

## Fact sheet No. 17 – Weather observations

### Introduction

Meteorological observations are made for a variety of reasons. The aim of all these observations are essentially to provide data and are a valuable source of information, which is used in a variety of different ways, for example:

- as input to supercomputer forecasting models, which produce local/global weather forecasts
- to help with any weather related issues, e.g. aviation safety
- for climatological analyses, i.e. frequency of extreme events, such as gales or heavy rain
- to answer legal enquiries, where data may have to be presented in a law court



**Figure 1.** Automatic and manual weather observations.

Those observations made primarily for the purpose of providing information for weather forecasts are termed 'synoptic'.



**Figure 2.** Met Office synoptic observing stations (November 2007).

These synoptic observations are not by themselves sufficient to meet all of the needs of, for example, hydrology and industry. Hence, in the United Kingdom there is a further network of voluntary co-operating stations maintained by private individuals, schools and colleges, industrial concerns, local authorities etc. whose records supplement those from the synoptic reporting stations. In addition there is a much larger number of 'rainfall stations' where the only records regularly maintained are those of rainfall.

The Met Office maintains a number of stations undertaking specialised functions; these include observatories and upper-air stations. There are two observatories at Lerwick (Shetland) and Eskdalemuir (Dumfries and Galloway) and six upper-air stations. These are at Lerwick, Albermanle (Northumberland), Watnall (Nottinghamshire), Herstmonceux (East Sussex), Camborne (Cornwall) and Castor Bay (Northern Ireland). Of the six upper air stations, two are manned sites and the remaining four are fully automatic (autosonde). The manned sites are Camborne and Lerwick. Upper-air observations are covered in fact sheet no. 13 in this series.



**Figure 3.** Balloon-borne radiosonde being launched.

## **United Kingdom land-based observing network**

The network consists of synoptic (including auxiliary) or climatological (including rainfall only) stations. The classification of each station depends on the observations it makes.

## **Synoptic stations**

A synoptic station is an observing site where meteorological observations are made for the purpose of synoptic meteorology (i.e. the branch of meteorology which is concerned with the recording of current weather and to the prediction of its future development). A manned synoptic station, which also includes Semi-Automatic Meteorological Observing System (SAMOS) and Enhanced Synoptic Automatic Weather Station (ESAWS), generally makes observations every hour. Synoptic observations are the most frequent and most detailed observations. These are coded for sending straight away and are typically done by Met Office observers, but less often at some auxiliary stations.

Observations at each scheduled hour are usually made in the following order:

- **Temperature, dry-bulb**
- **Temperature, wet-bulb** (used in conjunction with the dry-bulb reading to derive the vapour pressure, relative humidity and dew-point)
- **Amount of precipitation**
- **Amount of cloud**
- **Types of cloud** (see fact sheet no. 1 – Clouds)
- **Height of cloud base**
- **Present weather**
- **Visibility**
- **Wind speed and direction**
- **Pressure tendency and characteristic**
- **Atmospheric pressure**
- **Past weather and any special phenomena occurring either at the time of observation or since the last observation**

In addition, a number of additional routine observations are made in the United Kingdom at certain specified hours. These include:

- **Extreme screen temperatures (maximum and minimum):** read and reset at each of the hours 0600, 0900, 1800 and 2100 GMT
- **Grass minimum temperature:** at 0900 GMT (also at 0600 GMT without resetting)
- **Soil temperatures:** at 0900 GMT at selected stations
- **Concrete-slab minimum temperature:** at 0900 GMT
- **State of concrete slab:** at 0900 GMT
- **State of ground:** 3-hourly at 0000, 0300, 0600, 0900, 1200, 1500, 1800 and 2100 GMT
- **Snow depth**
- **Duration of bright sunlight** (most Met Office sites now record sunshine using automatic sunshine recorders. However, Campbell-Stokes sunshine recorders are still used at Lerwick, Waddington and Camborne Met Office stations and at some climate stations to record sunshine durations).

## Climatological stations

Climatological stations are classified by the World Meteorological Organization as 'principal' (readings taken hourly or observations made at least three times daily in addition to hourly tabulations from autographic records), or 'ordinary' (observations made at least once daily, including daily readings of extreme temperature and amounts of precipitation). Stations may also be classed as 'precipitation stations' (in normal British terminology, 'rainfall stations') where this is the only element observed; as 'climatological stations for specific purposes' where only a specific element or elements are observed; or as 'agricultural meteorological stations' where meteorological and biological data, or data otherwise contributing to the establishment of the relationship between the weather and the life of plants and animals, are observed.

Elements observed at a climatological station, include:

At 0900 GMT:

- **Maximum temperature** (for the period 2100 GMT (previous day) to 0900 GMT, or 0900 GMT (previous day) to 0900 GMT if the station does not report at 2100 GMT)
- **Minimum temperature** (for the period 2100 GMT (previous day) to 0900 GMT, or 0900 GMT (previous day) to 0900 GMT if the station does not report at 2100 GMT)
- **Rainfall measurement** (for the period 2100 GMT (previous day) to 0900 GMT, or 0900 GMT (previous day) to 0900 GMT if the station does not report at 2100 GMT)
- **Dry-bulb temperature**
- **Wet-bulb temperature**
- **Grass minimum temperature**
- **Soil temperature** (at 10 cm, 30 cm and 100 cm depths)
- **Concrete-slab minimum temperature**
- **State of concrete slab** (at 0900 GMT)
- **Depth of snow** (at 0900 GMT)
- **Depth of fresh snow** (at 0900 GMT)
- **Total hours of bright sunshine** (for the previous day)
- **Occurrence of hail, thunder, gale, snow or sleet** (on the previous day)
- **Existence of fog** (at 0900 GMT)

At 2100 GMT:

- **Maximum temperature** (for the period 0900 GMT to 2100 GMT)
- **Minimum temperature** (for the period 0900 GMT to 2100 GMT)
- **Rainfall measurement** (for the period 0900 GMT to 2100 GMT)

## Rules for making climatological observations

The most important requirements for stations to be accepted into the Met Office's co-operating observing network are as follows:

- Observations are to be made each day of the year by a competent observer at the fixed time of 0900 GMT (9 a.m. clock time in winter and 10 a.m. clock time during British Summer Time)
- The instruments should be of a standard design and, must be certified by an appropriate body
- The instruments should be correctly set-up on generally level ground away from immediate influence of close obstructions such as fences, plants, trees or buildings
- The proposed site should be representative of its general location and should not duplicate data from existing sites in the network
- The site should have a planned lifespan of more than ten years

The *minimum* weather elements measured at a climatological station in the United Kingdom are dry-bulb temperature (at 0900 GMT), wet-bulb temperature (at 0900 GMT), daily maximum air temperature, daily minimum air temperature and daily rainfall amount, recorded over the period 0900 to 0900 GMT.

### **Automatic weather station**

Automatic stations also make observations. These are often located in difficult terrain and are useful for times when an observer is not available. A typical automatic station has a set of weather sensors connected to a central data logger, which measure, process and store data. A Semi-Automatic Meteorological Observing System (SAMOS) station can give hourly or 10-minute information as soon as the data are measured. At these sites rainfall is measured hourly.

Equipment typically found on an automatic weather station includes:

- **Data logger**
- **Dry-bulb thermometer (electrical resistance thermometer (ERT)/thermistor)**
- **Wet-bulb thermometer (ERT/thermistor)**
- **Thermometer screen**
- **Rain gauge (tipping bucket)**

Other equipment might include:

- **Grass-minimum thermometer (ERT/thermistor)**
- **Concrete-minimum thermometer (ERT/thermistor)**
- **Soil thermometers (ERT/thermistor at 10, 30 and 100 cm depths)**
- **Sunshine sensor**
- **Wind vane**
- **Cup anemometer**
- **Global radiometer**
- **Humidity sensor**



## **Measurement of air temperature**

The thermometers used for the measurement of air temperatures (dry-bulb, wet-bulb, maximum and minimum temperatures) are housed in a thermometer screen, sometimes called a Stevenson Screen. The Stevenson Screen was designed by Thomas Stevenson (1818-1887), a Scottish civil engineer, and father of Robert Louis Stevenson, the well known author.



**Figure 4.** Stevenson Screen at Heathrow Airport.

The Stevenson-pattern thermometer screen has double-louvered sides (i.e. slatted walls on four sides, the cross-section of the slats being an inverted V), a double roof and a floor made of three partially overlapping boards separated by an air space. Older type screens were made of wood but the Met Office has recently introduced plastic screens at our observing sites. The screen is painted white thus limiting the effects of direct solar or terrestrial radiation. The screen is mounted on a metal stand so that the bulbs of the dry-bulb and wet-bulb thermometers are 1.25 m above the ground (for most standard screens this means that the base of the screen is 1.10 m above the ground). The screen door faces north; again this limits the amount of direct sunlight falling inside the screen when the door is opened.



## **Thermometers used for synoptic and climatological observations**

Thermometers used for the measurement of air temperature are graduated in degrees Celsius and made in accordance with British Standards Specification BS692. All thermometers issued by the Met Office are engraved with the monogram (MO) followed by a serial number.

**Dry-bulb thermometer** – a normal mercury-in-glass thermometer with the bulb of the thermometer freely exposed to the air inside the thermometer screen.

**Wet-bulb thermometer** – a similar thermometer to the dry bulb, but its bulb is surrounded by a muslin wick which is kept wet from a reservoir of distilled water nearby. The wet-bulb cools by evaporation and should normally read lower than the dry bulb, although in some cases it can read the same.

**Maximum thermometer** – a mercury-in-glass thermometer which records the highest temperature reached since the thermometer was last set. A constriction in the bore of the thermometer holds the mercury in its highest position.

**Minimum thermometer** – an alcohol-in-glass thermometer which carries a small index within the bore. The minimum thermometer records the lowest temperature reached since the thermometer was last reset.

### **Concrete and grass-minimum thermometers**



**Figure 5.** Concrete-minimum thermometer.

#### **Concrete-minimum thermometer**

A reading obtained from a standard minimum thermometer which is exposed to the air with its bulb in contact with a concrete slab; the slab lies horizontally in an open situation and with its top almost flush with the ground. Such readings, introduced at Met Office stations on 1 December 1968, are less subject to very local influences than are grass minimum temperatures. They are also more relevant to such operational problems as the incidence of ice on roads.



**Figure 6.** Grass-minimum thermometer.

#### **Grass-minimum thermometer**

The minimum temperature indicated by a standard minimum thermometer freely exposed in an open situation at night with its bulb in contact with the tips of the grass blades on an area covered with short turf.

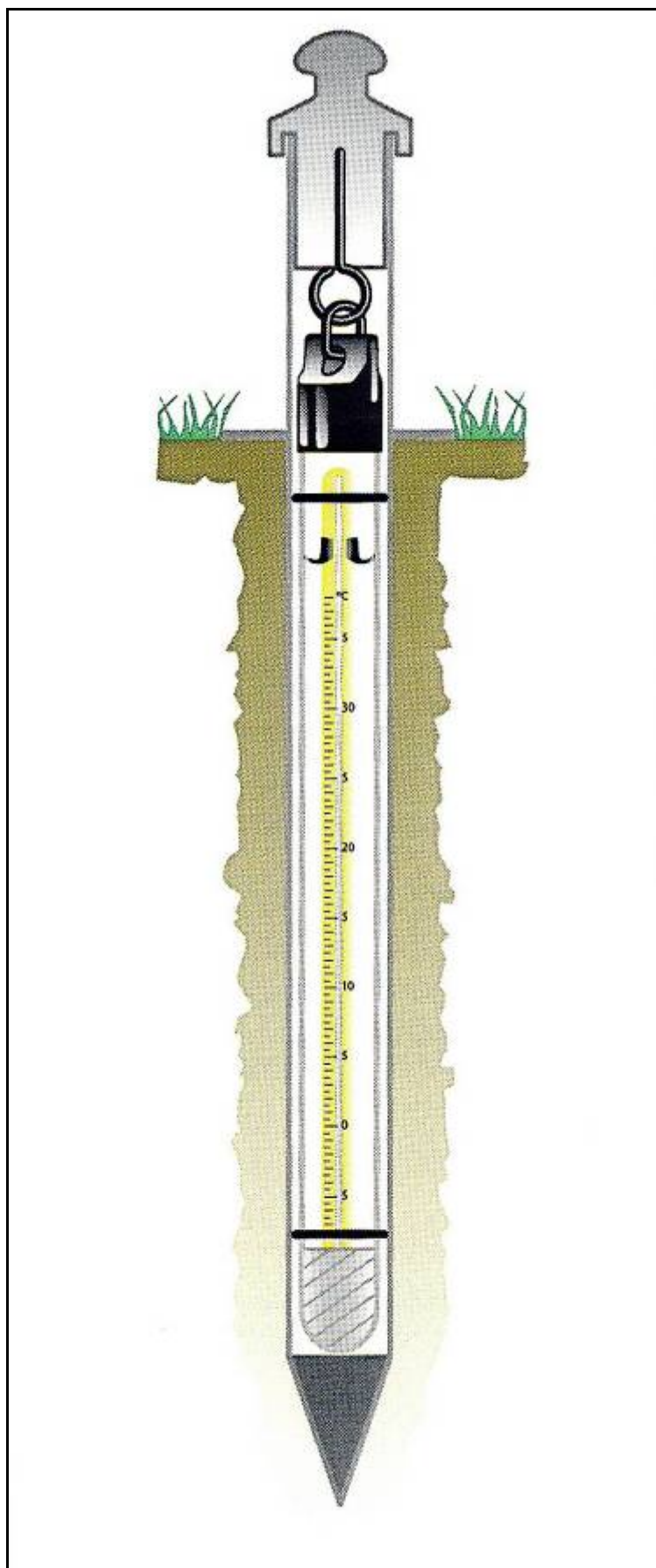
The use of the term 'ground frost' in forecasts signifies a grass minimum temperature below 0 °C (32 °F).



## Soil temperature thermometers

Soil temperatures are measured at a number of depths: 10, 30, and 100 cm. Thermometers for the 10 cm depth temperatures are right-angled mercury-in-glass. The bulb of the instrument is sunk to the appropriate depth but the stem of the thermometer remains on the surface. A different technique is used for the deeper measurements. The thermometer is suspended inside a tube with the bulb at the appropriate depth.

The thermometer, housed in an extra protective glass sheath, has its bulb set in wax to slow its response enough to allow it to be removed and read.



**Figure 7.** Soil thermometer.

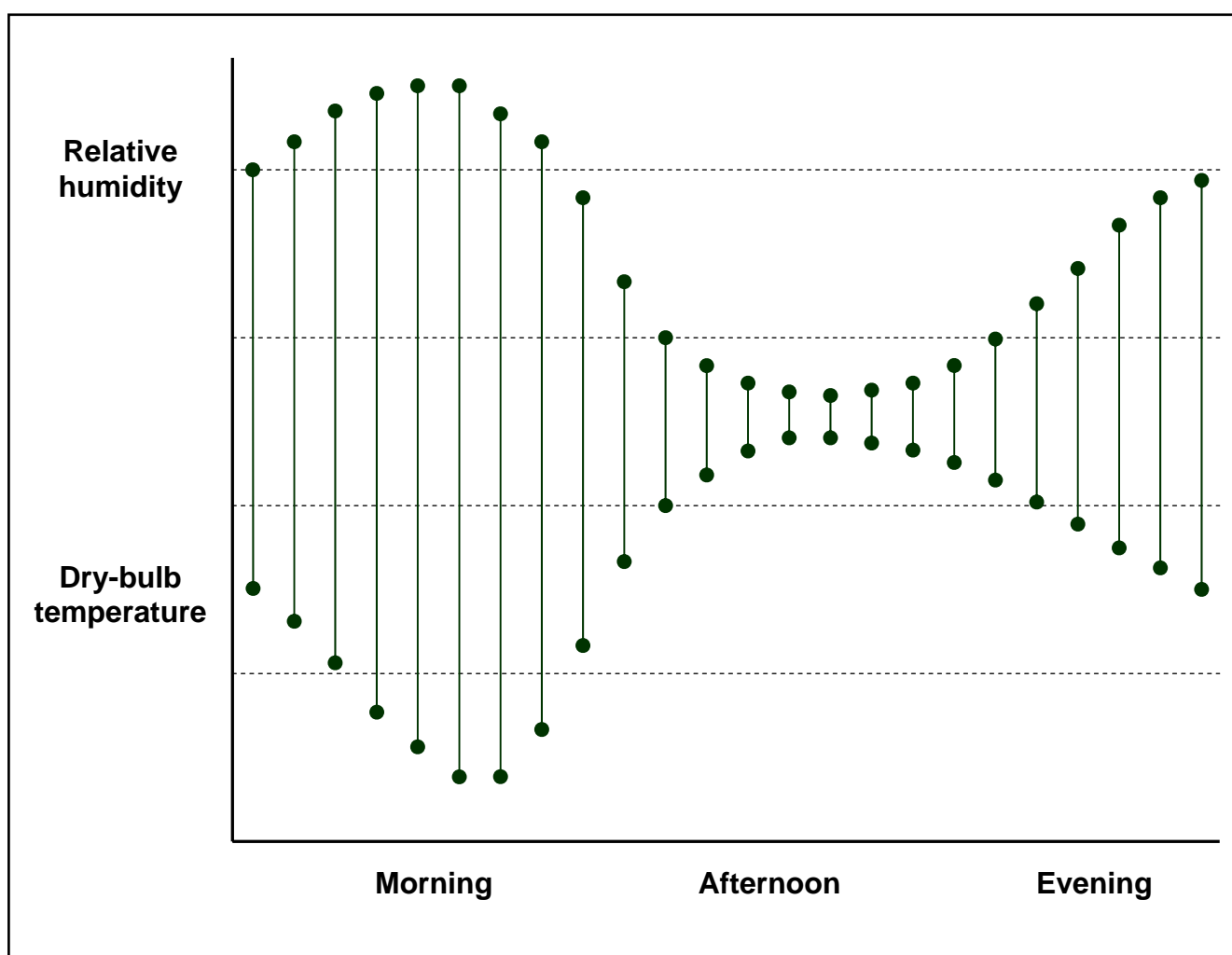
## **Electrical resistance thermometers**

Electrical resistance thermometers (ERTs) are often used to regularly measure dry-bulb and wet-bulb temperatures automatically. The readings are shown on a digital display (in deg. C and tenths).

## **Measurement of relative humidity**

There are two ways in measuring the humidity of the air, either directly using HygroClip humidity sensors which can be found at all SAMOS sites and used in most Climate Data Loggers or indirectly using dry-bulb and wet-bulb temperatures and calculating the humidity from the readings using hygrometric tables or a humidity slide rule.

Relative humidity has a marked systematic diurnal variation opposite in phase to that of temperature: that is to say, it has a daily maximum value around dawn and a minimum in the afternoon. It has a less well marked annual variation, more especially in afternoon hours, also of opposite phase to that of temperature.



**Figure 8.** Relationship between dry-bulb temperature and relative humidity during a 24-hour period.

Another theoretical method of calculating the relative humidity of the air is by using a tephigraph (see fact sheet no. 13 for more details).

## **Measurement of precipitation**

Precipitation can be defined as any liquid or solid aqueous deposit from the atmosphere. These include:



**Figure 9.** Rain.

### **Rain**

Liquid precipitation in the form of water drops of appreciable size (by convention, of diameter greater than about 0.5 mm, the limiting size of drizzle drops) from a cloud. The diameter and concentration of drops vary considerably according to the intensity of the precipitation and especially according to its nature and source (continuous rain, rain showers, etc).



**Figure 10.** Snow.

### **Snow**

Solid precipitation which occurs in a variety of minute ice crystals at temperatures well below 0 °C but as larger snowflakes at temperatures near 0 °C.



**Figure 11.** Hailstones.

### **Hail**

Solid precipitation in the form of balls or pieces of ice (hailstones) with diameters ranging from 5 to 50 mm or even more. The stones fall from cumulonimbus clouds and are commonly spherical or conical in shape although they sometimes form irregular lumps by a process called agglomeration.





**Figure 12.** Snow pellets.

### **Snow pellets**

Precipitation of white and opaque ice particles, which are spherical or sometimes conical; their diameter is in the range 2 to 5 mm. The pellets are brittle and easily crushed; when they fall on hard ground they bounce and readily break up. Precipitation of snow pellets generally occurs in showers, together with precipitation of snowflakes or raindrops, when surface temperatures are around 0 °C.

**Drizzle** – liquid precipitation in the form of water drops of very small size (by convention, with diameter less than 0.5 mm) and very close to one another. The drops appear almost to float, thus making them visible even in the slightest movements of air, and the effect of their individual impact on water surfaces is imperceptible.

**Ice** – water substance in solid form. It occurs in the atmosphere and/or on the earth's surface in many forms such as ice crystals, snow, hail, hoar-frost, rime, glaze, glacier, etc.

**Diamond dust** – precipitation of very small unbranched ice crystals forming in air supersaturated with respect to ice at temperatures below minus 30 °C. Diamond dust accounts for much of the annual average accumulated 'snowfall' in the interior of Antarctica.

**Snow grains** – precipitation of very small white and opaque grains of ice. These grains are fairly flat or elongated; their diameter is generally less than 1 mm. When the grains hit hard ground they do not bounce or shatter. Except in mountainous areas, they usually fall in small quantities, mostly from stratus or from fog, and never in the form of a shower.

**Ice pellets** – precipitation, generally from layered cloud, of transparent pellets of ice which are spherical or irregular, rarely conical, and which have a diameter of less than 5 mm.

**Glaze** – a generally homogenous and transparent deposit of ice formed by the freezing of supercooled drops of drizzle or rain on objects the surface temperature of which is slightly above 0 °C or below.

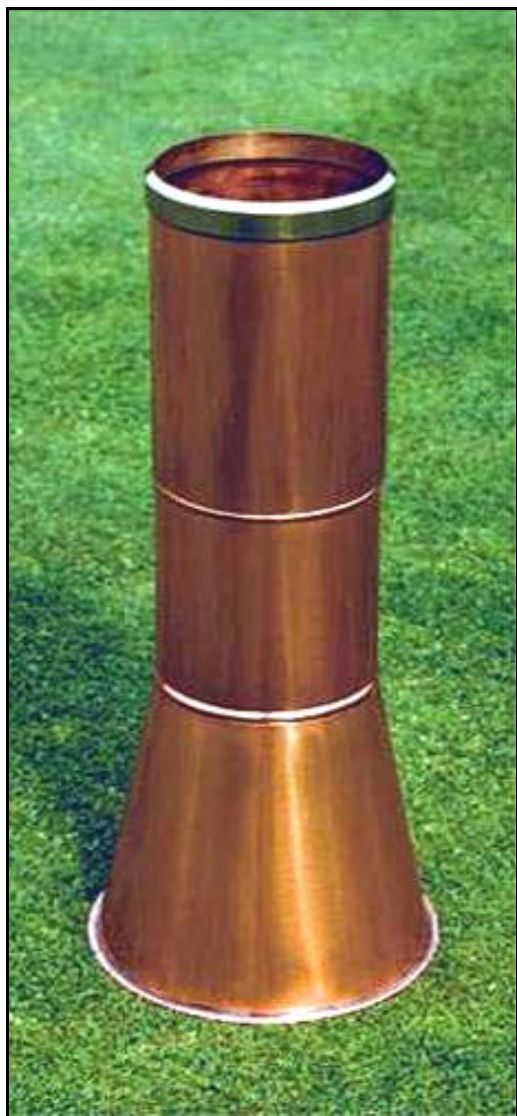
### **The rain gauge**

Many different types of rain-gauge have been designed and used. Most consist of a circular collector, delineating the area of the sample, and a funnel leading into a reservoir. The collected precipitation is then measured directly in millimetres and tenths using a rain measure graduated for use with the particular type of gauge. The shape and size of gauges vary according to the storage capacity required in the reservoir, this being dependent on whether the precipitation is measured daily, weekly or monthly. There are two kinds of rain gauge – storage and automatic. The storage type collects rain and stores it in a container for you to measure on a routine basis. The automatic type makes a record of each time a container of a specific volume is filled and emptied.

## Storage type rain gauges

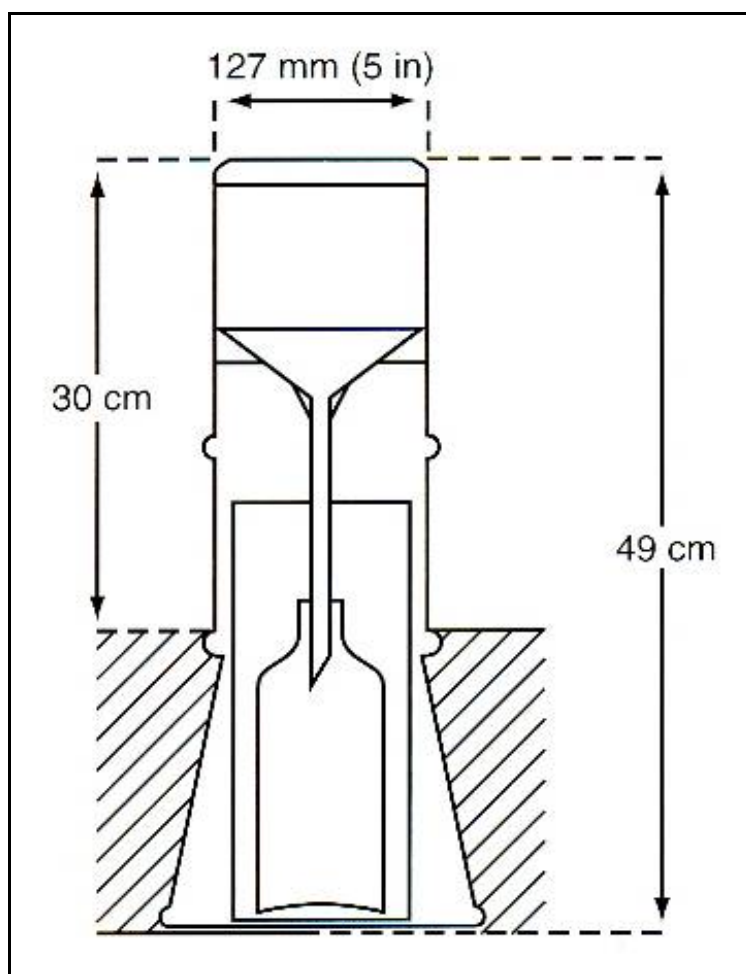
### The 5-inch rain-gauge

The standard rain-gauge used by the Met Office for daily climatological observations is the 5-inch copper rain-gauge. However, recently a 5 inch rain gauge made of stainless steel has been introduced and this is gradually replacing the copper type at Met Office stations.



**Figure 13.** 5-inch copper MK 2 rain-gauge.

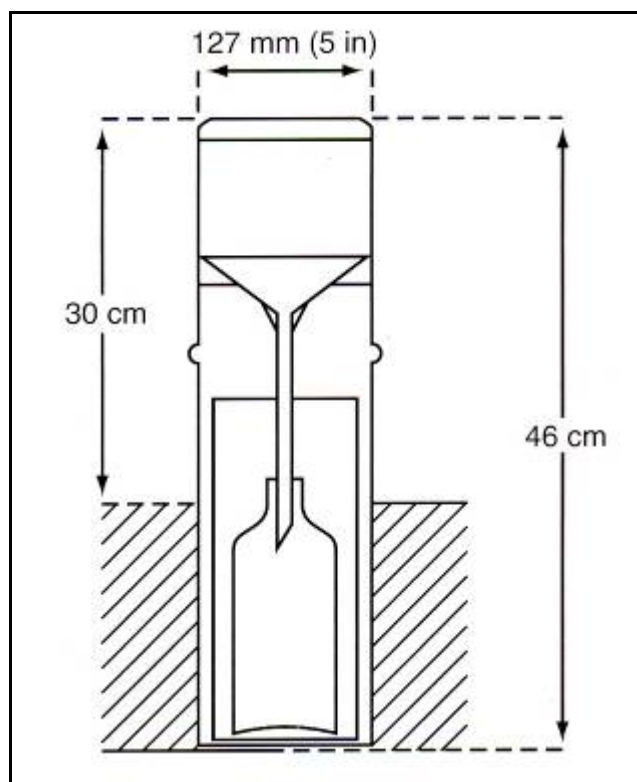
Both the copper and the stainless steel gauges have a 5-inch diameter (127 mm) collector which has a sharp brass or steel rim. It is sited so that the rim is horizontal and 30 cm (12 inches) above the ground. The rainfall that is collected is led into a narrow-necked bottle placed in a removable copper can.



**Figure 14.** Cross-section of a 5-inch MK 2 rain gauge.

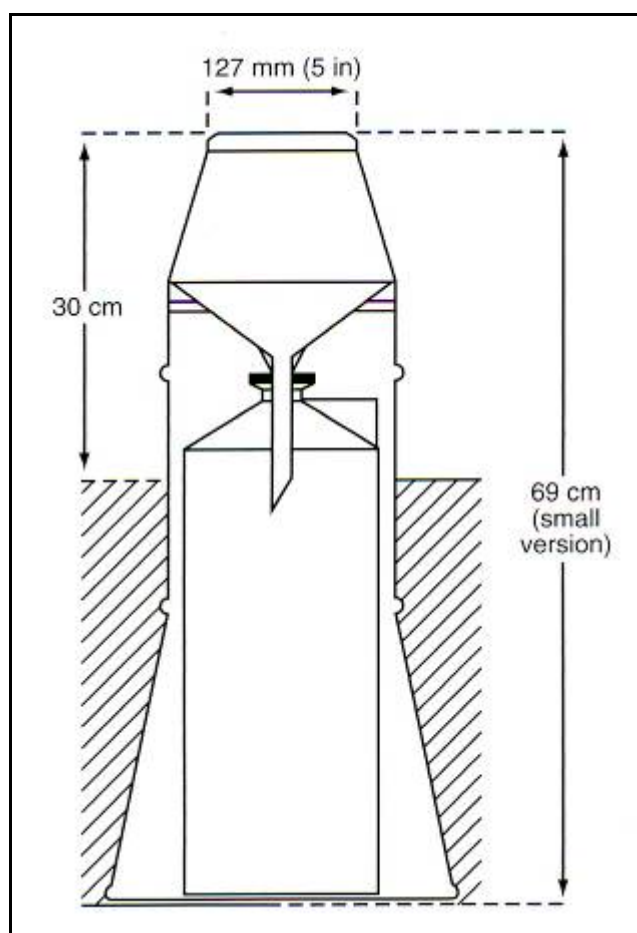
The bottle is easy to handle when pouring the sample into a rain measure, and reduces loss by evaporation. The inner can ensures the retention, for measurement, of exceptionally heavy rainfall which may overflow from the bottle into the can. Both bottle and inner can are housed within the splayed base of the gauge which is sunk firmly into the ground. An additional 5-inch gauge may be provided at those stations which report rainfall for synoptic purposes.

Other types of storage-type rain gauges are:



**Figure 15.** Cross-section of the Snowdon rain gauge.

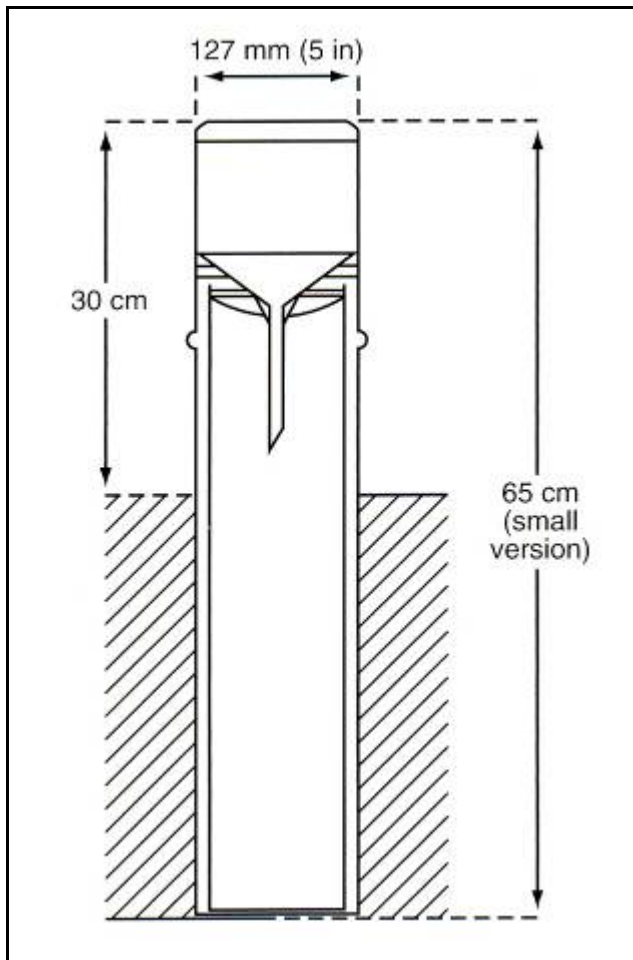
**The Snowdon** – similar in size and construction to the Mk 2 but this does not have a splayed base and so consequently it is not so firm in the ground. The Snowdon is mainly intended for daily readings.



**Figure 16.** Cross-section of an Octapent rain gauge.

**The Octapent** – this is a large rain gauge used for the measurement of monthly rainfall totals. There are two sizes of the Octapent rain gauge, namely the Octapent 27, a smaller capacity gauge used in the drier parts of the country and a larger capacity Octapent 50 gauge used in areas of high rainfall.





**Figure 17.** Cross-section of a Bradford rain gauge.

**The Bradford** – this is an adaptation of the Snowdon gauge but with a deeper storage can to hold the rainfall. This gauge is capable of being read monthly in fairly dry localities but is more often used for weekly readings.

### Rainfall measurements

The amount of precipitation collected by a gauge may be measured with the aid of glass vessels known as rain measures. Each measure is graduated to indicate, in millimetres, the amount of precipitation over the area of the collecting funnel of the rain-gauge; it is therefore essential that the rain measure should be one appropriate to, and calibrated for, the type of rain-gauge in use.

Met Office rain measures for use with daily gauges are tapered at the base to facilitate accurate measurements of small amounts. There are two standard rain measures used, the older one having a total capacity of 10 mm to the highest graduation and the newer having a graduated capacity of 10.5 mm. Amounts greater than the graduated capacity must therefore be measured in two or more stages.

The larger labelled divisions on the glass represent whole millimetres and the intermediate divisions represent tenths. The lowest division, the marking of which is carried completely round the glass represents half a tenth of a millimetre (0.05 mm). It is there for a special purpose, namely to distinguish between a reading to be logged as 0.1 mm and a reading to be logged as a 'trace'.

A large 50 mm flat-based measure is used with monthly gauges.

Snow or hail in the funnel of the rain gauge at the time of reading must not be thrown away but should be melted and added to any water in the bottle, and the whole amount measured.

## **Automatic type rain gauges**

### **Tipping-bucket rain-gauges**

The Met Office tipping-bucket rain-gauge is used to provide a remote indication of rainfall in increments of 0.2 mm. The collecting funnel has a sampling area of 750 cm<sup>2</sup> and the rim must be 450 mm above the surrounding ground level. To give the gauge the necessary stability it is bolted down on to a concrete slab.



**Figure 18.** Tipping-bucket rain-gauge MK5.

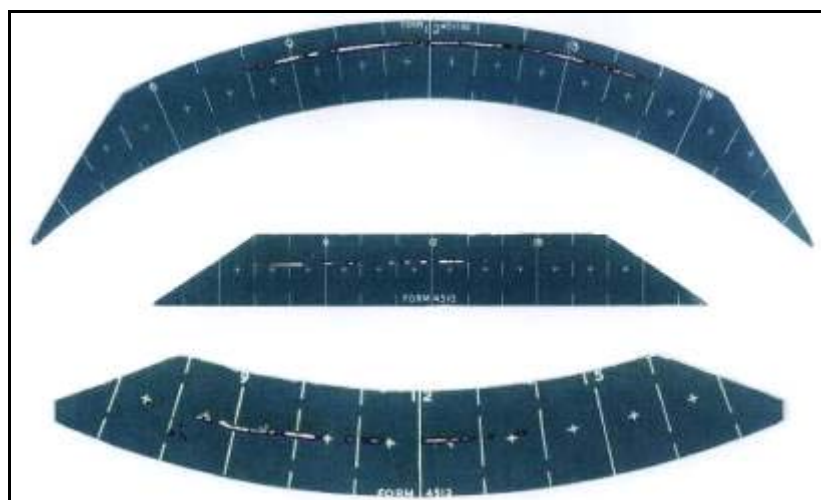
The principle of operation of a tipping-bucket is that a stainless-steel bucket, divided into two equal compartments, is pivoted at its base so that only one of the compartments will collect the water from the gauge funnel at any one time. When one compartment has collected 15 cc (equivalent to 0.2 mm of rainfall) the bucket overbalances, tips and empties, bringing the second compartment under the collecting funnel. Stops are fitted to prevent the bucket from completely overturning. Each tip of the bucket either updates the display on a Semi-Automatic Meteorological Observing System (SAMOS) display or adds the amount to the data logger.

## Measurement of sunshine

The routine measurement of the recorded duration of bright sunshine, either in hourly or daily totals, is required from some stations for climatological purposes. The type of sunshine recorder approved and used by the Met Office utilises the heat from the sun's rays, focused by a solid glass sphere to an intense spot, to char a trace on a specially manufactured card. The type of equipment is called a Campbell-Stokes sunshine recorder.



**Figure 19.** Campbell-Stokes sunshine recorder.



**Figure 20.** Selection of sunshine cards for various times of the year.

In the northern hemisphere the cards are used as follows:

- Long curved cards (upper image) during the summer, from 12 April to 2 September inclusive.
- Straight cards (middle image) about the times of the equinoxes, from 1 March to 11 April and again 3 September to 14 October inclusive.
- Short curved cards (lower image) during the winter, from 15 October to the last day of February inclusive.



## Analysing the sunshine card

Ideally, at Met Office observing stations, the card is changed between sunset and sunrise; at stations where this is done the following details are entered on the back of the card before insertion: the station name, year, month, and date of the following day.

At many climatological stations sunshine cards are changed daily, usually at 0900 GMT.

In bright sunshine the burn can spread across the card as it becomes scorched. These burns have rounded edges and should be analysed only to the point halfway between the centre of curvature and the extreme visible limit of the burn. Burns are measured according to the following rules:

- a) all burns that are elongated and parallel to the edge of the card are included.
- b) tapered burns (that may not have burnt through the card) are also included – these usually occur close to sunrise and sunset.
- c) faint brown scorches due to the sun shining through haze, mist, thin high cloud or when the sun is low in the sky should also be included in the total.

Not included are small circular burns that are not elongated, unless there are no other burns, as these are due to very short periods of sunshine. In the sunshine total record, 0.1 hour is recorded for the whole day if the card is made up of this type of burn.

## Automatic sunshine recorders

Automatic sunshine sensors have now been developed and are slowly replacing the traditional Campbell-Stokes as the recommended method of measurement.



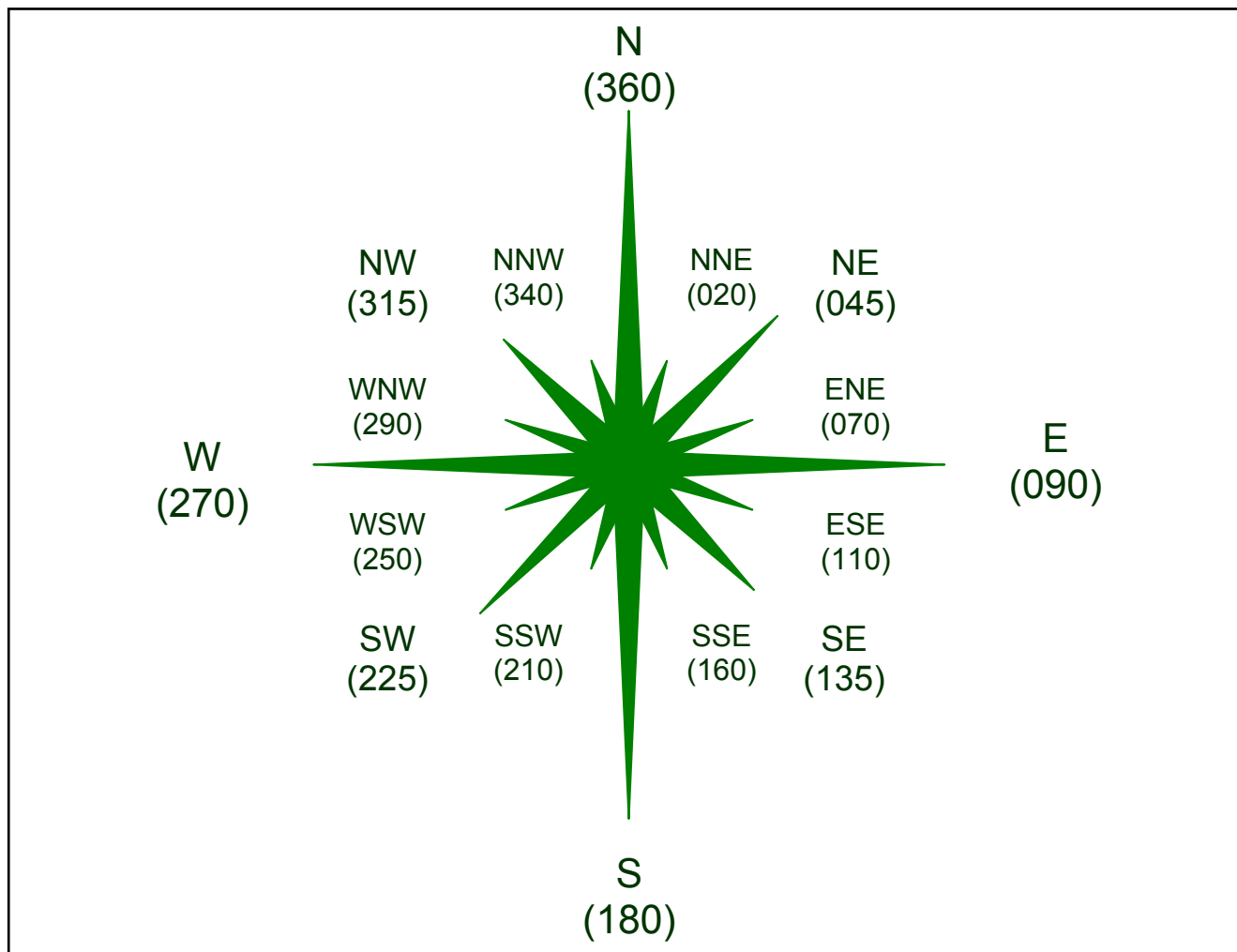
**Figure 21.** Kipp and Zonen automated sunshine recorder.

An automatic sunshine detector works on a different principle to the Campbell-Stokes in so far as instead of measuring the amount of actual direct sunshine received, it measures the amount of radiation the sensor in the unit receives and calculated the sunshine duration accordingly. Sunshine duration is defined by the World Meteorological Organization as the time during which the direct solar radiation exceeds  $120 \text{ Wm}^{-2}$ .

## Measurement of wind speed and direction

Wind is the horizontal movement of air and is specified by its speed and direction.

Wind direction is measured in tens of degrees relative to true north (not magnetic north). Direction is always reported from where the wind is blowing. Therefore a westerly wind is blowing from the west or 270 degrees.



**Figure 22.** The 16 compass points, with values in degrees (shown in brackets).

The official unit of horizontal wind speed in the United Kingdom is the knot.

As a result, surface wind is always reported with wind direction in tens of degrees and from true north and the wind speed in knots.

### Exposure of surface wind sensors

The motion of the air near Earth's surface is much affected by such factors as the roughness of the ground, the type of surface, heat sources, the presence of buildings, trees, etc.; moreover, wind speed normally increases with height above Earth's surface. It is therefore necessary to specify a standard exposure for making measurements of surface wind so that observations made at different locations may be compared. The standard height for surface wind measuring instruments is 10 metres above the ground in an open and level terrain.

## Terminology

Specific terms used to describe phenomena associated with the surface wind, are:

**Gale** – a gale is defined as a surface wind of mean speed of 34-40 knots, averaged over a period of 10 minutes. Terms such as 'strong gale', 'storm', etc are also used to describe winds of 41 knots or greater. (See fact sheet no. 6 – The Beaufort Scale and fact sheet no. 8 – The Shipping Forecast for more details).

**Squall** – a squall is a strong wind that rises suddenly, lasts for at least a minute and then dies away comparatively suddenly. It is distinguished from a gust by its longer duration.

**Gust** – a rapid increase in the strength of the wind relative to the mean strength at the time. A gust is of shorter duration than a squall and is followed by a 'lull' or slackening of the wind speed.

**Calm** – no appreciable motion of the air; speed less than 2 knots.

**Veering** – a clockwise change in wind direction; for example, from south to west through south-west.

**Backing** – a counter-clockwise change in wind direction; for example, from south to east through south-east.

## Measuring the wind

The instrument used for measuring wind speed is called an anemometer and wind direction is measured using a wind vane.



**Figure 23.** Cup generator anemometer and wind vane.



There are various ways of obtaining wind readings:

- wind vane
- cup anemometer
- hand anemometer
- estimation

#### Wind vane – direction only

A device for indicating or recording the direction from which the wind is blowing. It usually consists of a horizontal arm carrying at one end a fin, either a vertical flat plate with its edge to the wind or an aerofoil, and at the other end a balance weight which also serves as a pointer; the arm is carried on a vertical spindle mounted on bearings which allow it to turn freely in the wind.

#### Cup anemometer – speed only

The standard instrument used by the Met Office for measuring wind speed is called a cup anemometer. Cup anemometers consist of three or four cups, conical or hemispherical in shape, mounted symmetrically about a vertical spindle. The wind blowing into the cups causes the spindle to rotate, and in standard instruments the design of the cups is such that the rate of rotation is directly proportional to the speed of the wind to a sufficiently close approximation.

#### Hand anemometer – speed only



This gives a direct reading of wind speed, which is shown by a digital display housed between the cups and the handle. To get the mean equivalent speed at 10 metres you have to correct this reading by adding 30%.

Stand in a well-exposed place (away from obstructions) and hold the anemometer with your arm aloft to measure a representative wind speed.

**Figure 24.** Hand anemometer.

## Estimation

If you don't have instruments, or they are not working, you can estimate the wind speed and direction. Wind speed is best estimated using the Beaufort force descriptions and then converting this to the mean equivalent value in knots.

Force	Description	Specifications for use on land	Mean speed (knots)
0	Calm	Smoke rises vertically	00
1	Light air	Direction of wind shown by smoke drift but not by wind vanes	02
2	Light breeze	Wind felt on face; leaves rustle; wind vanes move	05
3	Gentle breeze	Leaves and small twigs in constant motion; wind extends light flag	09
4	Moderate breeze	Raises dust and loose paper; small branches are moved	13
5	Fresh breeze	Small trees in leaf begin to sway; crested wavelets form on inland waters	19
6	Strong breeze	Large branches in motion; umbrellas used with difficulty	24
7	Near gale	Whole trees in motion; inconvenience felt when walking against wind	30
8	Gale	Breaks twigs off trees; generally impedes progress	37
9	Severe gale	Slight structural damage occurs ( <i>chimney pots and slates removed</i> )	44
10	Storm	Seldom experienced inland; trees uprooted, considerable structural damage	52
11	Violent storm	Very rarely experienced; accompanied by widespread damage	60
12	Hurricane force	Extremely rare; devastation and loss of life	≥ 64

**Table 1.** Estimation of wind speed using the Beaufort Scale.

For wind directions, choose a well-exposed place (away from obstructions) and face into the wind for at least 20 seconds. Estimate the mean direction from which the wind is coming by reference to the true direction of known landmarks.

## Measurement of atmospheric pressure

The pressure of the atmosphere at any point is the weight of the air which lies vertically above the unit area at the point.

### Units of atmospheric pressure

The unit of pressure in the International System (SI) is the Newton per metre squared ( $\text{Nm}^{-2}$ ) to which has been given the name pascal and the symbol Pa. The Met Office has now adopted the unit hPa (hectopascal) as the official unit of atmospheric pressure. However, most barometers still read in the older International Committee on Weights and Measures (CIPM) allocation of the millibar (mb).

The relationship between these pressure units is: 1 mb = 1 hPa

## Instruments for measuring atmospheric pressure

The instrument most commonly used for measuring the pressure of the atmosphere is the precision aneroid barometer.

An aneroid barometer in which the movement of the face of the evacuated capsule is shown, not by means of a train of pivoted levers attached to a pointer, but by the deflection of one light, pivoted, counter-balanced electrical contact arm mounted in jewelled bearings. Electrical contact is established by manually rotating a micrometer screw. The reduction in backlash and friction to negligible proportion greatly increases the absolute accuracy of the instrument and versions have now generally replaced mercury barometers at synoptic stations.

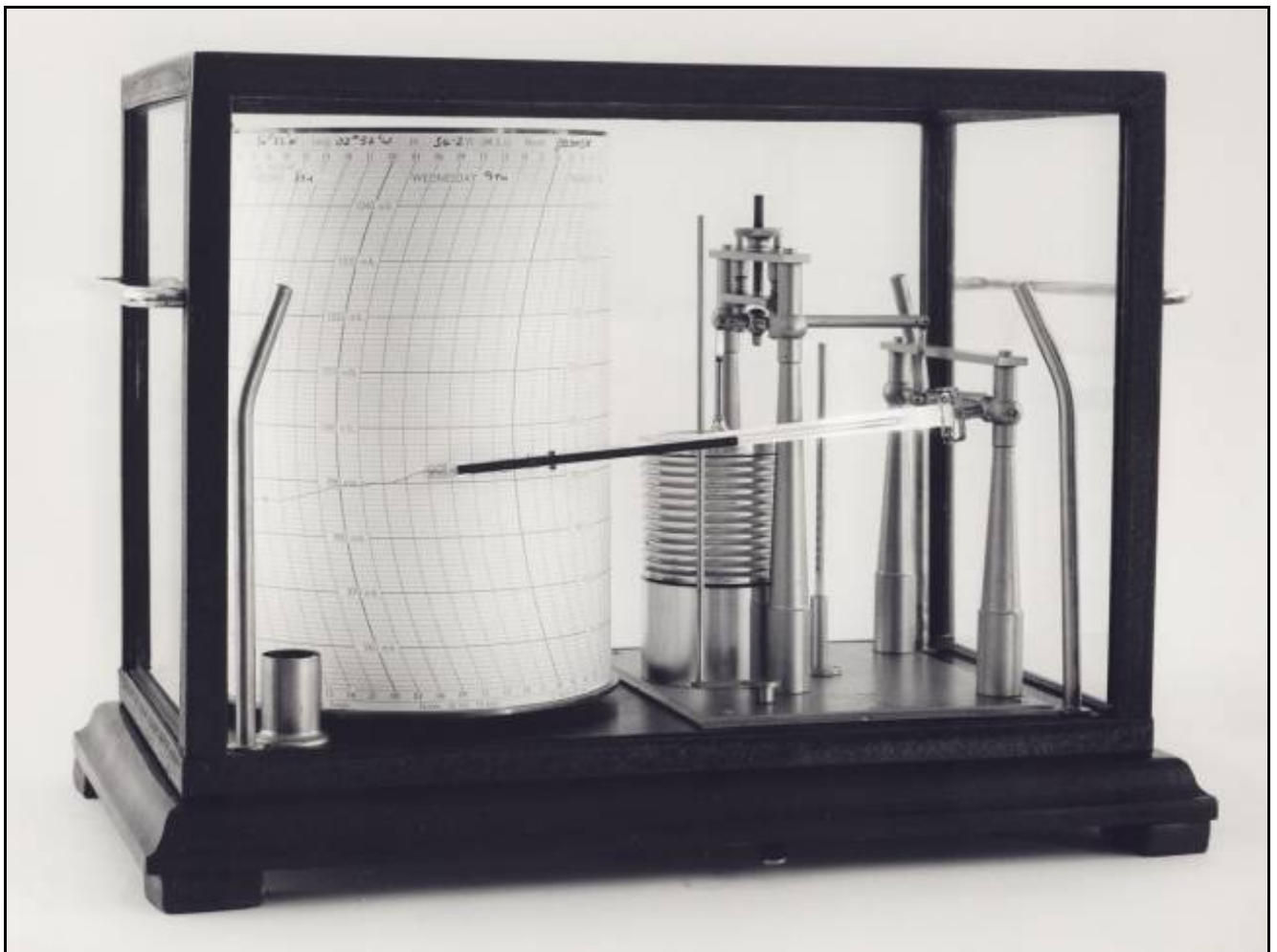


**Figure 25.** Precision aneroid barometer mk 2.

## Barographs

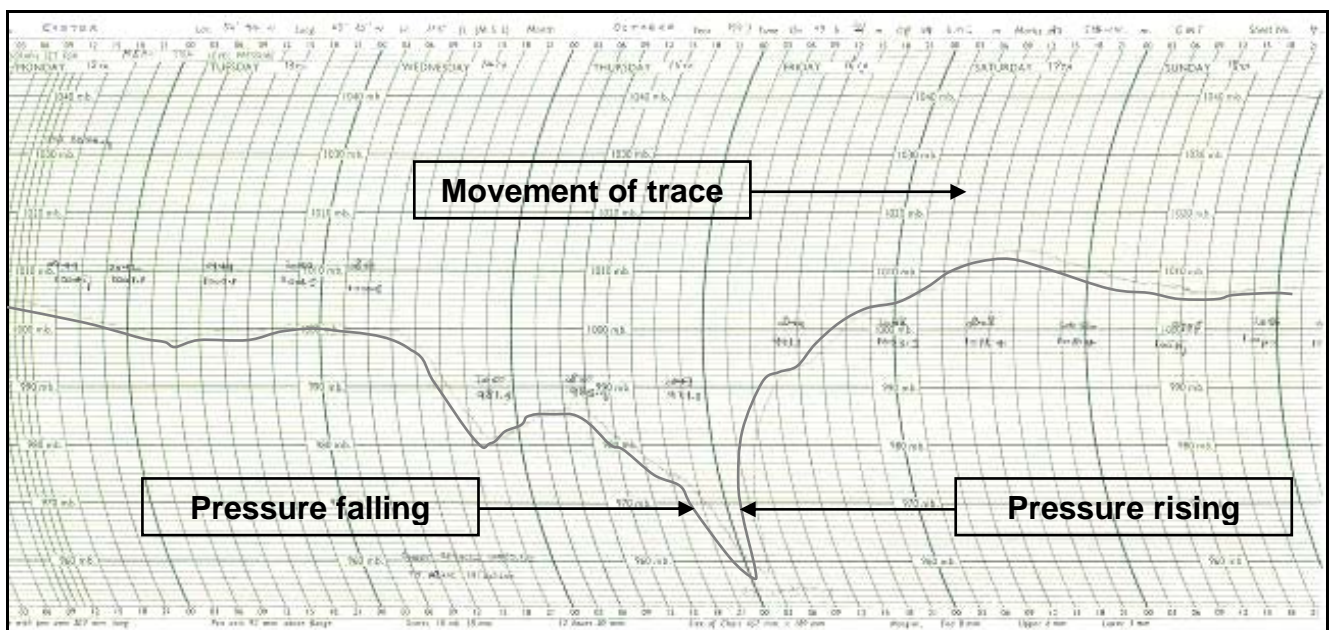
The two standard types of barograph are both aneroid instruments and are known as the 'open scale' and the 'small pattern', which differ in the type of aneroid element and lever mechanism used. Their action depends upon the response to variations of atmospheric pressure of disc-shaped capsules made of this corrugated metal. These capsules are nearly exhausted of air and their surfaces are held apart by an internal spring. If the atmospheric pressure falls, the capsule surfaces move apart. If the pressure rises, the capsule surfaces are compressed and move together. The small movements thus produced in a bank of such capsules are magnified by a system of levers and communicated to a pivot arm that carries a recording pen. The pen is given vertical movement and writes on a chart (barogram) wrapped round a drum which is rotated by clockwork about a vertical axis.














**Figure 26.** Barograph.

By studying the barogram, it is possible to work out the pressure characteristic over a given period of time.



**Figure 27.** Barogram trace for Exeter - week beginning 12 October 1987.

Pressure trace	Description of curve	Pressure now compared with 3 hours ago
	Rising, then falling	The same or higher
	Rising, then steady, or rising then rising more slowly	Higher
	Rising (steadily or unsteadily)	Higher
	Falling, then rising	Higher
	Steady	Same
	Falling, then rising	The same or lower
	Falling, then steady, or falling then falling more slowly	Lower
	Falling (steadily or unsteadily)	Lower
	Steady or rising, then falling; or falling then falling more quickly	Lower

**Table 2.** Pressure tendencies.

## **Measurement of visibility**

Meteorological visibility is defined as the greatest distance at which a black object of suitable dimensions can be seen and recognised against the horizon or sky or, in the case of night observations, could be seen and recognised if the general illumination were raised to the normal daylight level.

Visibilities of 5000 m or less are expressed in metres, where as visibilities of 6 km or more are expressed in kilometres.

When measuring visibilities, for values of 5000 m or less, the value goes up in 100 m units. Visibilities of between 6 km and 30 km are measured in 1 km units. For visibilities above 30 km, the unit increase is 5 km.

<u>Visibilities of 5000 m or less</u>		<u>Visibilities of between 6 km and 30 km</u>	<u>Visibilities of 30 km or more</u>
100 m	1100 m	6 km	35 km
200 m	1200 m	7 km	40 km
300 m	1300 m	8 km	45 km
400 m	1400 m	9 km	50 km
500 m	1500 m	10 km	55 km
<i>and so on until</i>	<i>and so on until</i>	<i>and so on until</i>	<i>and so on until</i>
1000 m	5000 m	30 km	70 km or greater

**Table 3.** Visibility measurements.



## Visibility objects

At observing sites where there are manual readings of visibility made, the observer will have a list of objects which they can make references to. These objects might be a range of hills in the distance or a building such as a church tower or chimney.

The visibility objects are selected in as many directions as possible, standing above the horizon or in stark contrast to their background.



**Figure 28.** Automatic visiometer.

Many Met Office observing sites now have automatic instruments for measuring the visibility. These are usually visimeters, which consist of remote transmitting and receiving equipment and a local display unit. The equipment is sited to be representative of an area 5 km in radius. However, automatic visibility sensors can only measure the visibility between the projector and receiver, and this is not necessarily a representative value.

Changes in visibility are the direct result in changes in the number of particles in the air and the humidity of the air.



There are a number of phenomena that can affect the transparency of the air and these include precipitation, fog, mist, dust, smoke or haze.

**Fog** – a suspension of very small, usually microscopic, water droplets in the air, reducing visibility at Earth's surface to less than 1000 m. The air in fog usually feels raw, clammy or wet, and the associated relative humidity is generally near 100 per cent.

**Mist** – a suspension in the air of microscopic water droplets or wet hygroscopic particles, reducing the visibility at Earth's surface. The term 'mist' is used in weather reports when the associated visibility is 1000 m or more and the corresponding relative humidity is 95 per cent or more but is generally lower than 100 per cent. Mist forms a generally fairly thin greyish veil which covers the landscape.

**Drifting snow and blowing snow** – an aggregate of snow particles raised from the ground by a sufficiently strong and turbulent wind.

- a) **Drifting snow** – an aggregate of snow particles raised by the wind to small heights above the ground and which veils or hides small obstacles. The visibility is not sensibly diminished at eye-levels. The motion of the snow particles is more or less parallel to the ground.
- b) **Blowing snow** – an aggregate of snow particles raised by the wind to moderate or great heights above the ground. The concentration of the snow particles may sometimes be sufficient to veil the sky and even the sun. Vertical visibility is diminished according to the intensity of the phenomena; horizontal visibility at eye-level is generally very poor.

**Haze** – a suspension in the air of extremely small, dry particles invisible to the naked eye and sufficiently numerous to give the air an opalescent appearance. There is no upper or lower limit to the horizontal visibility in the presence of which haze may be reported. Haze imparts a yellowish or reddish tinge to distant objects or lights seen through it, while dark objects appear bluish, mainly as a result of scattering of light by the haze particles. These particles may have a colour of their own which also contribute to the colouration of the landscape.

**Smoke** – a suspension in the air of small particles produced by combustion.

**Drifting and blowing dust or sand** – an aggregate of particles of dust or sand raised, at or near the station, from the ground to small or moderate heights by a sufficient strong and turbulent wind. The wind conditions (speed and gustiness) necessary to produce these phenomena depend on the nature and state of the ground, for example on the degree of dryness of the ground.

- a) **Drifting dust or drifting sand** – dust or sand by the wind to small heights above the ground. The visibility is not sensibly diminished at eye-level (1.8 m above the ground). The motion of the particles of dust or sand is more or less parallel to the ground.
- b) **Blowing dust or blowing sand** – dust or sand raised by the wind to moderate heights above the ground. The horizontal visibility at eye-level is sensibly reduced. The concentration of the particles of dust or sand may sometimes be sufficient to veil the sky and even the sun.

**Dust storm or sandstorm** – an aggregate of particles of dust or sand energetically lifted to great heights by a strong and turbulent wind. Surface visibility is reduced to low limits; the qualification for inclusion in a British report is visibility below 1000 m.

Dust storms or sandstorms generally occur in areas where the ground is covered with loose dust or sand; sometimes, after having travelled over great distances, they may be observed over areas where neither dust nor sand covers the ground.



**Figure 29.** Fog.



**Figure 30.** Mist.



**Figure 31.** Smoke.

## State of ground and concrete slab observations

Observations of the state of ground and of a concrete slab form part of the normal routine at synoptic and some climatological stations. At synoptic stations, state-of-ground observations are made at each synoptic hour (that is three-hourly from 0000 GMT) and state-of-concrete-slab observations are made at 0900 GMT. At climatological stations, observations of state of both ground and concrete slab are recorded once a day, at 0900 GMT, and, exceptionally, state of ground at other hours laid down for the station.

### State of ground.

For the state of ground, the observer selects the state from one of the scales detailed below:

State of ground without snow or measurable ice cover

- Dry (without cracks and no appreciable amount of dust or loose sand)
- Moist
- Wet (standing water in small or large pools on the surface)
- Flooded
- Frozen
- Glaze on ground
- Thin layer of loose, dry dust or sand not covering the ground completely
- Thin layer of loose, dry dust or sand covering the ground completely
- Moderate or thick layer of loose, dry dust or sand covering ground completely
- Extremely dry with cracks

State of ground with snow or measurable ice cover

- Mostly covered by ice
- Compact or wet snow (with or without ice) covering less than half of the ground
- Compact or wet snow (with or without ice) covering at least half of the ground
- Even layer of compact or wet snow covering ground completely
- Uneven layer of compact or wet snow covering ground completely
- Loose, dry snow covering less than half of the ground
- Loose, dry snow covering at least half of the ground
- Even layer of loose, dry snow covering ground completely
- Uneven layer of loose, dry snow covering ground completely
- Snow covering ground completely, deep drifts

### State of concrete slab

The state of the concrete slab is selected from the following scale:

- Slab dry
- Slab moist
- Slab wet
- Slab icy

When the concrete slab is covered by snow or the ground is frozen, or the state of the slab cannot be adequately described by the above scale, no record is made.



This fact sheet has been produced in conjunction with the Met Office's Observation Networks – Land Surface section.

For more information about the observing network, please contact the Met Office Customer Centre.

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