings on adjacent land, or by increases (or decreases) in road or air traffic including that due to change in use of runways or taxiways will provide neither representative nor homogeneous data.

A climatological observing station should be sited at a location which permits the correct exposure of the instrumentation (this may occasionally give rise to a split site), and allows the widest possible view of the sky and surrounding country if visual (i.e., non-instrumental) data are required. Ordinary and Principal Climatological Stations should be sited on a level piece of ground covered with short grass; the site should be well away from trees, buildings, walls, and steep slopes and should not be in a hollow. A plot size of about 9 m x 6 m is sufficient for outdoor temperature and humidity sensing instruments, and within this an area of 2 m x 2 m of bare ground is ideal for observations of the state of the ground and soil temperature measurements. A slightly larger plot (say 10 m x 7 m) may be necessary to enclose a rain gauge in addition to the other sensors. A rule used in many Services is that the distance of any obstacle, including fencing from the gauge must be more than twice, and preferably four times the height of the object above the rain gauge. Prevention of unauthorized entry is a very important consideration, and may demand enclosure by anything from low, open palings to open high wire fences. Sunshine recorders, rain gauges and anemometers must be on sites with suitable exposures and need not be on the same site as other instruments. In general terms, anemometers require exposure at a distance from any obstruction of at least 10, and preferably 20 times the height of the obstruction, while gauges need some shelter from the wind. Automatic stations will normally need a high level of security to protect against animal and unauthorized human entry, and require the availability of suitable power supplies, and possibly additional protection against floods, leaf debris and blowing sand. A local caretaker is normally needed to cut any grass and for other "housekeeping".

In addition, Ordinary and Principal Climatological Stations should be located at such a place and under such administrative conditions that will allow the continued operation of the station, with the exposure remaining unchanged, for a decade or more. For stations used or established to determine long-period climate change, such as reference climatological stations and other baseline stations in the GCOS network, constancy of exposure and operation is required over many decades. Additional constraints on siting apply to Global Atmosphere Watch (GAW) stations established to provide data on atmospheric chemical composition (see chapter B2 of WMO No. 49, Technical Regulations). These include the need for no significant changes in land use practices within 30-50 km of the site of global stations, and freedom from the effects of local and regional pollution; for example, from major population centres, industrial and extensive farming activities, highways, volcanic activity, forest fires and dust storms. Both global and regional GAW stations should be within 50-70 km of an upper air synoptic station.

When a major relocation of a climatological station is necessary, or when one station is to be replaced by another nearby, it is highly desirable to operate both observing stations for an overlapping period of at least one year to determine the effects of changed instruments or sites on the climatological data. There are thus distinct advantages in supporting long-term operation of two climatological stations in climatologically homogeneous areas.

Reference: Guide to Agricultural Meteorological Practices (WMO No. 134; 2nd edition, 1981)

2.2.2 **Site selection of a station**

The site of a station should be fairly level and free from obstructions. It should be sodded, but wherever the normal climate and soil do not permit a sod cover to be maintained, the ground cover should have, as far as possible, natural cover common to the area. Weeds should be removed and grass in and around the enclosure should be frequently mown to keep it uniformly short. Under no circumstances should the site be concrete, asphalt, or crushed rock. Obstructions such as trees, buildings, and nearby shrubs should not be closer to the instruments than eight to ten times their height. No obstructions should cast shadows during the greater part of the day; brief periods of shadows near sunrise and/or sunset are sometimes unavoidable.

Ideally, the weather station should be located in a place truly representative of the natural conditions in the agricultural or silvicultural region concerned. Areas subject to cold air drainage, near ponds or swamps, particularly if temporary, or locations with frequent sprinkling or flooding, should be avoided. Observations from a standard reference station should be compared with other nearby sites to obtain quantitative differences in the local climatic régime.

Accessibility to the weather station should be another criterion for selection of site from the point of view of both taking observations and maintenance of instruments.

If the weather station is part of a network, another factor to be considered is the use of the data - whether for climatological or for real-time information purposes. If for the latter, a rapid communication system is necessary.

2.2.3 **Layout of station instruments**

To minimize tampering by animals and people, it is very desirable to fence the weather station. A sample layout is shown in Figure 1. This layout for northern hemisphere stations is designed to eliminate as far as possible the shadowing effect of fence posts on instruments and to ensure that direct sunlight does not enter the thermometer screen during observations. In the southern hemisphere the general orientation of instruments will be the reverse, the door of the thermometer screen, for example, will open to the south. At equatorial and tropical stations, of course, the thermometer screen will have doors opening to both the north and the south. All radiation instruments and sunshine recorders should be carefully mounted in a position free from all shadows at all times. The minimum distance between instruments is also indicated in the figure. A larger area is recommended when other instruments and small plants for phenological observations are used.

NORTH

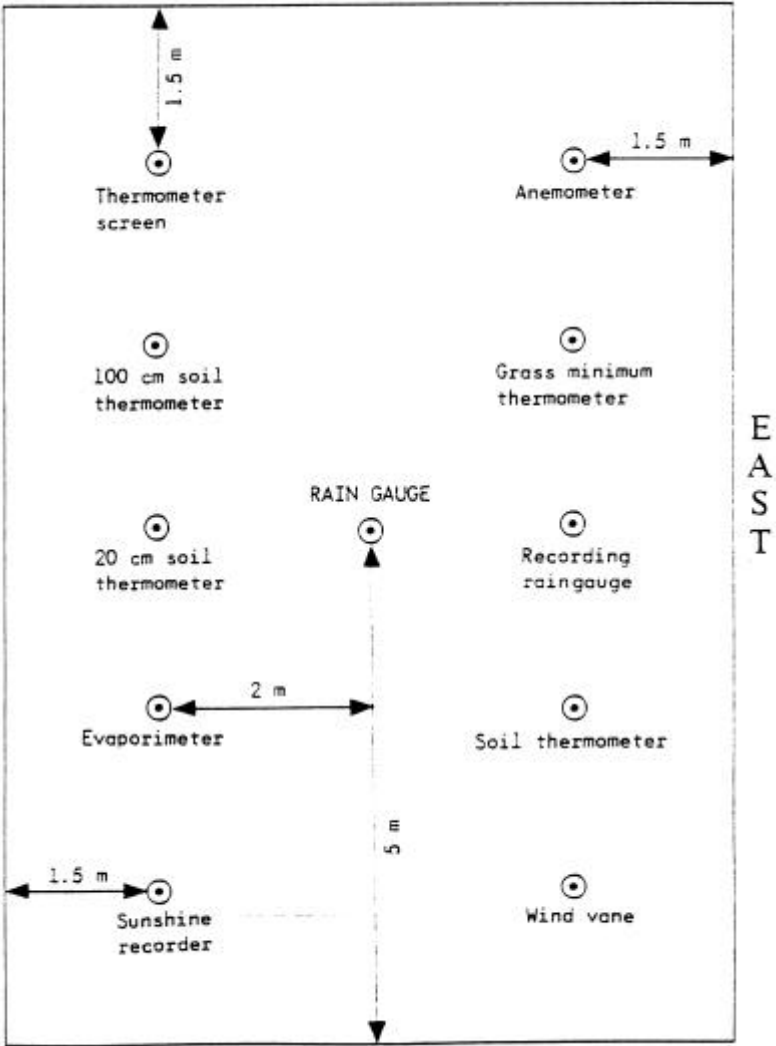


Figure 1 - Sample layout of station