CHAPTER 4

WEATHER

4.1. NATURE OF THE OBSERVATIONS

The observations to be recorded under the headings 'present weather' and 'past weather' include the following phenomena:

(*a*) Precipitation (including 'showery' precipitation) comprising rain or freezing rain, drizzle or freezing drizzle, sleet,* snow, snow pellets, snow grains, ice pellets, hail, small hail, and certain fine ice crystals referred to as 'diamond dust'.

(*b*) Atmospheric obscurity and suspensoids comprising haze, mist, smoke, fog or ice fog, drifting or blowing snow, duststorms and sandstorms, and dust whirls or sand whirls.

(*c*) Spout.

(*d*) Squalls.

(*e*) Lightning, thunder and thunderstorms.

(*f*) State of the sky.

These phenomena, termed 'meteors' (see 4.2) with the exception of (*d*) and (*f*), form the basis of the international weather code which is used in compiling synoptic reports, as detailed in the *Handbook of weather messages,* Part II. In climatological records their occurrence in present and past weather is noted in Beaufort letters (see 4.5). In synoptic reports their occurrence in past weather is noted in Registers in Beaufort letters and a code figure. The record of past weather should be as complete as possible even though all the information cannot be included in the coded report. For present weather, only the code figures are noted. It is essential that a more or less continuous watch should be kept so that the weather between observations can be accurately recorded. At synoptic stations, in particular, any sudden or significant changes which may occur should be recorded with the least delay.

4.1.1. Climatological stations. The observer enters in the Register the code figure for the weather at the time of the observation. Additionally, he is asked to note the times of beginning and ending of precipitation, fog, thunderstorms and other phenomena so that a brief account of the weather of the whole day may be entered in the weather diary on the climatological return. Details of the present-weather code used at climatological stations, and Beaufort letters and symbols for use in the weather diary, are given in Metform 3100A (the supplement to the Pocket Register for climatological observations.).

4.1.2. Synoptic stations. Present weather is entered as code figures and the observer also records in the appropriate column of the Daily Register a

*The term 'sleet' is commonly used in the United Kingdom to describe precipitation of snow and rain (or drizzle) together, or of snow melting as it falls, but it has no agreed international meaning.

Beaufort letter, or groups of Beaufort letters (see 4.5), describing as exactly as possible the weather since the last observation. The observer amplifies this information, whenever possible, by noting in the remarks column of the Register the time of beginning and ending of precipitation, fog, thunderstorms etc. to maintain an exact and detailed record of the weather. Provision is made in Beaufort letters for indicating the intensity of many phenomena, and the value of the record is increased by adding as much amplifying detail of this kind as possible. The reports of present weather and past weather have to be made in accordance with the synoptic codes as detailed in the *Handbook of weather messages,* Parts II and III, and *Abbreviated weather reports*.

4.2. DESCRIPTIONS OF PHENOMENA

Most of the phenomena recorded in weather observations are composed of meteors. The *International cloud atlas,* Volume I, 1975 gives the following definition:

> A meteor is a phenomenon observed in the atmosphere or on the surface of the earth, which consists of a suspension, a precipitation, or a deposit of aqueous or non-aqueous liquid or solid particles, or a phenomenon of the nature of an optical or electrical manifestation.

Meteors are classified in four groups: hydrometeors (see 4.2.1), lithometeors (see 4.2.2), electrometeors (see 4.2.3) and photometeors (see Chapter 11).

Photometeors (luminous phenomena such as rainbows) are not items of weather as the term is generally understood, but their occurrence should be recorded because of their general meteorological interest.

4.2.1. Hydrometeors. A hydrometeor is a meteor consisting of an aggregate of liquid or solid water particles

(*a*) falling through the atmosphere (rain, drizzle, snow, snow pellets, snow grains, ice pellets, hail, small hail and diamond dust); they originate mostly in clouds and commonly reach the earth's surface (precipitation), though they may completely evaporate during the fall (virga);

(*b*) suspended in the atmosphere (clouds, fog, ice fog, mist);

(*c*) blown by the wind from the earth's surface (drifting snow, blowing snow and spray) and generally confined to the lowest layers of the atmosphere; or

(*d*) deposited on objects on the ground or in the free air (dew, hoar frost, rime, glaze, fog droplets) occurring either in the form of aggregates of particles, more or less individually discernible in spite of the fact that they are often partially linked together (hoar frost, rime), or as smooth homogeneous layers in which no pellet structure can be distinguished (glaze).

The most common hydrometeors are listed below with a brief description of each.

4.2.1.1. *Rain:* precipitation of drops of water (by convention having a diameter of more than 0·5 mm) 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.).

Freezing rain: raindrops with the temperature below 0 °C and which freeze on impact with the ground or with objects on the earth's surface. (It is of course assumed that the objects are not artificially heated above, or cooled below, the temperature of the surrounding air.)

4.2.1.2. *Drizzle:* fairly uniform precipitation comprised exclusively of very fine drops of water (less than 0·5 mm in diameter) and very close to one another. The drops appear almost to float, thus making visible even slight movements of the air, and the effect of their individual impact on water surfaces is imperceptible.

Drizzle falls from a fairly continuous and dense layer of stratus cloud, usually low, sometimes touching the ground (fog).

Freezing drizzle: drizzle-drops with temperature below 0 °C and which freeze on impact with the ground or with objects on the earth's surface. (It is again assumed that the objects are not artificially heated above, or cooled below, the temperature of the surrounding air.)

4.2.1.3. *Snow:* precipitation of ice crystals, most of which are branched, from a cloud. The form, size and concentration of snow crystals differ considerably according to the temperature at which they form and the conditions in which they develop. At temperatures warmer than about −5 °C the ice crystals are generally agglomerated into snowflakes. Small flakes, up to 4 or 5 mm in diameter, especially those occurring at the beginning of a snowfall in very cold weather, often show a six-rayed starlike structure of great beauty. Larger flakes usually consist of tangled aggregates of such crystals so that the geometrical structure ceases to be perceptible.

4.2.1.4. *Snow pellets:* precipitation of white and opaque ice particles which are generally rounded but sometimes conical; their diameter is in the range 2–5 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.

4.2.1.5. *Snow grains:* precipitation of very small, white, opaque particles of ice which 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. This precipitation corresponds as it were to drizzle, and occurs when the temperature is in the approximate range of 0 °C to −10 °C.

4.2.1.6. *Ice pellets:* precipitation of transparent ice particles which are spherical or irregular, rarely conical, and which have a diameter of less than 5 mm. Usually ice pellets are not easily crushable; when they fall on hard ground they generally bounce with an audible sound on impact. Precipitation in the form of ice pellets generally falls from altostratus or nimbostratus.

4.2.1.7. *Hail:* precipitation in the form of either transparent, or partly or completely opaque, particles of ice (hailstones). They can be spheroidal, conical or irregular in form, with a diameter between about 5 and 50 mm. They fall, either separately or agglomerated into irregular lumps, only in showers and are generally observed during heavy thunderstorms. Hailstone structure varies from alternate layers of opaque and transparent ice (usually the more common variety) to only transparent or opaque ice which has formed around a core which is not necessarily at the geometric centre.

If the opportunity arises and the facilities are available, large hailstones should be weighed and measured and, if possible, photographed whole and in cross-section. Failing this, comments on their structure and size, determined before they disperse, can be of value.

4.2.1.8. *Small hail* (formerly called 'ice pellets, type (b)'): precipitation of translucent ice particles, almost always spherical but sometimes having conical tips. Their diameter may attain and even exceed 5 mm.

Small hail consists of snow pellets in a thin layer of ice which has formed from the freezing either of water droplets intercepted by the pellets or of water resulting from the partial melting of the pellets.

Usually small hail is not easily crushable; when it falls on hard ground it bounces with an audible sound on impact. It always occurs in the form of showers.

4.2.1.9. *Diamond dust:* precipitation which falls from a clear sky as very small ice crystals, often so tiny that they appear to be suspended in the air. The crystals are visible mainly when they glitter in the sunshine, giving rise to generally well-marked halo phenomena. Diamond dust can be observed in polar regions and in the interior of continents in winter, especially in clear, calm and cold weather. It is not often observed in the United Kingdom.

4.2.1.10. *Fog:* a suspension of very small, usually microscopic, water droplets in the air, reducing visibility at the earth's surface to less than 1000 m When sufficiently illuminated, individual fog droplets are frequently visible to the naked eye; they are often seen to be moving in a somewhat turbulent manner.

The conditions resulting from the simultaneous occurrence of fog and heavy air pollution in urban and industrialized areas are widely referred to as 'smog' (smoke and fog).

The air in fog usually feels raw, clammy or wet, and the associated relative humidity is generally near 100 per cent.

Ice fog: a suspension of numerous minute ice particles in the air, reducing the visibility at the earth's surface to less than 1000 m. It forms when water vapour (mainly resulting from human activities) is introduced into the atmosphere at temperatures below −30 °C. This vapour condenses, forming droplets which freeze rapidly into ice particles having no well-defined crystalline form. Owing to their lack of form, these particles do not produce a halo which is only produced in ice fog when it contains diamond dust.

Shallow fog: fog lying on the surface of the ground or the sea, the depth of fog being below eye-level (about 1·8 m on land or 10 m at sea), with a visibility of 1000 m or more above the fog layer.

4.2.1.11. *Mist:* a suspension in the air of microscopic water droplets or wet hygroscopic particles, reducing the visibility at the 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.

4.2.1.12. *Drifting snow and blowing snow:* an aggregate of snow particles raised from the ground by a sufficiently strong and turbulent wind. The occurrence of these hydrometeors depends on the wind conditions (speed and gustiness) and the state and age of the surface snow.

(*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-level. (Eye-level is defined as 1·8 m above the ground.) 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 phenomenon; horizontal visibility at eye-level is generally very poor. When the phenomenon is severe it is sometimes difficult to distinguish whether snow is falling at the same time. Generally the blowing snow will be smaller in size than falling snow and at night, in particular, this difference may be detected by watching the snow passing through a light beam from either a torch or a cloud searchlight.

4.2.1.13. *Spray:* an aggregate of water droplets torn by the wind from the surface of an extensive body of water, generally from the crests of waves, and carried up a short distance into the air. When the water surface is rough, the droplets may be accompanied by foam.

4.2.1.14. *Deposit of fog droplets:* deposit of non-supercooled fog (or cloud) droplets on objects, the surface temperature of which is above 0 °C.

This hydrometeor is observed especially in high areas where orographic clouds are frequent. When the phenomenon is marked, the droplets run together and drip on to the ground.

4.2.1.15. *Dew:* a deposit on objects of water drops produced by the direct condensation of water vapour from the surrounding clear air. It can form in two ways:

(*a*) *Dew proper* is formed when exposed surfaces are sufficiently cooled, generally by nocturnal radiation, to bring about the direct condensation of the water vapour from the surrounding air. Dew is deposited ordinarily on objects at or near the ground, mainly on their horizontal surfaces. It is observed especially during the warmer part of the year when the air is calm and the sky is clear.

(*b*) *Advection dew* is formed when exposed surfaces are sufficiently cold to bring about direct condensation of the water vapour contained in the air coming into contact with those surfaces, usually through a process of advection. Advection dew is deposited mainly on vertical exposed

surfaces and is observed especially during the colder part of the year when relatively warm damp air suddenly invades a region after a period of moderate frosts.

The term 'white dew' is used for a deposit of white frozen dewdrops.

Dew should not be confused with the deposit of droplets from low fog on exposed surfaces, or, in the case of plants, with the droplets they may exude by a process known as guttation. This exudation of liquid water from the leaves of plants under warm, moist soil conditions often takes place at the same time as the deposit of dew, but can occur quite separately.

4.2.1.16. *Hoar frost:* a deposit of ice which forms on objects and is generally crystalline in appearance, and produced by the direct sublimation of water vapour from the surrounding air. There are two types:

(*a*) *Hoar frost proper* is a deposit of ice which generally assumes the form of scales, needles, feathers or fans. It forms on objects whose surfaces have been sufficiently cooled, generally by nocturnal radiation, to bring about the direct sublimation of the water vapour contained in the air.

(*b*) *Advection hoar frost* is a deposit of ice, generally in crystalline form, which forms on objects whose surfaces are sufficiently cold to bring about the direct sublimation of the water vapour contained in the air coming into contact with these surfaces through a process of advection. It is deposited mainly on exposed vertical surfaces, usually when relatively warm damp air invades a region after a long period of hard frosts.

4.2.1.17. *Rime:* a deposit of ice generally formed by the freezing of supercooled fog or cloud droplets on objects whose surface temperature is below or slightly above 0 °C. The thickness of the layer of rime should be measured and noted when practicable.

There are three species of rime: soft rime, hard rime and clear ice:

(*a*) *Soft rime* (see Plate XVI) is a fragile deposit consisting mainly of thin needles or scales of ice. It mainly forms when the ambient air temperature is lower than −8 °C. At and near the ground it is deposited under calm or light wind conditions on all sides of exposed objects. The deposit can easily be dislodged by a slight shake.

(*b*) *Hard rime* is a granular deposit, usually white, adorned with crystalline branches of grains of ice which are more or less separated by entrapped air. Hard rime mainly forms at air temperatures between −2 and −10 °C when supercooled water droplets rapidly freeze more or less individually and leave gaps between the frozen particles.

At and near the ground it is deposited mainly on the surface of objects exposed to a moderate or strong wind. In the windward direction the deposit may build up to form a thick layer. The deposit is rather adhesive but can be scratched off objects.

(*c*) *Clear ice* is a smooth, compact deposit which is usually transparent. It is fairly amorphous with a ragged surface and structurally resembles glaze. In nearly every case the temperature of the ambient air is between 0 and −3 °C, and clear ice is formed by the slow freezing of the supercooled water droplets. Before freezing, these water droplets penetrate the gaps between other fragments of ice.

At and near the ground, clear ice is deposited mainly on the surface of objects exposed to the wind; it is most likely to occur in mountain regions. The deposit is very adhesive and can only be removed from objects by being broken or melted.

4.2.1.18. *Glaze:* a smooth, compact deposit of ice, generally transparent, formed by the freezing of supercooled drizzle droplets or raindrops on objects the surface temperature of which is below or slightly above 0 °C. It covers all parts of surfaces exposed to precipitation, and is generally fairly homogeneous and resembles clear ice.

At and near the ground it is observed when drizzle droplets or raindrops fall through a layer of air below 0 °C of sufficient depth. It forms by the slow freezing of the water remaining in the liquid state after the cessation of supercooling, and the water is therefore able to penetrate the crevices between the particles of ice before freezing (see Plate XVI).

The deposit of ice formed by the freezing of fog not supercooled at the time of impact with objects the temperature of which is well below 0 °C, is also known as glaze.

Note: Glaze on the ground must not be confused with ground ice, which is formed when

(*a*) water from a precipitation of non-supercooled drizzle droplets or raindrops *later* freezes on the ground, or

(*b*) snow on the ground freezes again after having completely or partly melted, or

(*c*) snow on the ground is made compact and hard by traffic.

4.2.1.19. *Spout:* it consists of an often violent whirlwind, revealed by the presence of a cloud column or inverted cloud cone (funnel cloud) protruding from the base of a cumulonimbus, and of a 'bush' composed of water droplets raised from the surface of the sea or of dust, sand or litter raised from the ground.

The axis of the funnel cloud can be vertical, inclined, or sometimes sinuous. Not uncommonly, the funnel merges with the 'bush'.

The air in the whirlwind rotates rapidly, most often in a cyclonic sense: a rapid rotary movement may also be observed outside the funnel and the 'bush'. Further away the air is often calm.

The diameter of the cloud column, which is normally of the order of 10 metres, may in certain regions occasionally reach some hundreds of metres. Several spouts may sometimes be observed connected with a single cloud.

Spouts are often very destructive in North America (where they are called tornadoes). They may leave a path of destruction up to 5 km wide and several hundred kilometres long.

Weak spouts are occasionally observed under cumulus clouds.

When a spout is observed, the height, diameter, sense of rotation and path of the cloud funnel (also called 'tuba') should be noted as far as possible. It is also useful to obtain information about any damage done.

4.2.2. Lithometeors. A lithometeor is a meteor consisting of an aggregate of particles, most of which are solid or non-aqueous. The particles are (a) more

or less suspended in the air (haze, dust haze and smoke) and consist of very small dust particles, or sea-salt particles or combustion products, or (b) lifted from the ground by the action of the wind (drifting or blowing dust or sand, dust whirl or sand whirl, duststorm or sandstorm).

The most common lithometeors are described below.

4.2.2.1. *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 bright 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 contributes to the coloration of the landscape.

4.2.2.2. *Dust haze:* a suspension in the air of dust or small sand particles raised from the ground prior to the time of observation by a duststorm or sandstorm. The duststorm or sandstorm may have occurred either at or near the station or far from it. Dust haze is reported only when there is an absence of turbulent or strong wind sufficient to raise dust from the ground at the time of observation.

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

This lithometeor may be present either near the earth's surface or in the free atmosphere. It is often the visible product of the incomplete combustion of coal; in the United Kingdom the frequency of this phenomenon has been greatly reduced by the introduction of 'smokeless zones'. Coal smoke consists of mainly carbon and hydrocarbon particles of very small size (about 0·1 μm) which remain in the air, on average, for one or two days. Viewed through smoke, the sun appears very red at sunrise and sunset, and shows an orange tinge when high in the sky. Smoke in extensive layers originating from fairly near forest fires scatters the sunlight and gives the sky a greenish-yellow hue. Evenly distributed smoke from very distant sources generally has a light greyish hue.

When visibility is impaired and the cause can be definitely attributed to smoke, then 'visibility reduced by smoke' is reported (as is provided for in the present-weather specification in the *Handbook of weather messages,* Part II, *Abbreviated weather reports* and in Metform 3100A).

4.2.2.4. *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 sufficiently strong and turbulent wind.

The wind conditions (speed and gustiness) necessary to produce these lithometeors 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 raised 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.

4.2.2.5. *Duststorm 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.

Duststorms 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.

The forward portion of a duststorm or sandstorm may have the appearance of a wide and high wall which advances more or less rapidly. Walls of dust or sand often accompany a cumulonimbus which may be hidden by the dust or sand particles. These walls may also occur without any clouds along the forward edge of an advancing cold air mass.

In a slight or moderate duststorm or sandstorm the visibility is less than 1000 m but not below 200 m and the sky is not usually obscured. In a severe duststorm or sandstorm the visibility is reduced below 200 m and the sky is usually obscured.

4.2.2.6. *Dust whirl or sand whirl (dust devil)*: an aggregate of particles of dust or sand, sometimes accompanied by small litter, raised from the ground in the form of a whirling column of varying height with a small diameter and an approximately vertical axis.

These lithometeors occur when the air near the ground is very unstable, as for instance when the dust or sand surface is strongly heated by the sun.

4.2.3. Electrometeors. An electrometeor is a visible or audible manifestation of atmospheric electricity. Electrometeors either correspond to discontinuous electrical discharges (thunder, lightning) or occur as more or less continuous phenomena (St Elmo's fire, polar aurora, both described in Chapter 11).

4.2.3.1. *Thunderstorm*: one or more sudden electrical discharges, manifested by a flash of light (lightning) and a sharp or rumbling sound (thunder).

Thunderstorms are associated with convective clouds and are most often, but not necessarily, accompanied by precipitation at the ground.

In recording observations, a thunderstorm is regarded as being at the station from the time thunder is first heard, whether or not lightning is seen or precipitation is occurring at the station. A thunderstorm is reported in present weather if thunder is heard within the normal observational period (10 minutes) preceding the time of the report. The World Meteorological Organization convention is that a thunderstorm is regarded as having ceased at the time of the last audible thunder and the cessation is confirmed if thunder is not heard for 10–15 minutes after this time. However, practice for Meteorological Office stations is that an observer should not report 'thunderstorm at the time of observation' when the cumulonimbus has already passed the station

even though it be less than 10 minutes since he heard the last peal of thunder. When he is not sure that the storm has passed he should report a 'thunderstorm at the time of observation' if thunder has been heard within the last 10 minutes.

4.2.3.2. *Lightning*: a luminous manifestation accompanying a sudden electrical discharge which takes place from or inside a cloud or, less often, from high structures on the ground or from mountains.

Three main types of lightning can be distinguished:

(*a*) *Ground discharges* (popularly called thunderbolts or forked lightning). This type of lightning occurs between cloud and ground; it comprises a leader stroke which follows a tortuous downward course and is often branched, from a distinct main channel (streak or ribbon lightning). One of these branches establishes an ionized path to the ground up which a return stroke then passes. It is the return stroke which carries the main energy transfer. Additional leader and return strokes may follow. A luminous globe has occasionally been observed, soon after a discharge to ground. This globe, the dimension of which has been reported to be generally between 10 and 20 cm, but is said sometimes to reach 1 m, is known as ball lightning. It moves slowly in the air or on the ground and usually disappears with a violent explosion.

(*b*) *Cloud discharges* (popularly called sheet lightning). This type of lightning takes place within the cumulonimbus; it gives a diffuse illumination without a distinct channel being usually seen. This type of lightning includes the so-called heat lightning, consisting of diffuse light flashed from distant thunderstorms seen near the horizon.

(*c*) *Air discharges*. This type of lightning occurs in the form of sinuous discharges, often ramified but with a distinct main channel, passing from a cumulonimbus to the air and not striking the ground. It frequently includes a long quasi-horizontal part. The name 'streak lightning' is also applied to this type of lightning.

4.2.3.3. *Thunder*: a sharp or rumbling sound which accompanies lightning, caused by a sudden heating and expansion of the air along the path of the lightning. The distance of a lightning flash may be roughly estimated from the interval between seeing the flash and hearing the thunder, counting 1 km for every three seconds. The long duration of thunder compared with the associated lightning flash is explained by the different distances travelled by the sound from different parts of the flash and by echoing from mountain sides. Echoing causes intensity variations; however, variations also arise from the multiple and tortuous nature of many lightning strokes.

Thunder is seldom heard at distances greater than 20 km. Owing to refraction of sound waves in the lower atmosphere, thunder is sometimes inaudible at distances much less than 20 km, especially when the initiating lightning flash is not to ground.

4.2.4. Other phenomena. Photometeors are dealt with in Chapter 11, together with some additional electrometeors which may be more accurately considered as atmospheric rather than weather phenomena. However, there are some phenomena not listed in the *International cloud atlas* as meteors

which should be recorded in weather observations and these are described below.

4.2.4.1. *Squall*: a strong wind that rises suddenly, lasts for at least a minute and then dies away comparatively suddenly (see 5.1.2.2, page 82). Squalls are frequently associated with cumulonimbus or with the passage of cold fronts. In the latter circumstances they occur in a line (the line of the front) and are typically accompanied by a sharp fall in temperature, a veer of wind, a rise of relative humidity, and a roll-shaped cloud with horizontal axis. These phenomena are known collectively as a line-squall.

4.2.4.2. *Snow lying*: snow lying means, in general, snow covering the ground, either completely or in patches. For the purpose of climatological returns a day with snow lying is one in which snow covers one half or more of the ground of an open area representative of the station at the morning climatological hour of observation (0900 GMT in the United Kingdom). The ground of an open area representative of the station should be taken to include the open, fairly flat ground easily visible from the station and not differing from it in altitude by more than 30 m. In judging whether half the ground is covered, no account should be taken of bare patches under trees or areas occupied by rivers, ponds, etc. (see 6.1.2, page 95).

There are provisions for reporting the character and depth of snow cover in the codes given in the *Handbook of weather messages*, Part II.

4.3. PRESENT WEATHER

The observation of present weather necessitates noting the state of the sky, or the change of the state of sky, and the phenomena occurring at the station, or within sight of the station, at the time of observation. Relevant coding procedures and instructions for climatological stations are given in Metform 3100A (Supplement to the Pocket Register), and for synoptic stations in the *Handbook of weather messages,* Parts II and III, and *Abbreviated weather reports*. These procedures provide for the occasions when precipitation or fog, or a thunderstorm, has ceased during the past hour.

4.3.1. Definition of terms.

4.3.1.1. *Precipitation* is the general term given to water drops or ice particles formed at a higher level and falling to or towards the ground. It includes rain, drizzle, sleet, snow, snow pellets, snow grains, ice pellets, hail, small hail and diamond dust. The term does not include drifting or blowing snow, duststorms or sandstorms, or dust whirls and sand swirls, which are not formed at a higher level but merely raised by the wind. Surface condensation phenomena such as dew, hoar frost and rime which may contribute to the catch of a rain-gauge are not classed as precipitation under the heading of present weather.

4.3.1.2. *At the station* means literally at the place where the observations are normally taken. For thunderstorms, however, it is not necessary for the disturbance to be immediately overhead. The storm is regarded as occurring at the station if thunder is heard (see 4.2.3.1).

4.3.1.3. *Within sight* or *at a distance* means that although the weather in question is not actually occurring at the station, it is seen to be occurring in the vicinity. When applied to precipitation, the phrase should refer only to cases where the precipitation is seen to reach the ground, or to evaporate at a low level; it should not be used to describe virga (see 2.3.4) associated with cirrocumulus and altocumulus floccus.

4.3.1.4. *During the past hour* or *in the past hour* refers to the approximate one-hour period between the actual time of an observation of an element and the previous actual time of observation. Even if hourly observations are not made it still refers to the one-hour period before the actual time of observation.

4.3.1.5. *At the time of observation* is to be interpreted as the actual time of observation of the element concerned.

4.3.2. Continuity of precipitation. In observing and reporting present weather, precipitation is specified as intermittent, continuous or as showers. Precipitation, other than showers, is reported as continuous when it has continued for at least 60 minutes without a break. All other precipitation, except showers, is reported as intermittent. If precipitation stops before an observer has completed his observation, he will report 'precipitation in the past hour' in the present-weather code.

Continuous precipitation falls from layer clouds which usually form a dense covering to the whole sky.

Intermittent precipitation falls from layer clouds which almost always cover the whole sky, though there may be considerable variations in the thickness and opacity of the layer. Occasional brightening or change in coloration of the sky, without a definite break in the cloud, is not unusual and lifting of the cloud base may occur at times.

4.3.2.1. *Showers* are said to occur when solid or liquid precipitation falls from convection (cumuliform) clouds. The amount of cloud usually varies greatly during the course of an hour or so, and often within much briefer periods. Convection clouds are usually seen either building up at a station before the shower begins or approaching the station before the precipitation reaches the station. When a well-developed shower cloud is over a station it may for a time cover the whole sky, but after the shower there is usually a partial, and sometimes a complete, clearance of the sky; the cloud may be seen to decay or to move away after the precipitation at the station has ceased. It is rare for a true shower to take the form of drizzle, while hail is always a shower type of precipitation. Rainbows are often associated with showers.

4.3.3. Intensity of precipitation. No international definitions have been agreed for the terms 'slight', 'moderate' and 'heavy' used in describing the intensity of precipitation. The Meteorological Office classifications of intensity of rain are given in 4.3.3.1. See 4.3.3.2. for showers (for which there is an additional classification, namely 'violent'), 4.3.3.3 for drizzle, and 4.3.3.4 for snow. Guidance on reporting the intensity of mixed precipitation is given in 4.3.3.5. The classifications refer to the rate of fall of the precipitation and not to the total amount.

If the intensity of any precipitation alters during the course of making an observation the observer should report the latest intensity.

4.3.3.1. *Intensity of rain.*

(*a*) Slight rain is rain of low intensity; it may consist of scattered large drops or more numerous smaller drops. The rate of accumulation on the ground is such that puddles form only slowly, if at all. The rate of accumulation in a rain-gauge is not more than 0·5 mm per hour.

(*b*) Moderate rain is rain falling fast enough to form puddles rapidly, to make downpipes flow freely, and to give some spray over hard surfaces. The rate of accumulation in a rain-gauge is between about 0·5 and 4 mm per hour.

(*c*) Heavy rain is a downpour which makes a roaring noise on roofs, forms a misty spray of fine droplets by splashing on road surfaces etc., and accumulates in a rain-gauge at a rate of more than 4 mm per hour.

At a station equipped with either a Meteorological Office tilting-siphon rain recorder, or tipping-bucket gauge with 750 cm^2 collector and an indicating counter, the observer can make use of either of these instruments in assessing the intensity of rainfall.

As noted in 4.3.3 above, an observer must report the intensity he last observed and this will not necessarily be the intensity shown either by the rain-recorder chart when it was examined, or by the final counter reading if a tipping-bucket gauge is used to assess intensity, as suggested in the previous paragraph. By noting these recorded intensities, and noting any changes which occur while making his observation, it should be possible for him to assess the intensity last observed. On occasions when the assessment is on the borderline of two intensities the higher intensity should be reported.

As a guide, Figure 5 shows examples of the slope of the trace on the chart (Metform 4423A) of a Meteorological Office tilting-siphon rain recorder in prolonged steady rain of slight, moderate and heavy intensity (at A, B and C respectively).

At a station equipped with a tipping-bucket gauge with 750 cm^2 collector and an indicating counter, the observer notes the counter reading at the beginning of the observation, and a further reading taken precisely six minutes later. A difference in the readings of 3 or more indicates that the rainfall

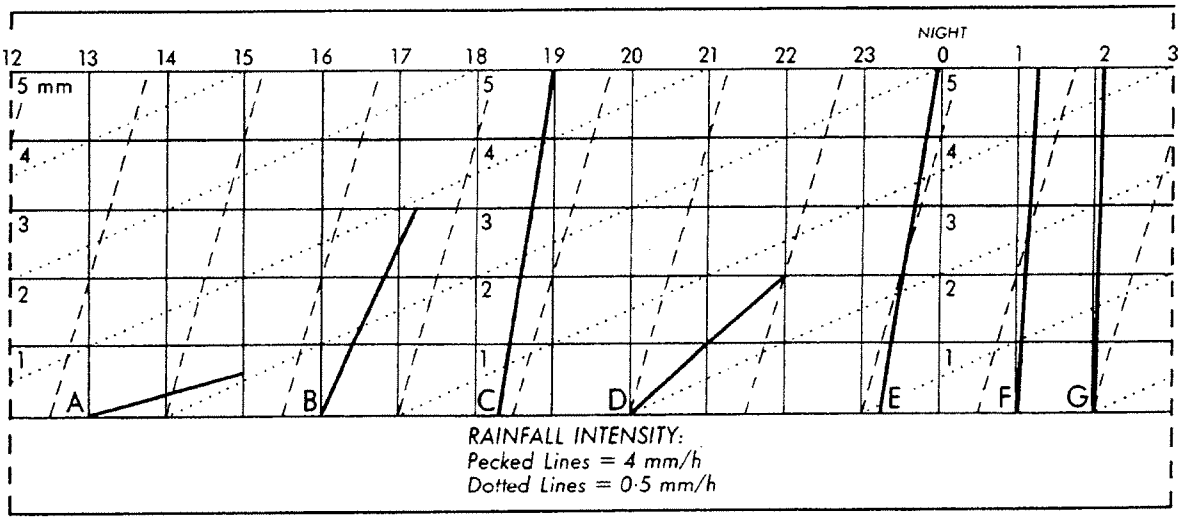

Figure 5. Sample traces on a tilting-siphon rain-recorder chart

has been heavy, averaged over the six minutes. A difference of 2 or less is inconclusive, so the observer will have to use his own judgement as to whether the intensity of the rain is slight or moderate.

4.3.3.2. *Intensity of showers.* The scales of intensity quoted above for slight, moderate and heavy rain need to be increased when applied to rain showers because the convective processes which cause showers are generally more vigorous than the frontal or orographic uplift of air associated with continuous precipitation. The following descriptions and rate of fall should be taken as a guide:

(*a*) Slight showers. These vary from scattered drops to drops falling fast enough to form puddles. The rate of accumulation in a rain-gauge is less than about 2 mm per hour.

(*b*) Moderate or heavy showers. These form puddles rapidly and in the heavier precipitation make a roaring noise on roofs and produce a misty spray when the drops strike a hard surface. Visibility is often impaired significantly. The rate of accumulation in a rain-gauge of a moderate shower is about 2–10 mm per hour; in a heavy shower it is about 10–50 mm per hour.

(*c*) A violent shower is one in which the intensity is exceptional for the British Isles, although not uncommon in the tropics. The rate of accumulation in a rain-gauge is greater than about 50 mm per hour.

In Figure 5 examples of the slope of the trace on a chart of a Meteorological Office tilting-siphon rain recorder in showers of slight, moderate, heavy and violent intensity are shown at D, E, F and G respectively. In the same way as described in 4.3.3.1, the intensity as shown by the recorder may be used as a guide but with a degree of caution, for three reasons. Firstly, the slope of the trace is often steep and is therefore difficult to judge correctly. Secondly, a uniform intensity is often not maintained long enough for the trace to appear on the chart as a straight line. Thirdly, and this applies generally, conditions are not favourable for precise observation while the chart is still on the drum of the instrument.

The window of the recorder should not be opened if the precipitation is heavy because water splashing from the ground may ruin the chart. If the chart gets wet its adjustment on the drum is likely to be affected and the subsequent part of the trace may be falsified.

At a station equipped with a tipping-bucket gauge the observer notes the counter reading in precisely the same manner as given in 4.3.3.1. A difference in the counter readings, averaged over six minutes, of 2, 3 or 4 counts per minute indicates a moderate shower, 6–24 a heavy shower, and more than 24 a violent shower.

The notes below should be used as a guide for reporting hail showers. (Guidance for reporting snow showers is given in 4.3.3.4.)

(*a*) Slight hail consists of sparse hailstones, usually of small size and often mixed with rain.

(*b*) Moderate hail means a fall of hail abundant enough to whiten the ground and to produce, when melted, an appreciable amount of precipitation. As for rain, however, it is the intensity of the fall and not the total amount which determines the classification.

(*c*) Heavy hail is exceptional in the British Isles and includes at least a proportion of stones exceeding 6 mm in diameter. Ground crops are damaged and leaves knocked off trees. Glass may be broken in greenhouses, garden frames, etc.

4.3.3.3. *Intensity of drizzle.* As defined in 4.2.1.2, drizzle is fairly uniform precipitation composed exclusively of fine drops of water very close to one another. The diameter of the drops is usually less than 0·5 mm.

The effect of their individual impact on water surfaces is imperceptible. Continuous drizzle may produce a run-off from roofs and road surfaces, and a rate of accumulation in the rain-gauge equal to or exceeding that produced by slight rain. Moderate or heavy drizzle will have a marked effect on the visibility.

The estimation of intensity of drizzle is especially difficult. However, the classification given below should be used as a guide.

(*a*) Slight drizzle can readily be detected on the face and, for example, on the windscreen of a car, but produces very little run-off from road surfaces or roofs.

(*b*) Moderate drizzle causes windows and road surfaces to stream with moisture.

(*c*) Heavy (dense) drizzle impairs visibility significantly, and accumulates in the rain-gauge at a rate up to 1 mm per hour.

Drizzle frequently occurs in association with mist or fog, but may produce poor visibility in otherwise clear air.

4.3.3.4. *Intensity of snow and snow showers.* The classification of intensity of snowfall is qualitatively made as indicated below:

(*a*) Slight when the flakes are sparse and usually small. In calm weather the rate of accumulation of the snow cover does not exceed 0·5 cm per hour.

(*b*) Moderate when the snowfall consists of usually large flakes falling sufficiently thickly to impair visibility substantially. The snow cover increases in depth at a rate up to 4 cm per hour.

(*c*) Heavy when visibility is reduced by the falling snow to a low value and the snow cover increases at a rate exceeding 4 cm per hour.

In the above statements as to the depth of snow, it is assumed that the temperature is below freezing point so that melting does not occur, and that drifting is not taken into account.

It should be noted that the term 'blizzard' is not recognized as a description of the weather. However, it is a term used during the occurrence of severe winter conditions and the following definitions have been accepted for use within the United Kingdom in order that some uniformity of practice is established in the use of the term.

Blizzard: the simultaneous occurrence of moderate or heavy snowfall and winds of at least force 7 (28 knots) which causes drifting snow and a reduction of the visibility to 200 m or less.

Severe blizzard: the simultaneous occurrence of moderate or heavy snowfall and winds of at least force 9 (41 knots) which causes drifting snow and a reduction of the visibility to near zero.

These terms will not be applied to passing snow showers but only if a wide area is affected and the conditions last long enough to cause serious interference to human mobility, or the disruption of communications.

The hydrometeors snow grains (see 4.2.1.5), ice pellets (see 4.2.1.6) and diamond dust (see 4.2.1.9) are all reported without classification of intensity. However, any relevant observations of intensity should be noted in the remarks column of the observation Register.

4.3.3.5. *Intensity of mixed precipitation.* When mixed precipitation occurs such as drizzle and rain, or hail and snow, the intensity of each type is not given separately. The intensity of the heaviest precipitation is used to denote the intensity of the mixture. If any doubt exists on this point, the best estimate of the following, in order of precedence shown, should be reported: (1) hail, (2) snow, (3) rain, (4) drizzle.

4.4. PAST WEATHER

Details of the procedures and use of the figure code for reporting past weather are given in the *Handbook of weather messages*, Parts II and III and *Abbreviated weather reports*.

4.4.1. Climatological stations. In general, climatological stations are not asked to report past weather as such, although a weather diary is required (see 4.1.1, page 57); it should however be noted that the Health Resort stations do report past weather in their evening coded messages (see 1.5.2, page 8).

4.4.2. Synoptic stations. At synoptic stations the interval covered by the past-weather description is six hours in reports at 0000, 0600, 1200 and 1800 GMT, three hours in reports at 0300, 0900, 1500 and 2100 GMT, and one hour in reports at other times. Particular exceptions to this rule are detailed in the *Handbook of weather messages*, Part III.

4.5. BEAUFORT LETTERS AND INTERNATIONAL SYMBOLS

Beaufort letters are used by the Meteorological Office to provide a continuous record of the weather in a brief form. The code of letters indicating the state of the weather, past or present, was originally introduced by Admiral Sir Francis Beaufort early in the nineteenth century for use at sea, but they are equally convenient for use on land. Since his day the code has been substantially modified.

Beaufort letters can also be used as a means of describing the weather over a period of time for transmission either by telephone or teleprinter. This method is used by selected stations and by stations which participate in the Health Resort Scheme (see page 79). The *Handbook of weather messages*, Part III, gives instructions on their use in the Daily Register.

The appropriate letters from the first column of the table given in 4.5.1 are selected for entry in the relevant column of the Register. The second column gives the international symbols and some others. These provide a convenient way of noting at any time, in the limited space of the remarks column of the

Register, the occurrence of any phenomena which might otherwise go unrecorded. Such small additions provide some background information to the record of a station.

4.5.1. Table of Beaufort letters, international symbols for meteors, and some additional symbols.

State of sky

b		Total cloud amount 0-2/8
bc		Total cloud amount 3/8-5/8
c		Total cloud amount 6/8-8/8
o		Uniform thick layer of cloud completely covering the sky: 8/8

Hydrometeors

r		rain
r		freezing rain
d		drizzle
d		freezing drizzle
s		snow
h		snow pellets
h		diamond dust
h		hail
h		small hail
h		ice pellets
sh		snow grains
f		fog
f		ice fog
fe		*wet fog
fg/fs		*patches of shallow fog over land/sea
fg/fs		*more or less continuous shallow fog over land/sea
m		mist
ks		drifting and blowing snow
ks		drifting snow
ks		blowing snow

		spray
w		dew
w		advection dew
w		white dew
x		hoar frost
x		advection hoar frost
		rime
		soft rime
		hard rime
		clear ice
		glaze
		spout

(mixed precipitation)

dr		drizzle and rain
rs		rain and snow (sleet)
hs		hail and snow
hr		hail and rain

Lithometeors

z		haze
		dust haze
		smoke
		drifting and blowing dust or sand
		drifting dust or sand
		blowing dust or sand
kz		duststorm or sandstorm
		wall of dust or sand
		dust whirl or sand whirl (dust devil)

Photometeors

		solar halo
		lunar halo

		solar corona
		lunar corona
		irisation
		glory
		rainbow
		fog-bow
		Bishop's ring
		mirage
		*zodiacal light

Electrometeors

tl		thunderstorm
l		lightning
		St Elmo's fire
		polar aurora

Miscellaneous

j		phenomenon within sight of but not at the station
e		wet air, without rain falling
y		dry air (less than 60 per cent relative humidity)
u		ugly threatening sky
v		abnormally good visibility
p		shower (used in combination with the type of precipitation)

Surface wind

g		*gale, mean speed 34-47 knots over a period of 10 minutes or more
G		*storm, mean speed 48 knots or more over a period of 10 minutes or more
q		*squall
kq		*line squall

*Not internationally accepted symbols.

4.5.2. Recording Beaufort letters. When Beaufort letters are used for recording the weather in the Register, the phenomena are recorded in the order in which they occur. Beaufort letters for the weather during the full course of an observation will be allocated to the period preceding the observation. If the weather at the time of the observation continues into the next observational period the appropriate Beaufort letters should be included in both observations.

In a sequence of Beaufort letters a change from one set of conditions to another is indicated by the insertion of a comma between the sets.

When several phenomena occur simultaneously they are recorded in the following order:

(1) state of sky
(2) thunderstorm
(3) precipitation
(4) atmospheric obscurity
(5) other phenomena.

4.5.2.1. *State of sky.* The state of sky is required to be recorded in every combination of Beaufort letters except when the sky is obscured, when no letter is required. Note that the state of sky refers to the amount of cloud cover. The use of the Beaufort letter 'u', an ugly threatening sky, is not used in this context.

4.5.2.2. *Thunderstorm.* A thunderstorm is regarded as being at the station from the time thunder is first heard whether or not lightning is seen or precipitation is occurring at the station.

4.5.2.3. *Precipitation*: type, intensity, continuity. In recording precipitation in Beaufort letters account must be taken of the variations that can arise in type, intensity, continuity, or combinations of some or all of them. These are dealt with in detail below.

(*a*) *Type.* The type of precipitation is indicated by the appropriate letter, or combination of letters if there is a mixture of precipitation. For example:

d = drizzle; r = rain; dr = drizzle and rain.

If the precipitation is of the showery type (falling from convective cloud), the prefix 'p' is used in combination with the type of precipitation. For example:

pr = shower of rain; ps = shower of snow.

(*b*) *Intensity.* The intensity of precipitation is recorded in four categories: slight, moderate, heavy and violent. These are indicated in the following manner:

(1) Slight: by the addition of the subscript 'o' to a small Beaufort letter. For example:

r_o = slight rain; s_o = slight snow; pr_o = slight shower of rain.

(2) Moderate: by a small Beaufort letter. For example:

r = moderate rain; s = moderate snow; pr = moderate shower of rain.

(3) Heavy: by a capital Beaufort letter. For example:

R = heavy rain; S = heavy snow; pR = heavy shower of rain.

(4) Violent: by the addition of the subscript '2' to the capital Beaufort letter. For example:

pR_2 = violent shower of rain.

When mixed precipitation occurs, such as drizzle and rain, or rain and snow, the intensity of each type is not given separately, but the intensity of the heaviest precipitation is used to denote the intensity of all the other types in the mixture. For example:

slight drizzle and moderate rain = dr.

The intensity of a thunderstorm is judged by the intensity of the thunder and lightning, whilst the intensity of the precipitation in the storm is indicated separately. For example:

TLr_o = heavy thunderstorm with slight rain
tl_oR = slight thunderstorm with heavy rain.

When showers are reported, the qualification of intensity is given to the precipitation, but not to the shower prefix 'p'.

(*c*) *Continuity.* Precipitation falling from layer cloud is described by letters referring to the continuity as well as to the type of intensity in accordance with the following rules:

(1) Intermittent precipitation: the Beaufort letters indicating the type and intensity of the precipitation are prefixed by the letter 'i'. For example:

ir_o = intermittent slight rain
iS = intermittent heavy snow
idr = intermittent moderate drizzle and rain.

The prefix indicates that there has been a break or breaks occurring at intervals of less than one hour in the overall period of the precipitation. Note that an individual break lasting one hour or more requires subsequent precipitation to be recorded as the commencement of another period.

(2) Continuous precipitation: the Beaufort letter(s) indicating the type and intensity of the precipitation are repeated. For example:

r_or_o = continuous slight rain
SS = continuous heavy snow
$d_or_od_or_o$ = continuous slight drizzle and rain.

The repetition indicates that the period of precipitation has lasted for at least one hour without a break.

(3) Precipitation not specified as intermittent or continuous: the Beaufort letter(s) indicating the type and intensity of the precipitation are used alone. For example:

R = heavy rain
d_o = slight drizzle
dr = moderate drizzle and rain.

This indicates that the period of precipitation has not lasted for one hour to qualify it as continuous, and that there have been no breaks to qualify it as intermittent.

(*d*) Changes of type and/or intensity. During a period of precipitation a change of type and/or intensity is indicated by successive use of letters

descriptive of each new type or intensity. Repetition of letters to indicate continuity will be appropriate only when precipitation of one particular type and intensity has continued for at least one hour without a break. A change in type or intensity of continuous precipitation where the new type or intensity does not last for one hour will require the use of a single letter as described in (c)(3) above. At each change of type and/or intensity it is necessary to record all the appropriate letters in the order specified in 4.5.2 (page 76), and a comma is placed between each group of letters. For example:

cr_or_o, cr, cr_o, cd_or_o.

4.5.2.4. *Atmospheric obscurity.* The appropriate Beaufort letter describing the cause of the obscuration is selected from the table in 4.5.1.

(*a*) Fog. Whenever the visibility is reduced to less than 1000 m and the obscuration is caused by fog (as defined in 4.2.1.10, page 60), the letter 'f' (fog) will be used down to and including 200 m, and the capital letter 'F' (thick fog) when the visibility is less than 200 m.

When patches of fog exist, i.e. the visibility varies with direction and the minimum visibility is less than 1000 m while the maximum is outside fog limits, the letters 'if' (intermittent fog) will be used.

The recording of continuity of fog is governed by the same rules as those governing the recording of continuity of precipitation in 4.5.2.3(c). Note also that continuity of precipitation and fog are assessed separately.

Changes of observed visibility in a period of fog which pass through the limit of 200 m will require the successive use of the letters 'f' and 'F', as appropriate. Repetition of either of these letters to indicate continuity will require one hour or more of fog in the particular range of density without a break; for example:

bcif, cf, ff, F.

(*b*) Mist (as defined in 4.2.1.11, visibility 1000 m or more) and

(*c*) Haze (as defined in 4.2.2.1).

In order to differentiate between obscuration caused by water droplets and dry particles, it is United Kingdom practice to use the following criteria: 'The obscuration is caused predominantly by water droplets if relative humidity is 95 per cent or more, and by dry solid particles if the relative humidity is less than 95 per cent. It is necessary, however, to preserve continuity in observations of present weather and it may, for this reason, be necessary not to apply the 95 per cent criterion too strictly on some occasions.'

4.5.2.5. *Description of phenomena within sight.* The letter 'j' is used in combination with various other Beaufort letters to record phenomena occurring within sight of but not at the station; for example:

jp = precipitation within sight
jf = fog within sight
jks = drifting snow within sight
jkz = sandstorm or duststorm within sight.

No qualification of intensity or indication of the type of precipitation is applied to adjacent precipitation, 'jp', even though this might be surmised.

Adjacent precipitation is not used to describe a shower which was previously reported at the station and is still visible on the horizon.

4.5.3. Beaufort letters sent with coded messages. In addition to the Health Resort stations which receive separate instructions (1.5.2 refers), selected stations make reports for the Press at 6 p.m. clock time and include Beaufort letters to describe the past weather in the morning and the afternoon. These stations are limited to two sets of five letter-spaces each for their Beaufort letter reports (see *Handbook of weather messages*, Part III). Exceptionally, the Beaufort letters 'e' and 'w' will be reported, when applicable, to explain the presence of measurable amounts of precipitation not otherwise accounted for. The letter 'z' will not be used.

When Beaufort letters are sent by teleprinter only capital letters can be used and the following conventions for indicating intensity apply:

slight	— the Beaufort letter preceded by 'N'
moderate	— the Beaufort letter
heavy, severe or intense	— the Beaufort letter preceded by 'A'
violent	— the Beaufort letter preceded by 'AA'.

Continuity is reported by prefixing each letter by the letter designated for intensity, for example:

NRNR = continuous slight rain
ARAR = continuous heavy rain.

Intermittent is indicated by the prefix 'I', for example:

INS = intermittent slight snow.

When showers are reported, the qualification of intensity is applied only to the letter indicating the precipitation, for example:

PAR = shower of heavy rain.