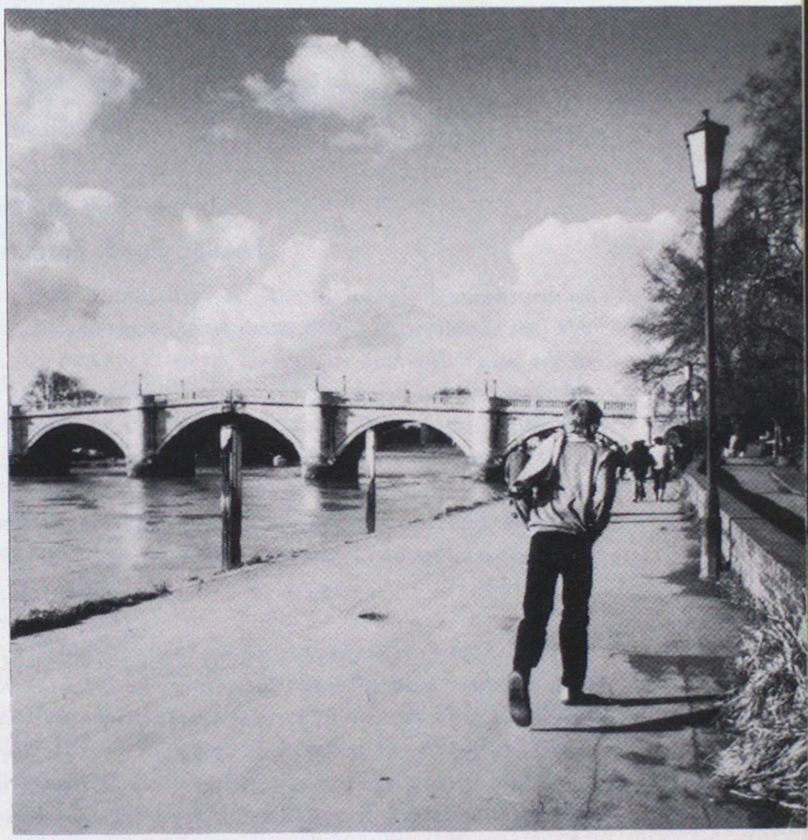
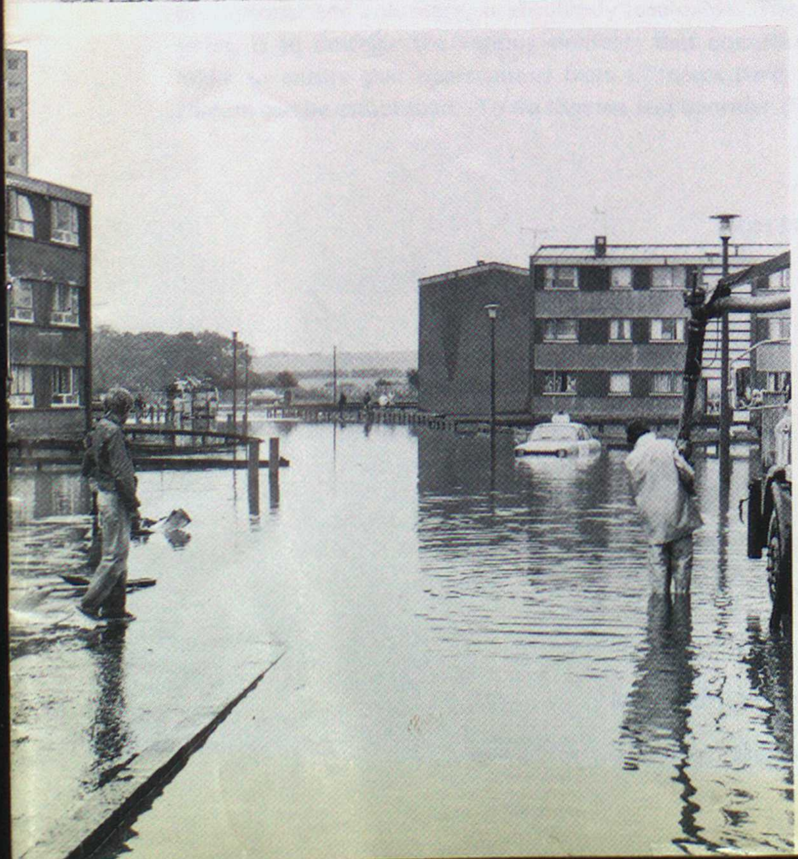
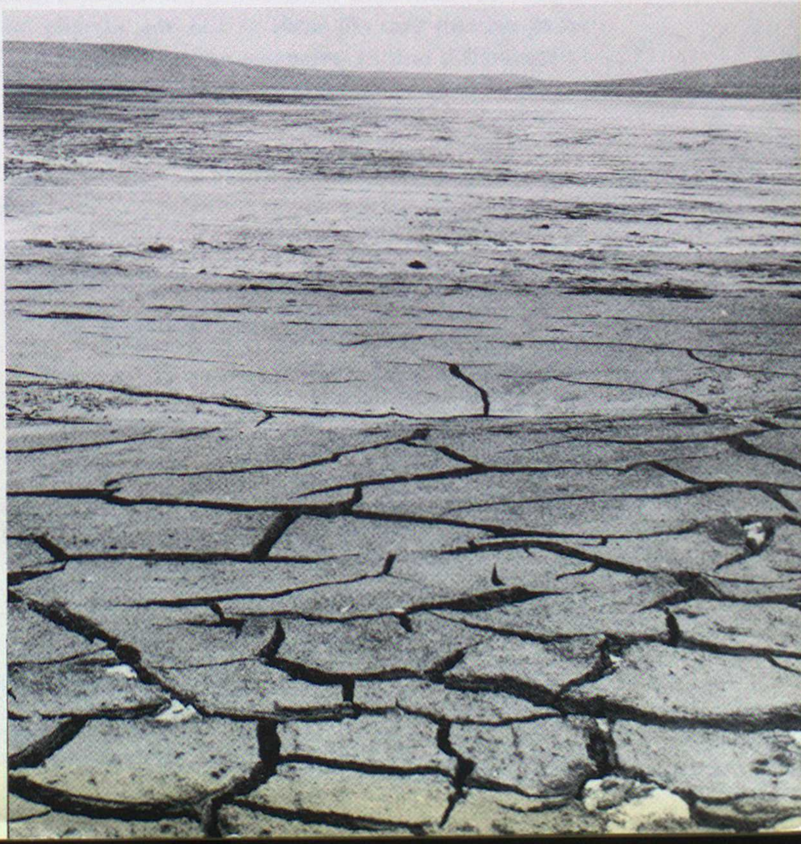
THE CLIMATE OF GREAT BRITAIN

AN INTRODUCTION TO THE SERIES

Climatological Memorandum 113







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An Introduction to the Series

INTRODUCTION

It has often been said, jocularly and somewhat unkindly, that Britain has no climate, merely a succession of weather. This comment amply reflects the high level of interest in, and in many cases dependence on, the day-to-day variations in weather that we experience. But what exactly is meant by climate and why do we try to define it? Basically it is a description of the weather, often in statistical terms, over a period long enough for short-lived extreme conditions not to have an undue influence on the overall picture. The weather normally experienced in Shetland is patently different in many respects from that of Cornwall and there are many regions in between that have a distinct and recognizable climate. The series of Memoranda *The Climate of Great Britain* presents a broad description, in simple terms, of the climate of a particular region. Much more detail is available within the Meteorological Office, and anyone wishing to obtain more information should write to one of the addresses given on page 13.

The climate of a locality is determined by latitude, altitude, local geographical features, position relative to land masses and seas, as well as the tracks of the major weather systems. This wide range of influences, together with the inherent year-to-year variability experienced in our latitudes, means that any descriptions must be based on a long period of good-quality observations so that the average and, often of equal importance, the variability about the average may be defined with confidence. Thus, observations of the weather are the basis of all studies of climate and it can never be stressed too much that the contribution of the national network of regular observers, professional and voluntary, is absolutely invaluable. The purpose of this Memorandum, as an introduction to the series, is to describe the various elements that comprise our climate, and also to show the care that has to be taken to ensure that observations from different parts of the country can be compared so that differences in climate can be established. To do that we will consider the weather elements one at a time.

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Met O 3 (Climatological Services)

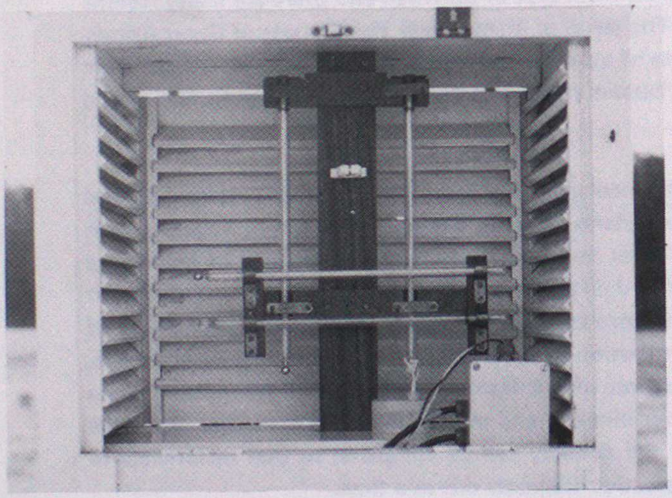
March 1982

TEMPERATURE

Of prime importance in any description of climate must be temperature. All our outdoor activities are affected to some extent by ambient temperatures. The energy required to undertake many indoor activities and operations is also primarily dependent on the prevailing temperature outside.

There have been many devices to measure temperature since the first thermometer (usually attributed to Galileo) was invented. There have also been several different proposals for the two fixed points necessary to define a temperature scale (e.g. freezing-point of oil of aniseed, Robert Boyle, 1664; temperature of a healthy human body, Isaac Newton) and the number of divisions between such points (e.g. 12, Newton; 96, Fahrenheit; 80, Réaumur; 100, Celsius and others). The Celsius scale (formerly known as Centigrade) uses the melting-point of ice and the boiling-point of water as the fixed points with 100 divisions between them.

Even with a standard scale of reference there are occasions when temperatures need to be described qualitatively. For example, a temperature of 10 ^{o}C might be described as very mild in most parts of Britain in January but very cold in July. Humidity can influence how a person feels at a given temperature, and wind has a considerable effect by dissipating heat, thus giving an impression of a much lower temperature.

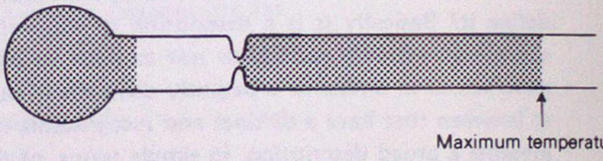


Inside an ordinary thermometer screen

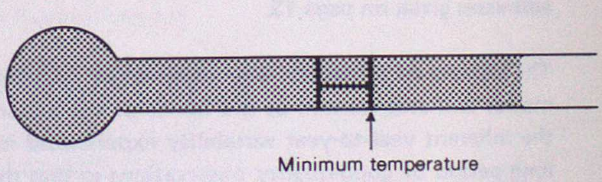
Nevertheless, temperature is of fundamental importance and several different readings are taken for climatological purposes. Most important are those measured in the thermometer screen (of a type designed by Thomas Stevenson, father of Robert Louis Stevenson). This is simply a naturally ventilated box, with a double roof and louvered sides, mounted at a standard height so that the bulbs of the thermometers inside are 1.25 metres above a ground surface which, ideally, should be of short grass. The door giving access to the thermometers faces north (in the northern hemisphere) and the whole structure is painted white. This well-established design ensures that the instruments are shielded from precipitation and from direct radiation from both sun and earth so that temperatures recorded within it are as near as possible to true air temperatures.

Typically, four thermometers are housed in the screen. Two of them are identical mercury-in-glass types, but one has its bulb covered with muslin which is kept moist by means of a wick dipped in clean water. This thermometer is known as the 'wet-bulb' thermometer and the difference between the 'dry-bulb' and the 'wet-bulb' temperatures, known as the wet-bulb depression, is used to determine the humidity of the air. It is very important that the muslin and wick and the water are kept clean, otherwise the wet-bulb temperature will be too high, with consequent effects on the humidity calculation.

Of the remaining two thermometers, one is a mercury-in-glass type with a constriction in the bore close to the bulb. As the temperature rises, mercury from the bulb is forced past the constriction but is unable to return when the temperature subsequently falls. This thermometer measures the maximum temperature achieved since the thermometer was last read and reset. The fourth thermometer uses alcohol instead of mercury and contains a small, light, dumb-bell shaped index inside the liquid. As the temperature falls, the alcohol column contracts, moving the index with it. When the temperature subsequently rises the alcohol flows past the index, leaving it behind to indicate the minimum temperature.



Maximum thermometer after fall of temperature



Minimum thermometer after rise of temperature

The majority of observations made for climatological purposes are taken at 0900 GMT and the maximum and minimum temperatures refer to the 24-hour period prior to the observation. However, in some cases observations are made more frequently and it is then normal practice to split the 24-hour period, recording a 'day maximum' and a 'night minimum'. These two practices give slightly different average values for maximum and minimum temperatures, particularly for winter months, though typically the difference is only a few tenths of a degree.

In addition to temperatures measured inside the thermometer screen, certain other temperatures are of interest. One example is the lowest temperature reached during the night in an open position immediately over short grass — the *grass minimum*. This is measured by setting a minimum thermometer just in contact with the tips of the blades of grass. Measurements are also made of the minimum temperatures observed on the surface of a concrete slab. For agricultural purposes temperatures are also recorded at various depths in the ground between 5 cm and 100 cm.

Winter temperatures in Great Britain are influenced to a very large extent by the surface temperature of the surrounding seas. The waters off western coasts are a degree or so warmer than off North Sea coasts and this leads, on average, to a temperature decrease across the country from west to east. In spring, summer and autumn, however, the dominating effect is the amount of heat from the sun and this depends on latitude. The following table illustrates these points by giving mean temperatures for January/July at various locations around the coast.

	Mean temperatures (°C)	
	January	July
Stornoway (Western Isles)	4.1	12.9
Auchincruive (Strathclyde)	3.4	14.3
Aberystwyth (Dyfed)	5.1	15.6
Weston-super-Mare (Avon)	4.5	16.9
Clacton-on-Sea (Essex)	3.3	16.9
Skegness (Lincs.)	3.2	15.9
Edinburgh (Lothian)	2.9	14.7
Wick (Highland)	3.1	12.5

Altitude also has an effect on temperatures which, as a general rule, decrease with increasing height. On average, the decrease is about 0.5 °C/100 m for minimum temperatures and 0.7 °C/100 m for maxima.

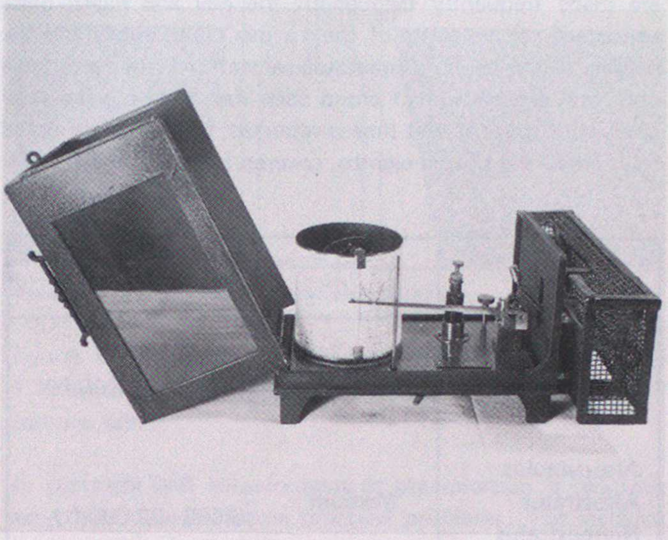
Extremes of temperature, both high and low, can adversely affect plants, animals and materials of various kinds. In Britain, persistent high daily maximum temperatures may be pleasant for the holiday-maker but can cause water supply problems and have serious effects on the growth of crops. However, such conditions rarely occur. On the other hand, temperatures below freezing-point are much more commonplace, often disrupting routine activities and causing damage to unprotected materials and plants. Thus the number of days with *ground frost* and *air frost* is an important aspect of the description of the climate of an area. 'Frost' is the term popularly used to describe icy deposits which may form on surfaces with temperature below freezing-point, but ground frost and air frost are terms used in meteorology to describe temperature conditions only, and do not give an indication of formation of ice.

For many years a ground frost was recorded when the grass minimum temperature (described on page 2) was at or below 30 °F (somewhat below freezing-point, 32 °F or 0 °C). In 1961 the definition was changed and nowadays statistics refer to grass minimum temperatures below 0 °C. An air frost is said to have occurred when the air temperature measured inside a thermometer screen has fallen below 0 °C.

Minimum temperatures are very dependent on local topography and marked differences can occur over quite small distances when, for example, sites on a hillside are compared with those at the bottom of a valley. Cold air, being denser than warm air, tends to drain away from high ground towards low ground and to collect in valleys and hollows. Areas where this cold air collects are known as *frost hollows* and are subject to a greater incidence of frosts, and to more severe frosts, than elsewhere (e.g. Rickmansworth, Herts.; Braemar, Grampian; Corwen, Clwyd).

HUMIDITY

If it were not for the very small proportion of water vapour in our atmosphere (less than 4 per cent by weight) we would not have any weather to describe – no cloud, no precipitation, no fog and, consequently, day after day of uninterrupted sunshine. In fact, the behaviour of the atmosphere is profoundly affected by the presence of water and it is important to have some means of measuring the water-vapour content of the air.



Hair hygrograph (see below)

There are a number of ways of expressing the humidity of a sample of air, all of which have particular applications. The *dew-point* of a sample of air is the temperature to which the sample must be cooled to make it saturated. Hence the closer the air temperature is to the dew-point, the nearer is the air to saturation. Dew-point does not vary a great deal within an air mass of particular origin and is therefore useful in weather forecasting for locating warm and cold fronts, which are boundaries between different air masses.

Relative humidity (humidity expressed as a percentage) is a measure of the amount of water vapour in the air compared to the maximum which could be contained by air at the same temperature. If the amount of water vapour in the air remains constant, the relative humidity decreases (or increases) as the temperatures rise (or fall). A normal diurnal range might be from 95 per cent around dawn to 60 per cent in the afternoon. Values below 40 per cent are unusual and only rarely do they fall below 10 per cent in this country.

The normal method used by the Meteorological Office to determine humidity is to read the wet-bulb and dry-bulb thermometers (described on page 2). Using suitable tables, or a specially designed humidity slide-rule, both dew-point and relative humidity can be calculated from these values. One other instrument in fairly common use is the hair hygrograph. This depends for its action on the fact that the length of a clean, degreased human hair varies with relative humidity but is virtually constant with other meteorological elements. This variation can be measured and calibrated to give a continuous record on a chart.

CLOUD

Clouds are continuously forming and decaying and, therefore, appear in a wide variety of forms which are observed all over the world. The present classification is derived from that originated by Luke Howard at the beginning of the nineteenth century. It is based on ten main groups (genera), which can be classified as low, medium or high according to that part of the atmosphere in which they are normally observed.

At meteorological offices observations of the state of the sky are made frequently throughout the day and night; these consist of the amounts of the various cloud types and the heights of the bases. Climatological stations, however, make only one observation of cloud each day and only the total amount of cover at that time is reported; this is the estimated fraction of the sky, in eighths, covered by cloud of all forms.

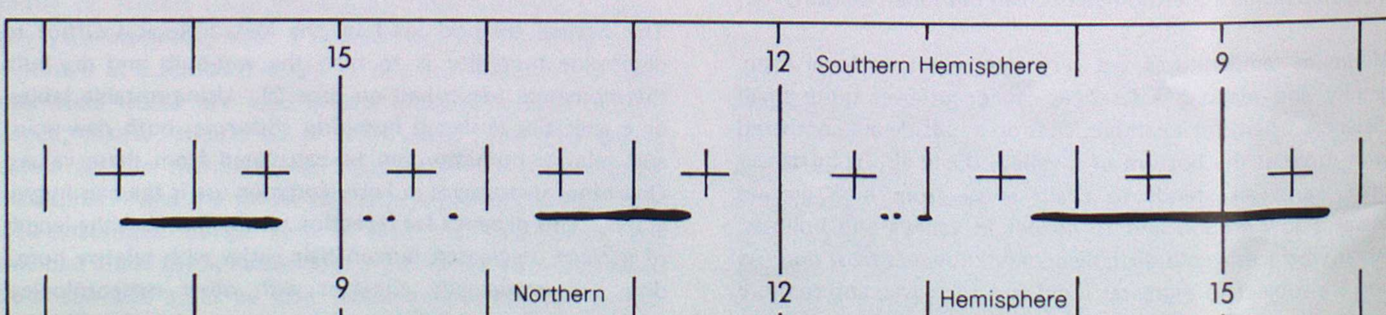
Genera	Observed heights	
Cirrus Cirrocumulus Cirrostratus	High	5–14 km (16 500–45 000 ft)
Altocumulus Altostratus Nimbostratus	Medium	2–7 km (6500–23 000 ft)
Stratocumulus Stratus Cumulus Cumulonimbus	Low	Surface–2 km (up to 6500 ft) These two can be of great vertical extent

SUNSHINE

Less than half of the incoming radiation from the sun actually reaches the earth's surface. About 40 per cent is reflected back into space and a further 15 per cent is absorbed by the earth's atmosphere. Detailed radiation measurements are made at a selection of locations around the United Kingdom but there is a more extensive network of observers who simply record the duration of bright sunshine. The method used is to concentrate the sun's rays, using a solid glass sphere, so that they burn a hole in a card which is graduated with a time-scale. Thus, the sunshine recorder is the only meteorological recording instrument which has no moving parts.

Finding a suitable site for a sunshine recorder can often be a problem. Ideally, the horizon between north-east and north-west through south should be clear above an elevation of 3 degrees to avoid a shadow being thrown over the recorder. The daily record itself sometimes needs careful measurement as short bursts of bright sunshine can exaggerate the duration.

Sunshine recorder



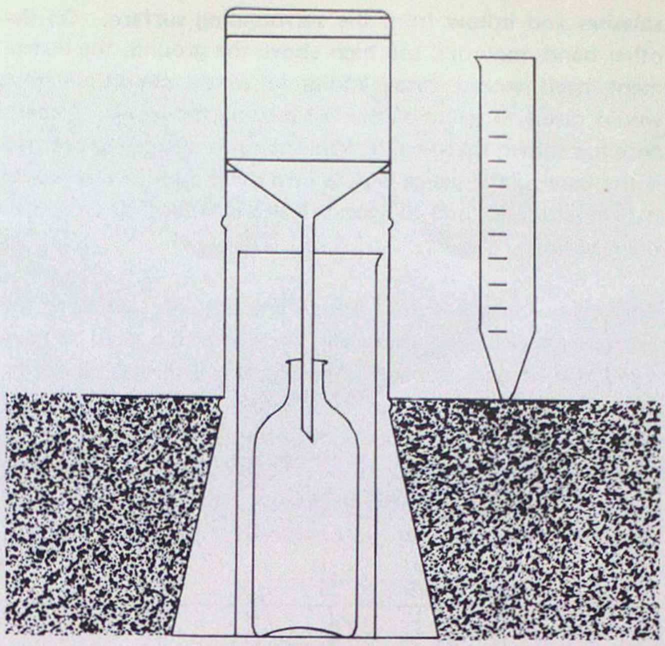
Burns on a sunshine card

RAINFALL

Rainfall is a particularly important element of our climate in view of the effect it has on many aspects of our lives. Most large reservoirs depend on rainfall over several months for their replenishment. Heavy rain over a few days can cause flooding of major rivers. A few minutes' downpour can lead to overflowing of urban storm sewers and culverts. In each case climatological information on rainfall and its variability is required to optimize design and to assess the frequency of failure to cope with extreme rainfall events and the likely consequences. Getting the right amount of rain at the right time is also of fundamental importance in agriculture and horticulture, and this ultimately affects us all.

Rain is a very variable meteorological element in both space and time. It may come from a depression covering several thousand square kilometres and last for many hours. On the other hand it may take the form of scattered showers, any one of which may be very heavy for a matter of minutes, falling only over a small area, perhaps just a few square kilometres. Windward slopes of hills experience most rain, with areas on the leeward side getting much less. Therefore, in order to build up a good understanding of the rainfall characteristics of an area, it is desirable to have a dense network of rain-gauges. The map below shows the location of gauges read daily in a strip across the Pennines and shows a marked variation in network density. This is primarily due to variations in population density — in rural areas there are fewer people available to maintain gauges at accessible and suitably exposed sites.

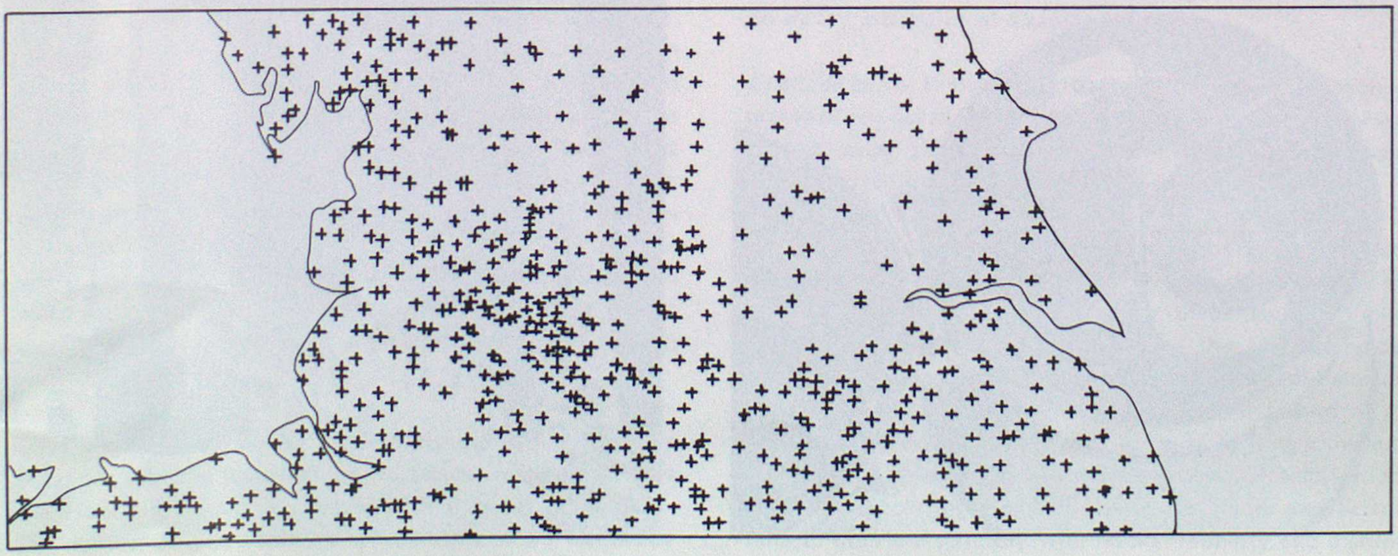
A variety of rain-gauges has been designed over the years, all on the same principle — to catch precipitation falling within a circle of known area in a given period and funnel it into a collecting device for subsequent measurement. The period is usually a day although in some cases, where access is difficult, only monthly totals are recorded. To ensure that measurements are comparable, rain-gauges are read at a standard time, 0900 GMT; the 24-hour period beginning at 0900 GMT is called the *rainfall day*. The amount of rain is conveniently expressed as the depth to which the area would be covered assuming no evaporation, drainage or run-off. To put such figures in perspective, 1 millimetre of rain is equivalent to 1 kilogram of water per square metre, or approximately 4 tons per acre.



Standard rain-gauge and measuring glass

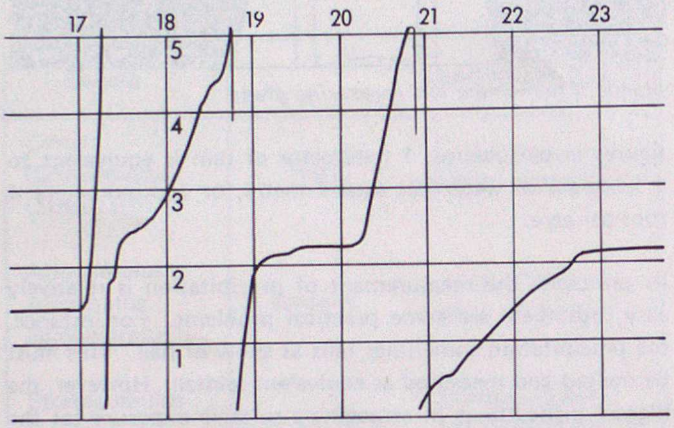
In principle, the measurement of precipitation is relatively easy, but there are some practical problems. For instance, the precipitation sometimes falls as snow or hail. This must be melted and measured as equivalent rainfall. However, the biggest difficulty is in arranging a suitable exposure for the gauge. The aim is to obtain a representative sample of the fall over a given small area that can be compared with measurements elsewhere. Thus the gauge must be situated so that it is neither over-sheltered by nearby buildings or trees, nor yet over-exposed to strong winds which would result in some of the fall missing the gauge because of turbulent eddies.

Having found a suitable location the other main problem is to ensure that the instrument makes a true measure of the rain actually falling. Buried with its top flush with the ground, the gauge would inevitably collect too much, being open to



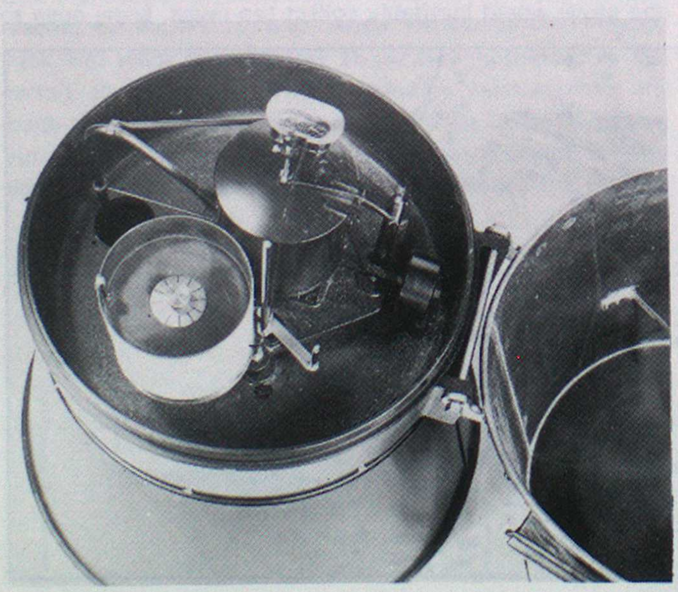
Part of the network of rain-gauge sites splashes and inflow from the surrounding surface. On the other hand, mounted too high above the ground, the instrument itself would cause eddies in windy conditions that would result in some of the fall missing the gauge. Experience has shown that an acceptable compromise can be reached if the base of the gauge is sunk into the ground, which keeps it firm and level, and the top set at a standard 30 cm above the ground.

For many purposes the actual amount of rainfall is of primary importance. However, there is also a need to have some idea of duration and intensity; this information can be determined by using rainfall recorders. The majority of these collect rainfall in a chamber and the movement of a light float is recorded on a paper chart held on a rotating drum. The float chamber eventually fills up and, although water is siphoned out automatically, rainfall cannot be



Traces on a rainfall recorder chart

recorded while this is happening. This is typical of a rainfall recorder – it generally collects slightly less precipitation than an ordinary gauge. Another type of recorder simply logs the time when a known small amount of rain (usually 0.2, 0.5 or 1.0 mm) has been collected. The record is not strictly continuous but, since it can easily be stored on magnetic tape, this type of instrument is useful in remote areas where daily readings would be impossible.


Tilting-siphon rain recorder

Defining whether a day has been 'wet' involves a certain amount of personal judgement. For instance, most people can afford to ignore overnight rain. Some combination of amount of duration also needs to be considered – 10 mm is an appreciable fall but it could be the result of one late afternoon shower marking the end of a hot sunny day. For the purposes of this series of Memoranda the following definition of a 'rainy day' has been adopted.

(i) The day is taken as 0700–1700 GMT
(ii) Hours with less than 0.2 mm of rain are ignored.
(iii) Rainfall duration in the remaining hours is accumulated.
(iv) A 'rainy day' is one where this accumulation is at least 2 hours.

ICE DEPOSITS

The terminology used to describe deposits of ice can be a little confusing and perhaps needs some explanation. To the general public 'frost' usually means some form of deposit although, as described on page 3, ground frost and air frost are defined strictly by reference to temperature. The common, white, frosty deposit is in fact *hoar frost*. As air comes into contact with a surface cooled to below freezing-point the water vapour is deposited as thin ice crystals, often in the form of scales, needles, feathers or fans. *Rime* is similar in appearance, but is unusual at low altitudes in Britain because it is formed by supercooled (i.e. below 0 °C) water droplets coming into contact with solid objects at a temperature below 0 °C. This supercooling is rare at low altitudes. It can be distinguished from hoar frost by its non-crystalline character and by its build-up on the upwind side of objects, often to considerable depths. *Glazed frost,* on the other hand, is smooth and clear and is usually formed by drizzle, rain or sleet falling on a surface whose temperature is below freezing-point. The term 'black ice' is often applied to conditions of glazed frost on a road surface, the dark colour of the road material showing through the clear ice.


Rime at Great Dun Fell, December 1964

Snow scene, February 1962

Descriptions of snowfall and depths of lying snow present major problems to the climatologist. The variability of rainfall has already been noted and snow is even more marked in its variations, not only from place to place but also from year to year.

The amounts of snow that fall over the British Isles are measured as rain. In other words, the snow caught in the rain-gauge is melted before being measured. Additionally, snow depths are measured at many observing stations. For comparison purposes these depths are taken in level undrifted snow since wind causes large variations in depths over quite small areas. Ten centimetres of freshly fallen snow is *very* roughly equivalent to one centimetre of rain.

Separate records are kept of the number of days with snow falling and snow lying. The number of days of snow falling and snow lying strongly reflect the topographic pattern. The rate of increase with height of the number of days for both snow falling and snow lying decreases from north to south. The number of days with snow falling varies from less than 5 days per year in southern Cornwall to around 60 days in the Northern Isles. However, it should be remembered that the remoteness of many upland areas of Britain means that a comprehensive snow-reporting network is impracticable. Also many of the reports that are received come from volunteer observers who cannot always maintain a 24-hour watch on the weather. Undoubtedly there are occasions when falling snow is not noted in some locations and these records are not as complete or reliable as might have been wished.

Days with snow lying are more easily defined. These are occasions when at least half of the ground representative of the reporting station is covered with snow at 0900 GMT. The number of such occasions is dependent on the frequency and quantity of snowfall, the subsequent prevailing temperatures and the characteristics of the observing site such as altitude and aspect. Average annual values range from less than 5 days in southern and western coastal districts to more than 100 days on peaks in the Grampians. These averages mask considerable variations from year to year. For example, during the winter of 1962/3 Exeter had 40 days with snow lying, but only 2 the following winter.

A snowflake is an aggregate of ice crystals and occurs in a variety of shapes and forms. At very low temperatures small flakes of simple structure are predominant, but near freezing-point a snowflake can be made up of a very large number of crystals and have quite a large diameter. Flakes of up to 5 mm diameter often show a six-rayed starlike structure but larger onces are usually a collection of such flakes and the geometrical structure is usually obscured.

Rain and snow falling together, or partly melted snowflakes, are referred to as *sleet* in this country, although the term has no agreed international meaning.

Granular snow (snow grains) consists of rather flat opaque grains of ice usually less than 1 mm in diameter. If they are a little larger (2–5 mm diameter) and spherical they are often referred to as *snow pellets* or *soft hail*.

The term blizzard, which originally applied to intensely cold north-westerly gales accompanied by fine drifting snow in the USA, is used somewhat loosely these days in public terminology. The definition used by the Meteorological Office is rather more strict, requiring the simultaneous occurrence of moderate or heavy snowfall and wind of at least Beaufort force 7 (28 knots) to cause drifting snow and reduction of visibility to 200 metres or less. It is applied to conditions occurring over a wide area, lasting for a sufficient time to interfere seriously with human mobility and disrupt communications.

VISIBILITY

Visibility is defined as the greatest horizontal distance at which an object can be identified with the naked eye. It depends to a certain extent on such factors as contrast between object and background, position of the sun, and even the observer's eyesight, but it is primarily an indication of the transparency of the atmosphere which is governed mainly by the quantity of solid and liquid particles held in suspension.

Drifting sand or dust is by no means unknown in some parts of the country, often reducing visibility quite considerably, and almost anywhere it is possible for thick drizzle or heavy snow to reduce the visibility to a few hundred metres. Such occurrences tend to be short-lived however. The presence of minute particles of dust, smoke or water can lead to longer-lasting effects — haze in the case of the first two and mist or fog in the case of the latter two.

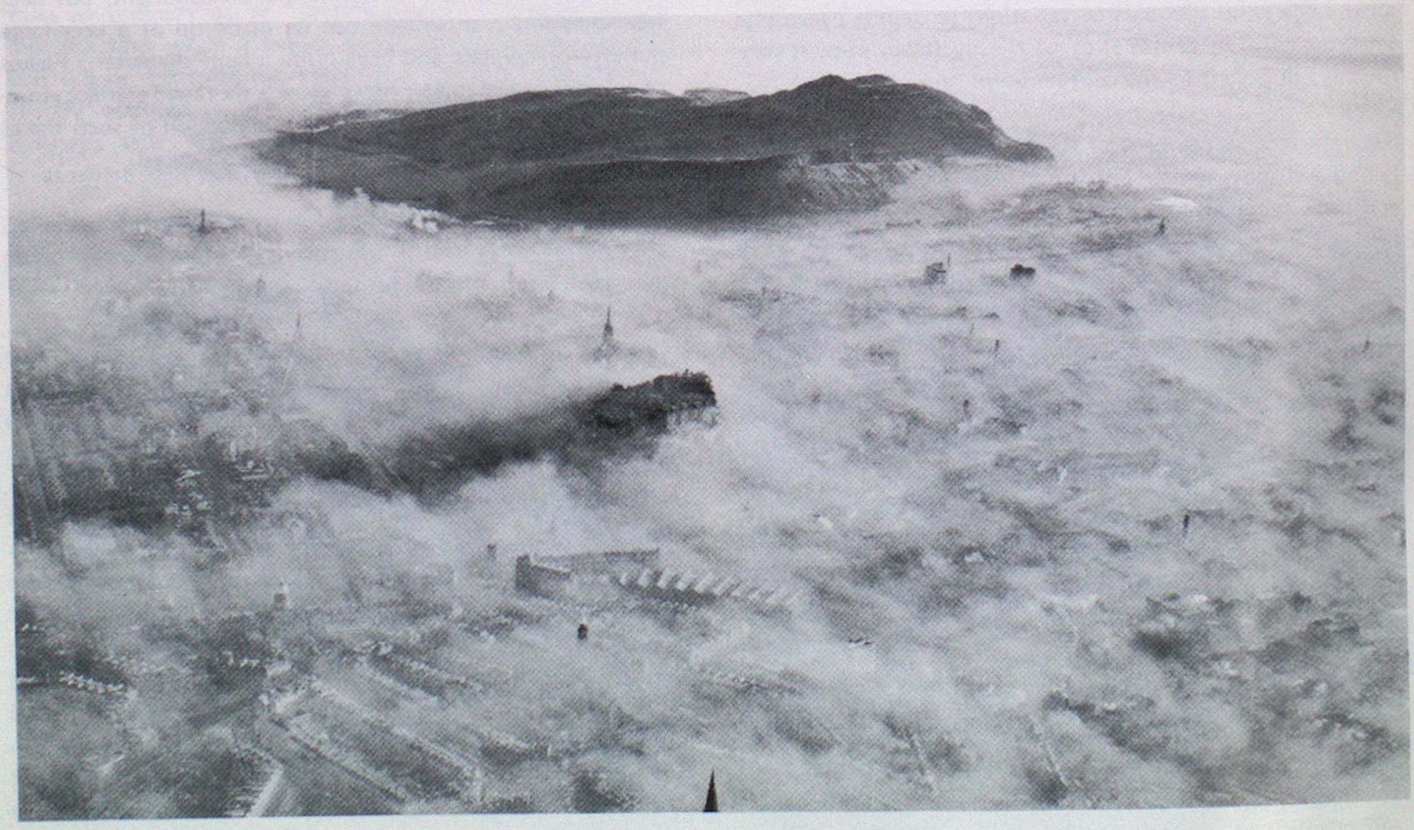
Fog is the reduction in visibility by minute water droplets or smoke particles or both to less than 1000 metres. This is the level at which aircraft and shipping movements are liable to be affected. In forecasts for the general public, on the other hand, fog implies visibilities below 200 metres because it is only at such values that road transport becomes affected. This is an example of the terminology being tailored to the user requirement.

There are a number of physical processes which can lead to the formation of fog. On nights with light winds and clear skies the land, losing heat by radiation, cools the air above it down to its dew-point. Fogs that form in these conditions are known as *radiation fogs*. An increase in wind speed will mix the fog-laden air with warmer, drier air above and can sometimes lead to an improvement in the visibility. Radiation fogs are usually dispersed during the day by the heat of the sun causing the water droplets to evaporate.

Radiation fogs only occur over land, but another type of fog is more typical over seas and windward coasts, and is known as *advection fog*. It is formed when warm moist air moves over an area where the surface temperature is sufficiently low to cool the advected air down to its dew-point. Thus sea areas with cold currents are favoured places for this type of fog to form. The fogs of the Grand Banks of Newfoundland are probably the best known example, but haar (or sea fog) frequently affects the east coast of England and Scotland. The fog-laden air can continue to move and invade coastal districts. In such areas the sun can disperse advection fog in the same way as radiation fog — by heating the land surface. However, since the sea surface warms much more slowly than the land, sea fog can persist much longer and light wind conditions can result in the fog from the sea replacing the coastal fog as quickly as it disperses. When cloud envelops high ground the term 'hill fog' is used. In hilly areas this particular feature is more common than radiation or advection fogs.

Upslope fog is a feature of windward slopes of high ground. When air is forced to rise by topography it expands and cools and, if the process continues, the air becomes saturated and condensation occurs.

Voluntary climatological observers make a once-daily estimate of visibility (at 0900 GMT) based on the sighting of a number of carefully chosen objects at known distances. Meteorological Office staff, many of them based at airfields, make more frequent and precise observations.



Haar (sea fog) over Edinburgh

THUNDER AND LIGHTNING

The occurrence of these two phenomena in a mature thunderstorm is without doubt one of the most dramatic manifestations of the power of the weather– fascinating to some, frightening to others, potentially extremely destructive and yet providing an essential balance-mechanism in the physics of the atmosphere.

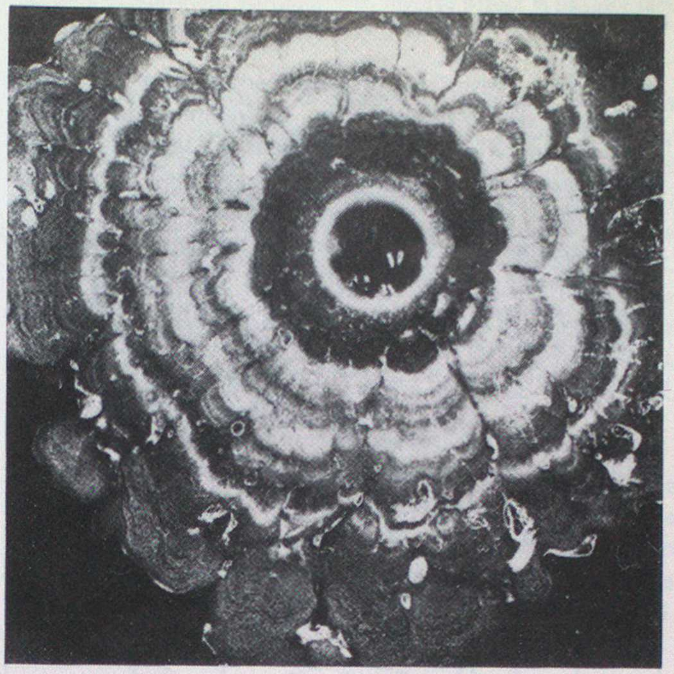
Lightning is simply a discharge of static electricity, usually taking place either between a cloud and the ground or between two clouds. In Britain about 45 per cent of lightning flashes are of the first type. Popular terminology distinguishes between forked and sheet lightning. The former term applies to lightning where many luminous paths of discharge are visible, the second to the diffuse glow that is seen when the discharge path is obscured by cloud. To say that lightning does not strike twice in the same place is an over-simplification – a structure that provides a convenient route to ground for the discharge will remain so until suitable precautions are taken. Nevertheless, estimates of lightning frequency in Britain suggest about one flash to ground per square kilometre per year; this is quite a low risk.

Ironically, to many people the frightening part of a thunderstorm is the thunder, and yet this is only the noise that follows the destructive element – the lightning. The intense heating caused by the flash produces a violent and noisy expansion of the air. This is often heard as a rumbling sound because of the differing times taken for the sound to travel from various parts of the flash. The difference between the speeds of light and sound account for the lag between seeing a lightning flash and hearing the thunder. The distance of the flash can be obtained, roughly, by estimating the lag in seconds and dividing by 3 to give the distance in kilometres (or dividing by 5 for miles).

The majority of observations of thunderstorms are of thunder heard and, since thunder is rarely heard at distances greater than 20 km, obviously some storms go unreported. Thunder is also a very variable element in Britain, and almost any part could experience 5 storms in one year and 20 in the next. However, on average, annual frequencies range from 5 days in western coastal districts and over much of central and northern Scotland to 15 days or so in parts of central and southern England. There is relatively little seasonal variation on the western seaboard, but elsewhere summer is the most thundery season.

HAIL

Hailstones are produced as a result of the vigorous convection currents found in towering cumulonimbus cloud. They are hard pellets of ice, variable in size, usually only a few millimetres in diameter although they can be much bigger – sometimes several centimetres across and weighing ½ kg or more. The pellets can be spherical, conical or irregular in shape and often have a structure of concentric layers of alternately clear and opaque ice, indicating that the hail has grown by accretion of both supercooled water droplets and ice particles.

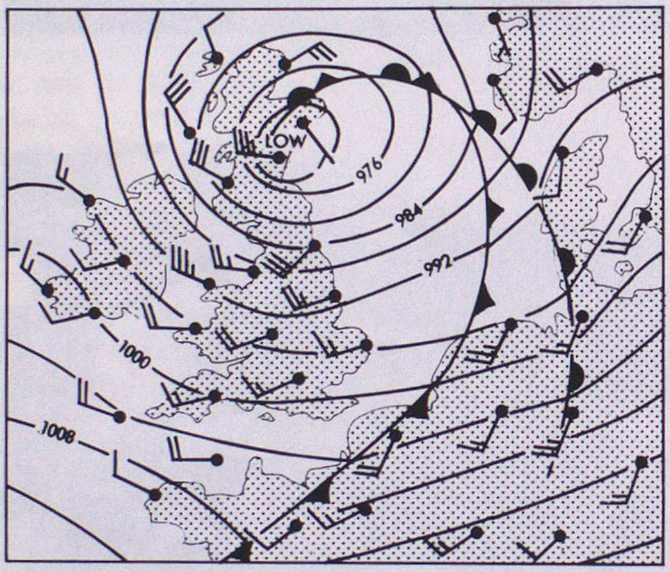


Cross-section of a hailstone

Hail damage to nose of aircraft

PRESSURE AND WIND

Atmospheric pressure is of fundamental importance when considering day-to-day weather. Its variations in time and space provide vital information about the location of significant areas of high and low pressure, and their likely movement. When averaged over a long period, however, pressure differences between various parts of the country are much less noticeable and when considering climate, rather than weather, pressure itself is of minor importance. At any given moment a difference in air pressure will give rise to a wind — a movement of air — and anyone familiar with television weather charts will be aware of the relationship between the spacing of the isobars (lines of equal pressure) and the wind — the closer the isobars are together the stronger the wind. In the northern hemisphere winds blow anticlockwise around areas of low pressure (depressions) and clockwise around areas of high pressure (anticyclones). Wind directions are more or less along the direction of the isobars.



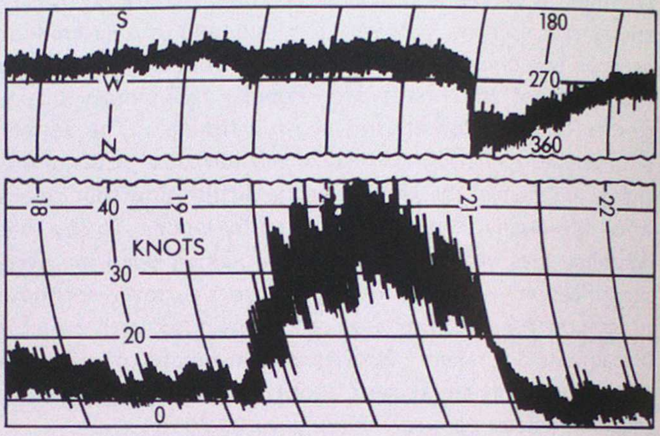
Isobaric chart with wind arrows

WIND

Wind is a vector quantity in that it has both speed and direction, and it is often important to have information about both. Wind direction is conventionally given as the direction *from* which the wind blows, either as a compass point or as degrees clockwise from true north. It is indicated by a wind vane which usually consists of a horizontal arm accurately balanced on a vertical spindle with a pointer at one end and streamlined fins of aerofoil cross-section at the other. Wind speed is measured by an anemometer, calibrated in either metres per second, statute miles per hour or nautical miles per hour (knots). One metre per second is roughly 2 knots; 6 knots is roughly equivalent to 7 miles per hour.

One of the commonest types of anemometer uses three or four cups mounted symmetrically on a vertical axis. Since the rate of rotation of the axis is proportional to the wind speed it can be used to drive a generator and produce a voltage which increases with increasing wind speed. Instantaneous values of direction and speed are usually displayed on dials.

However, friction between moving air and the underlying surfaces generates turbulence which is noticeable as short-period fluctuations, both in direction and speed. A continuous record is displayed on an anemogram where readings from the wind vane and anemometer are transferred to a chart. A typical example is shown below and amply illustrates the need to average readings over a suitable period, which can vary according to the eventual use to which the data will be put.



For climatological purposes direction and speed are averaged over an hour, but the highest recorded value (gust) in that hour is also noted to give some measure of the variability. Typically a gust will be measured over a period of a few seconds.

One of the biggest problems associated with measuring wind is finding a suitable and yet convenient site for exposing an instrument. For comparison purposes it is desirable for all measurements to be taken at a standard height above the ground and 10 metres is considered a suitable compromise between convenience and an attempt to minimize the effects of friction between the air and the ground. Ideally the ground should be level and open with no obstruction within 200 metres in any direction so that measurements can be considered representative not just of the observing site but also of a wider area round. Quite frequently these conditions just cannot be met in areas where wind records are required, so allowances must be made when the data are being compared with those from standard sites.

In short, wind is probably one of the most difficult of weather elements to measure adequately and yet it is most important to have a good description of it since records have very important practical applications in such fields as the design of wind-sensitive structures and planning for certain industrial processes.

Estimates of wind speed can be made by reference to the Beaufort scale. This was originally based on the behaviour of a man-of-war of the period 1800–1850 but it has since been adapted for land use as well, as shown in the table opposite. In particular, a *gale* is defined as a wind of force 8 on the Beaufort scale, or, more specifically, a wind whose mean speed over a period of 10 minutes is between 34 and 40 knots. Statistics of gales, such as the number of days of gale, refer to the attainment of mean speeds of 34 knots or more.

Local topography can modify the broad-scale wind both in speed and direction. A hill may give shelter with winds from one direction but increase wind speeds from another direction, while a valley may funnel winds along it, thus changing the direction and perhaps increasing the speed. In certain conditions differences in temperature from place to place can give rise to local winds which might be quite different from the overall picture suggested by an isobaric chart.

One of the commonest local variations is to be found near coasts from late spring to early autumn on occasions when overall wind speeds are low, say less than 10 knots. If there is not too much cloud then the land heats up more quickly than the sea and the land in turn heats the air above it. Horizontal pressure-differences are created which lead to a flow of air from sea to land. This is the *sea-breeze* which may reach 10 to 15 knots and dominate the local wind pattern. The effect of this local wind can be felt up to 25 kilometres or more inland. At night in similar situations the land cools more quickly than the sea and a *land-breeze* can become established, although this reverse effect is usually less marked than the sea-breeze.

A local wind that has more effect on nights with clear skies is experienced near sloping ground. The ground cools by radiation and the air in contact with it is also cooled and becomes more dense than nearby air at the same level. Being more dense it moves down the slope and can give rise to a *downslope* or *katabatic wind* of up to 5 knots. This may appear as a land-breeze around some of the Scottish lochs. This mechanism is the same as that described earlier in the temperature section in connection with frost hollows. The reverse process, daytime heating of the air by the land, can give rise to an *upslope* or *anabatic wind.*

Areas downwind of a range of mountains can experience a warm dry wind caused by the föhn effect. This is the process by which rising air on the windward side of hills forms cloud thick enough to give rain or drizzle, but on the lee side the descending air, having lost some of its water as precipitation, is warmer and drier.

BEAUFORT SCALE : SPECIFICATIONS AND EQUIVALENT SPEEDS

Force	Description	Specifications for use on land	Equivalent speed at 10m above ground						Description in forecasts
			Knots		Miles per hour		Metres per second		
			Mean	Limits	Mean	Limits	Mean	Limits	
0	Calm	Calm; smoke rises vertically	0	<1	0	<1	0.0	0.0–0.2	Calm
1	Light air	Direction of wind shown by smoke drift, but not by wind vanes	2	1–3	2	1–3	0.8	0.3–1.5	Light
2	Light breeze	Wind felt on face; leaves rustle; ordinary vane moved by wind	5	4–6	5	4–7	2.4	1.6–3.3	Light
3	Gentle breeze	Leaves and small twigs in constant motion; wind extends light flag	9	7–10	10	8–12	4.3	3.4–5.4	Light
4	Moderate breeze	Raises dust and loose paper; small branches are moved	13	11–16	15	13–18	6.7	5.5–7.9	Moderate
5	Fresh breeze	Small trees in leaf begin to sway; crested wavelets form on inland waters	19	17–21	21	19–24	9.3	8.0–10.7	Fresh
6	Strong breeze	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty	24	22–27	28	25–31	12.3	10.8–13.8	Strong
7	Near gale	Whole trees in motion; inconvenience felt when walking against wind	30	28–33	35	32–38	15.5	13.9–17.1	Strong
8	Gale	Breaks twigs off trees; generally impedes progress	37	34–40	42	39–46	18.9	17.2–20.7	Gale
9	Strong gale	Slight structural damage occurs (chimney pots and slates removed)	44	41–47	50	47–54	22.6	20.8–24.4	Severe Gale
10	Storm	Seldom experienced inland; trees uprooted; considerable structural damage occurs	52	48–55	59	55–63	26.4	24.5–28.4	Storm
11	Violent storm	Very rarely experienced; accompanied by widespread damage	60	56–63	68	64–72	30.5	28.5–32.6	Violent storm
12	Hurricane	–	–	>64	–	>73	–	>32.7	Hurricane

Gale damage in Edinburgh, 20 January 1976

CONVERSIONS FOR

Temperature

°C	–10	–5	0	5	10	15	20	25	30
°F	14	23	32	41	50	59	68	77	86

Rainfall

mm	1	5	10	50	100	500	1000	4000	5000
in	0·04	0·2	0·4	2·0	3·9	19·7	39·4	157·6	196·9

CLIMATOLOGICAL SERVICES AVAILABLE FROM THE METEOROLOGICAL OFFICE

The Meteorological Office collects and archives regular weather reports from a national network of observing stations, consisting of both Meteorological Offices manned by professional staff and co-operating stations operated by interested organizations or individuals. All these data are subjected to close scrutiny before being archived, to ensure consistency of standards, and are then available to meet the needs of the community.

Any undertaking which is at all weather-sensitive can benefit from a prior knowledge of the climate within which it is expected to operate. The building industry can use past-weather statistics to estimate likely delays on contracts, architects and civil engineers need to know the likely extremes of weather which a design must withstand, and many industrial processes are dependent on atmospheric conditions for their success. The agricultural industry uses such information for a variety of purposes, many relating to the viability of new crops and the weather-related incidence and spread of pests and diseases.

In addition to special analyses of weather data for these purposes, the Meteorological Office can supply factual statements on weather conditions for legal or insurance purposes. Enquiries on all aspects of past weather data should be directed to the appropriate address given on page 13. Charges for the supply of information depend mainly on the staff time taken to meet the request.

THE CLIMATE OF GREAT BRITAIN

This series of memoranda will cover the whole of Great Britain in due course. The areas to be covered, and the relevant Climatological Memoranda numbers, are:

SCOTLAND

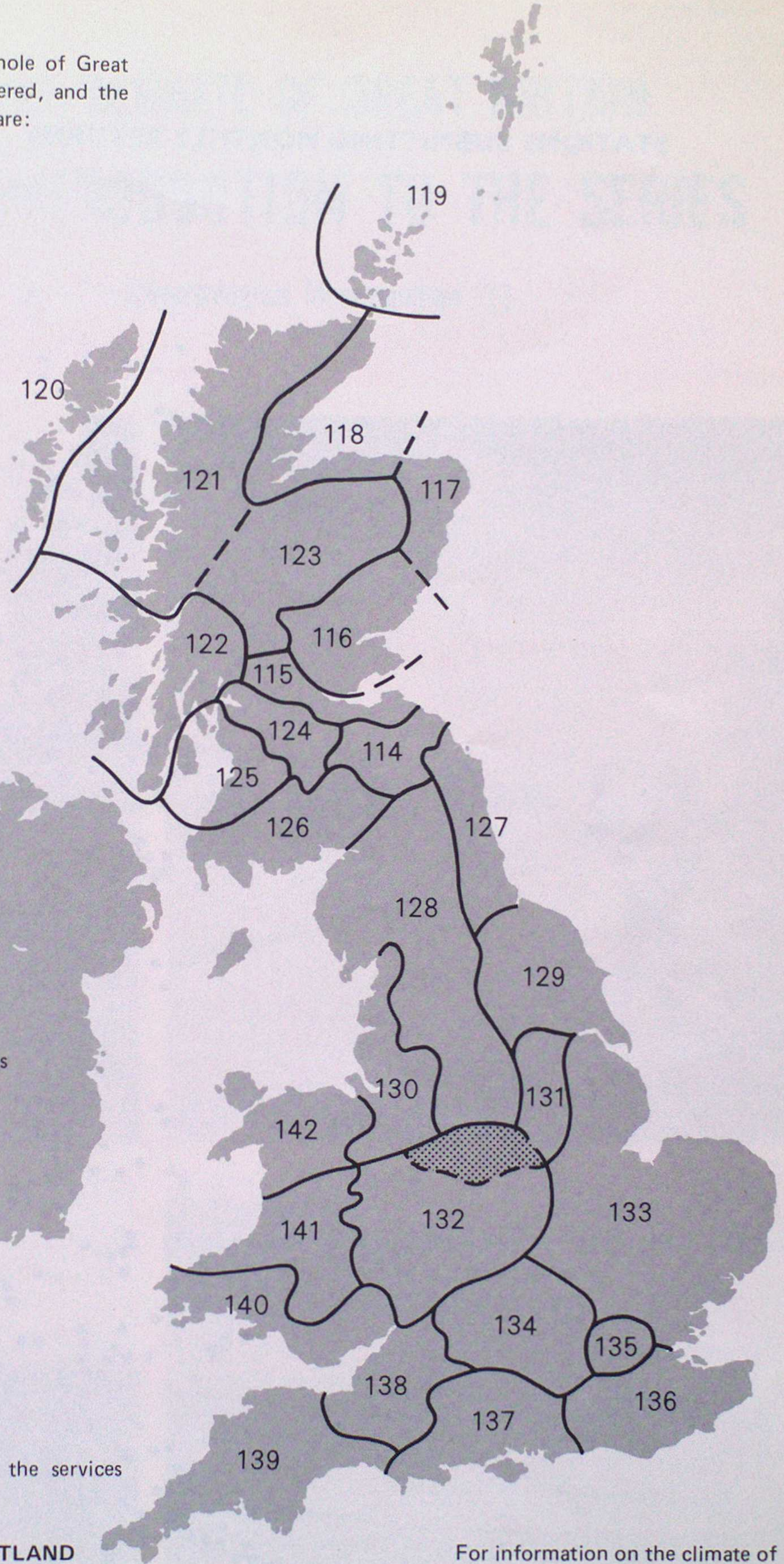
114 Borders Region
115 Edinburgh, Lothian Region and Stirling
116 Fife, Dundee and Perth
117 Aberdeen and Buchan
118 Moray Firth coastal Region
119 Northern Isles
120 Western Isles
121 Skye and the North-west
122 Argyll and the Inner Hebrides
123 The Grampians and Perthshire Highlands
124 Glasgow and the Clyde valley
125 Ayrshire and the Firth of Clyde
126 Dumfries and Galloway Region

ENGLAND

127 North-east England
128 Pennines and Lake District
129 East Yorkshire and North Humberside
130 Lancashire and Cheshire and Isle of Man
131 Trent Valley
132 Midlands
133 East Anglia and Lincolnshire
134 Thames Valley
135 London
136 South-east England
137 South England
138 Somerset and Avon
139 South-west Peninsula and Channel Islands

WALES

140 South Wales
141 Mid Wales
142 North Wales and Anglesey



Further details of these memoranda and of the services mentioned on page 12 can be obtained from:

FOR ENGLAND AND WALES

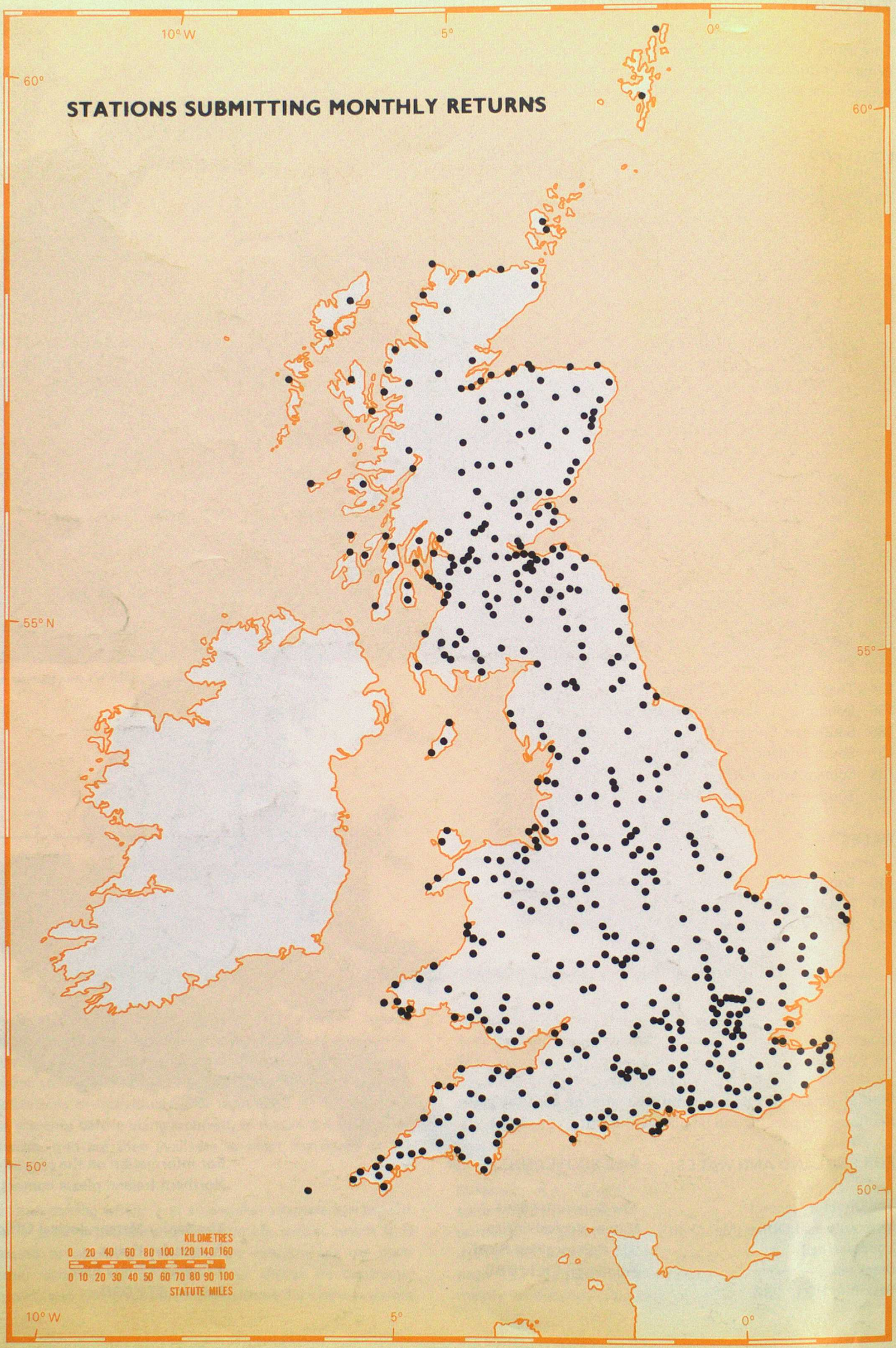
The Director General
Meteorological Office (Met O 3b)
London Road
Bracknell
Berkshire RG12 2SZ

FOR SCOTLAND

The Superintendent
Meteorological Office
231 Corstorphine Road
Edinburgh EH12 7BB

For information on the climate of Northern Ireland please contact:

The Senior Meteorological Officer
Progressive House
1 College Square East
Belfast BT1 6BQ


STATIONS SUBMITTING MONTHLY RETURNS
10° W
5°
0°
60°
60°
55° N
55°
50°
50°
KILOMETRES
0 20 40 60 80 100 120 140 160
0 10 20 30 40 50 60 70 80 90 100
STATUTE MILES
10° W
5°
0°