# 9th Barking & Dagenham Meteorologist Badge Pack

Name: ______________________________________

Patrol: ______________________________________

The Scout must complete these six activities.

1. Be able to explain and demonstrate how the following are measured:
    - Wind force and direction
    - Cloud type and amount
    - Temperature
    - Pressure
    - Rainfall amount
2. Keep a record of these weather conditions for at least two weeks.
3. Understand at least three different ways in which clouds are formed.
4. Know the typical weather produced in their own area by 'warm' and 'cold' air masses in summer and winter, noting the effects of land and sea. Understand the weather associated with a change of air mass at 'fronts'.
5. Know how synoptic weather maps are produced and be able to understand a simple map, with fronts and isobars, similar to those shown on television and printed in some newspapers. Relate their observations in requirement 1 to these maps.
6. Understand the effects of temperature, wind and water on the human body in cases of hypothermia and exhaustion.

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## Contents

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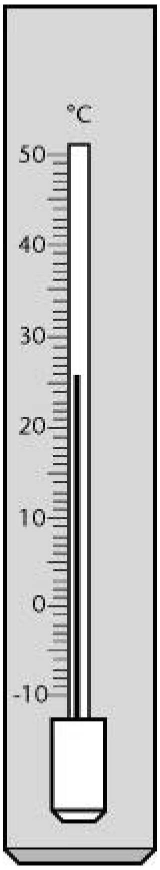
## Observations

Whatever instruments are used, ideally they should be sited over grass and have good exposure (i.e. they should be sited away from buildings, fences, trees and other obstacles). In reality it is usually possible to find a site where the exposure is reasonable even though it may not be ideal.

- Thermometers should be placed in the shade. Ideally, they should be in a white slatted box (thermometer screen) facing north. If this is not available they could be hung on a shaded wall or fence. They should not be placed on the side of a house as walls retain heat which spoils the readings.
- Rain gauges should be away from walls, fences, bushes, etc. as they affect the amount of rain caught in the rain gauge.
- Wind instruments should be well clear of walls, fences and houses as these cause eddies which spoil the speed reading and make the direction difficult to assess.

At some observing sites meteorologists make observations every hour. However, at most sites observations are made only once a day at 9 a.m. GMT (referred to by meteorologists as 0900 UTC as a 24-hour clock is used), and this is recommended for observations done at home. If this is not possible another time can be chosen, but it is important that observations are made at the same time each day.

Recordings can be entered in an exercise book suitably ruled up, including a column for 'remarks'. Plotting temperature and pressure readings on a graph at, say, 0900 GMT each day can produce interesting results over a period of time. Daily, weekly, monthly and annual totals of rainfall are also of great interest.




### *Temperature*

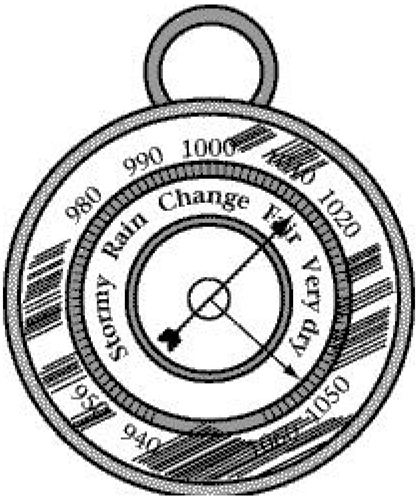
Meteorologists usually measure temperature in degrees Celsius, though degrees Fahrenheit are still used in a few places.

There are two basic types of thermometer, which are readily available.

- The liquid-in-glass thermometer depends upon the fact that a liquid expands by an amount depending upon the temperature. Consequently, as the temperature increases, the liquid (usually alcohol) in the bulb of the thermometer expands and pushes a column of liquid up a capillary tube. The length of the liquid on the scale gives the temperature by the side of the capillary tube.
- The other type of thermometer is based on a bimetallic strip, which winds and unwinds according to the temperature. This causes a pointer to move in such a way that the temperature is indicated on a semicircular scale.

As well as observing the temperature at various times of the day, it is interesting to record the highest (maximum) and lowest (minimum) temperatures. Instruments for doing this are usually based on the liquid-in-glass or bimetallic strip principles. Normally the instruments are read at 0900 GMT to give the minimum temperature the previous night (which usually occurs at about dawn) and the maximum temperature for the previous day (which usually occurs at about 1400 GMT). After reading, these instruments have to be reset.

## *Humidity*




The relative humidity is a measure of the amount of water vapour actually in the air compared with the amount of water vapour that the air could hold (i.e. the amount required to saturate the air).

Meteorologists measure the relative humidity by using two thermometers - one measures the normal temperature (the 'dry-bulb' temperature), whereas the other is a thermometer with its bulb kept wet by a cloth sleeve dipped in water (this gives the 'wet-bulb' temperature).

If the relative humidity of the air is low there is a lot of evaporation from the wet bulb. The resulting cooling causes the wet-bulb temperature to be much lower than that of the dry-bulb temperature. However, if the air is very moist there will be little difference between the wet- and dry-bulb temperatures. Consequently the larger the difference between the wet- and dry-bulb temperatures, the lower the relative humidity.

Instead of using wet- and dry-bulb thermometers, simple dial humidity gauges can be used. These use either paper or human hair which stretch when moist but shrink when dry.

## *Rainfall*

Usually the measurement of rainfall is made at 0900 GMT so the value gives the amount of rain which has fallen in the previous 24 hours.

A simple rain gauge consists of a tin can with the depth of water in the can giving the amount of rain. A more accurate rain gauge can be made with a plastic funnel placed in a collecting bottle, and some form of measuring cylinder. The rain gauge should be firmly fixed so that it remains upright with the funnel about 300 mm above the ground. The measuring cylinder can be calibrated by pouring in a known volume of water based on the diameter of the funnel. For example, for a 10 mm fall of rain, a funnel with a diameter of 100 mm would collect a volume of $3.14 \times 50 \times 50 \times 10 = 78.5$ ml (pi $r^2h$) If this volume is poured into the measuring cylinder and the level marked, ten subdivisions can be made to give markings, each for one millimetre.

If you want to take a mathematical approach, do the following. Measure the radius of the plastic funnel used as the rain gauge (R), the radius of the narrow measuring cylinder (r) and the depth (d) of the rain in the measuring cylinder. The amount of rain which fell in the plastic funnel is given by $r^2d$ divided by $R^2$.

It should be pointed out that 1 mm of rainfall recorded on a site means that if all the rain which fell in the surrounding area had not drained or evaporated away, it would have covered the entire surface to a depth of 1 mm.

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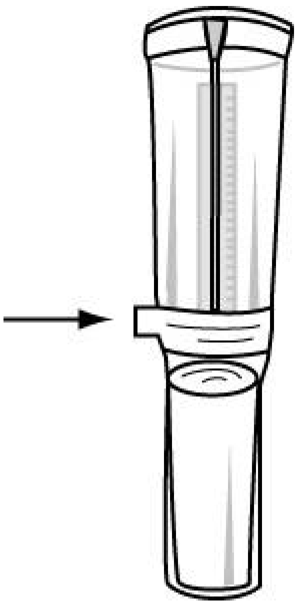
## *Wind*

Once true north has been located, it should be possible to estimate wind directions from the four cardinal points of the compass, as well as from their four intermediate points. This can be done by watching the smoke from nearby chimneys or a streamer attached to the top of a pole.



A homemade wind vane could be installed on the site, but it should be away from obstructions. Light winds can sometimes be detected by facing the wind and feeling the breeze on either a cheek or wetted finger. Note that the direction is recorded as that from which the wind is blowing.

Wind speeds can be estimated with the aid of the Beaufort wind scale.

| Force | Description | Wind speed | Typical effect overland |
|---|---|---|---|
| 0 | Calm | Less than 1 | Smoke rises vertically |
| 1–3 | Light | 1–12 | Smoke drifts or leaves rustle |
| 4 | Moderate | 13–18 | Small branches move |
| 5 | Fresh | 19–24 | Small trees in leaf begin to sway |
| 6–7 | Strong | 25–38 | Large branches or whole trees in motion |
| 8 | Gale | 39–46 | Twigs break off trees |
| 9 | Severe gale | 47–54 | Chimney pots and tiles removed |
| 10–11 | Storm | 55–72 | Trees uprooted, widespread damage |
| 12 | Hurricane | More than 73 | Devastation |

Some amateur observers make cup anemometers using four ice cream or margarine cartons mounted on a metal, plastic or wooden cross, which rotates horizontally about a vertical spindle at the top of a mast. One of the cups should be a different colour from the rest. By rotating the anemometer at a known speed and counting the number of revolutions per minute for various speeds, the equipment can be calibrated. Simple hand-held anemometers can also be purchased. Meteorologists measure the wind speed using an anemometer located 10 m above the ground.

A cheap and reliable alternative is a ventimeter in which wind blows into a hole in the side of the instrument and causes a disc to rise - the height reached by the disc is a measure of the wind speed.

## *Present Weather*

A description of the present weather can be made for the time of the observation or as a summary of the past 24 hours. Terms may be used such as sunny, cloudy, fair, rain, snow and thunderstorms. Abbreviations using Beaufort Letters may also be useful:

| | | | | | |
|---|---|---|---|---|---|
| **b** | clear sky | **bc** | partly cloudy | **c** | cloudy |
| **r** | rain | **d** | drizzle | **s** | snow |
| **rs** | sleet | **m** | mist | **f** | fog |
| **t** | thunder | **l** | lightning | **g** | gale |
| **p** | shower | **h** | hail | | |

A combination of the above letters can be used to describe the weather in more detail, e.g. ph is a hail shower.

## Cloud


Cloud Cloud classification can be very interesting. There are ten types of cloud which can be divided into high, medium or low cloud according to the height of their base.

- Cirrostratus, cirrocumulus and cirrus (high) altostratus, nimbostratus and altocumulus (medium) stratus, stratocumulus, cumulonimbus and cumulus (low)

Cloud amounts are measured in eighths (called oktas by meteorologists). However, for many purposes it would be adequate to record cloud in the following way.

- Clear - no cloud
- Partly cloudy - less than half cloud cover
- Mainly cloudy - more than half cloud cover but with some breaks in the cloud
- Overcast - complete cloud cover

## Visibility

In estimating visibility, general terms such as good, poor, foggy, etc. can be used. The following classification may be useful.

- Fog - less than 1 km
- Poor - 1 to 5 km
- Moderate - 5 to 10 km
- Good - more than 10 km

## Pressure

Many barometers allow pressure to be measured in terms of millibars, hectopascals, or inches of mercury. The easiest way to measure the pressure is to use an aneroid barometer (**Fig 7**) - this is the type of instrument found in many homes. Inside the barometer there are corrugated capsules which have no air inside. As the pressure changes, the capsule changes shape and the resulting very small movement is magnified so that a pointer shows the pressure on a circular scale.

Pressure is dependent upon height above mean sea level (msl) and the weather situation, so a barometer needs to be set so that it shows the pressure at msl. The actual msl pressure can be obtained by telephoning the Weathercall service for your area. However, if a correction for msl cannot be obtained, an indication of whether the pressure is rising or falling is a very useful thing to note.

A barometer does not have to be located in the open air or in a thermometer screen. It can be located in a house or building nearby.

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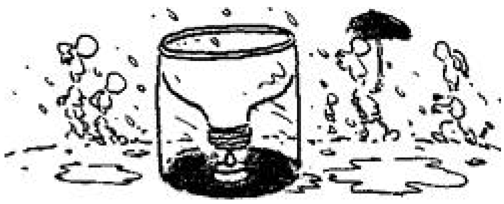
## Instruments

### *Rain Gauge*



To make a rain gauge you will need:

i) a large plastic fizzy drink bottle,
ii) a smaller plastic bottle,
iii) a pair of scissors.

Cut around the large bottle about two thirds of the way up. Turn the top upside down and check that it fits into the bottom, like a funnel. Place the small bottle inside the bottom part of the large bottle. Bury the large bottle so that the top is about 5 cm above the ground, in order to prevent large raindrops splashing into the gauge. When siting your rain gauge choose a position in the open and away from trees. Fit the funnel so that the end is in the top of the small bottle.

Check the rain gauge every day, preferably at the same time. Meteorologists do this at 9 a.m. Measure the amount of rainfall accumulated in the small bottle. It is important to check the rain gauge even if there has been no rainfall. This is because small amounts of dew may accumulate in the bottle, leading to false readings when rain does fall.

### *Thermometer Screen*

Meteorologists record shade temperatures only. In order to do this, and to ensure that the temperature is not affected by the wind or surroundings, thermometers are housed in a Stevenson screen. You can make you own thermometer screen using the following instructions.

To make a thermometer screen you will need:

i) a plastic box,
ii) scissors,
iii) white paint,
iv) a broom handle,
v) a thermometer

optional components are:
i) a piece of thin cloth,
ii) a small container of water

Take the plastic box and cut a number of slits into one side. Paint the outside of the box white. Attach the box to the broom handle. Site your thermometer screen over a grass surface, with the base of the box 1.25 metres above the ground. Place the thermometer inside the box, ensuring that the bulb is not resting on the base of the box.

You could also measure the wet-bulb temperature. Wrap a piece of thin cloth around the bulb of a thermometer, and place the thermometer in a small container of water. This thermometer can also be kept in your screen. By reading the wet- and dry-bulb temperatures, you can calculate the humidity using tables available from The Met. Office.

The thermometers can be read at the same time as you measure the rainfall. Alternatively, you can read them at regular intervals, e.g. one, two or three hours.

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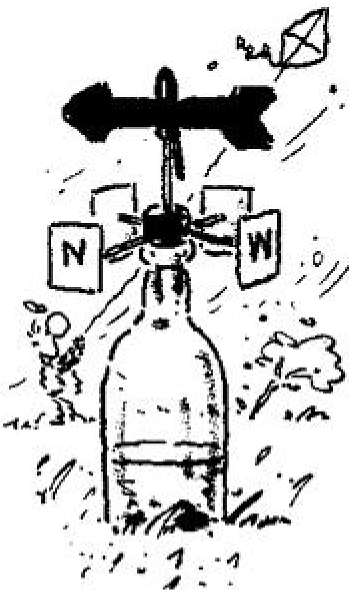
## *Anemometer*

To make an anemometer you will need:

i) a table-tennis ball,
ii) some fishing line or similar nylon cord
iii) a protractor

Thread the table-tennis ball onto the fishing line. Suspend this from the centre of the protractor so that it can swing freely. The fishing line should hang down the 90-degree line on the protractor. An indication of the wind speed will be given by the angle shown on the protractor when the instrument is held in the air. Wind speed readings can be taken at the same time as temperature measurements.

## *Wind Vane*



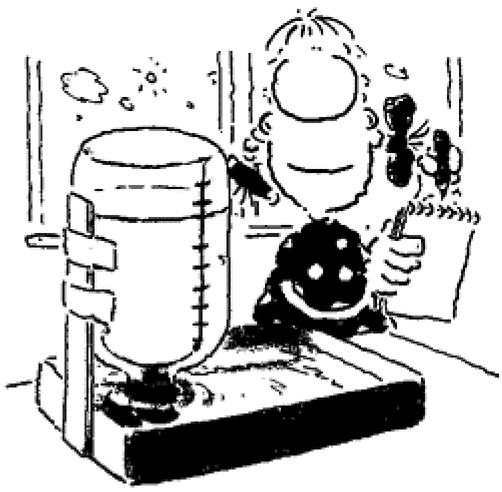

To make a wind vane you will need:

i) a pen top,
ii) a plastic fizzy drink bottle,
iii) card,
iv) a knitting needle,
v) matchsticks,
vi) a cork,
vii) sand

Draw an arrow 25 cm long on the card and cut it out. Draw around it and make another arrow the same size. Place the pen top between the arrows, in the centre, and glue together. Push four matchsticks into the cork at right angles to each other. Label these with the four main points of the compass.

Fill the bottle with sand to weigh it down. Push the knitting needle into the cork and balance the weather vane on top of the needle. Don?t forget to put the cork in the top of the bottle!

When siting your wind vane choose an exposed area, perhaps near your rain gauge. Point the north indicator in a northerly direction. Take readings whenever you measure the wind speed, and remember that the arrow always shows the direction from which the wind is blowing.



## *Barometer*

To make a simple barometer you will need:

i) a small plastic bottle,
ii) a dish,
iii) a piece of wood approx. 2.5 cm wide,
iv) sticky tape

Attach the wood to the dish and fill the dish with water, to about one third full. Fill the bottle with water to about three quarters full. Place your fingers over the end and turn the bottle upside down into the dish of water. Fix the bottle to the piece of wood so that it is straight. Mark the level of the water on the side of the bottle. When you make your observations mark whether the level of the water has changed. As the atmospheric pressure changes, so too will the water level.

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## Weather Record

Weather Records for Week Beginning…

| | Mon | Tue | Wed | Thu | Fri | Sat |
|---|---|---|---|---|---|---|
| 24-hour rainfall total | | | | | | |
| Dry-bulb temperature | | | | | | |
| Wet-bulb temperature | | | | | | |
| Humidity | | | | | | |
| Wind speed | | | | | | |
| Wind direction | | | | | | |
| Pressure | | | | | | |
| Amount of cloud | | | | | | |

Readings taken at ………………a.m. / p.m.

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**Clouds**

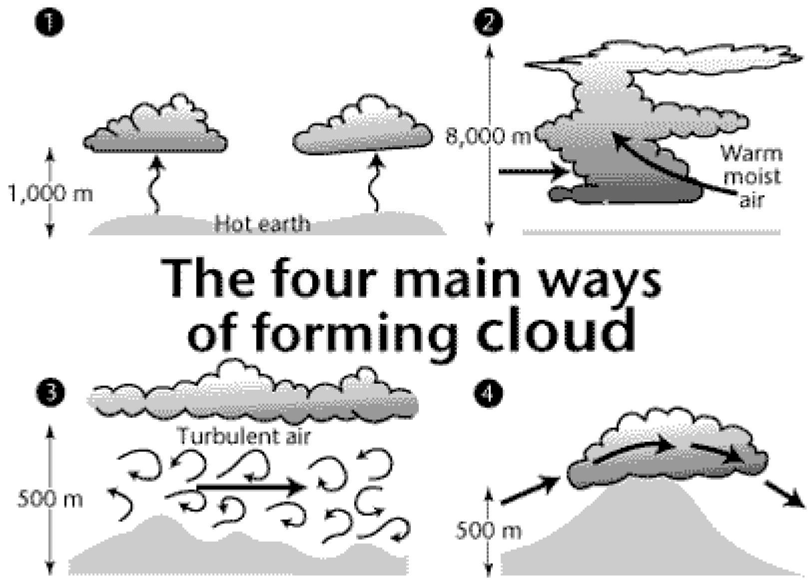
## *The nature of clouds*

A classification of clouds was introduced by Luke Howard (1772-1864) who used Latin words to describe their characteristics.

- Cirrus - a tuft or filament (e.g. of hair)
- Cumulus - a heap or pile
- Stratus - a layer
- Nimbus - rain bearing
- There are now ten basic cloud types with names based on combinations of these words (the word 'alto', meaning high but now used to denote medium-level cloud, is also used).

Clouds form when moist air is cooled to such an extent that it becomes saturated. The main mechanism for cooling air is to force it to rise. As air rises it expands - because the pressure decreases through the atmosphere - and therefore cools. Eventually it may become saturated and the water vapour then condenses into tiny water droplets, similar in size to those found in fog, and forms cloud. If the temperature reaches below about -20 °C, many of the cloud droplets will have frozen so that the cloud is mainly composed of ice crystals.

## *The main ways in which air rises to form cloud*




1. Rapid local ascent when heated air at the earth's surface rises in the form of thermal currents (convection).
2. Slow, widespread, mass ascent where warm moist air is undercut by cold air (the barrier between the warm and cold air is called a 'front').
3. Upward motion associated with turbulent eddies resulting from the frictional effect of the earth's surface.
4. Air forced to rise over a barrier of mountains or hills.

The first of these tends to produce cumulus-type clouds, whereas the next two usually produce layered clouds. The last can produce either cumulus-type cloud or layered cloud depending upon the state of the atmosphere. The range of ways in which clouds can be formed and the variable nature of the atmosphere give rise to the enormous variety of shapes, sizes and textures of clouds.

## *Types of cloud*

The ten main types of cloud can be separated into three broad categories according to the height of their base above the ground: high clouds, medium clouds and low clouds.

**High clouds** are usually composed solely of ice crystals and have a base betwen 18,000 and 45,000 feet (5,500 and 14,000 metres).

- Cirrus - white filaments
- Cirrocumulus - small rippled elements
- Cirrostratus - transparent sheet, often with a halo

**Medium clouds** are usually composed of water droplets or a mixture of water droplets and ice crystals, and have a base between 6,500 and 23,000 feet (2,000 and 7,000 metres).

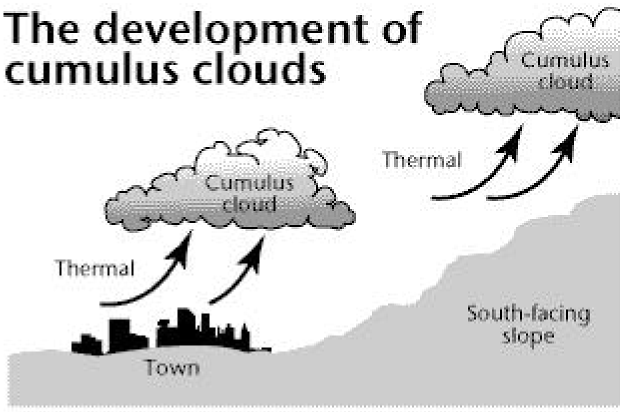
- Altocumulus - layered, rippled elements, generally white with some shading
- Altostratus - thin layer, grey, allows sun to appear as if through ground glass
- Nimbostratus - thick layer, low base, dark, rain or snow may fall from it

**Low clouds** are usually composed of water droplets - though cumulonimbus clouds include ice crystals - and have a base below 6,500 feet (2,000 metres).

- Stratocumulus - layered, series of rounded rolls, generally white with some shading
- Stratus - layered, uniform base, grey
- Cumulus - individual cells, vertical rolls or towers, flat base
- Cumulonimbus - large cauliflower-shaped towers, often 'anvil tops', sometimes giving thunderstorms or showers of rain or snow

Most of the main cloud types can be subdivided further on the basis of shape, structure and degree of transparency.

## Cumulus



*Cumulus clouds form due to thermals caused by a town or a south-facing slope*

Cumulus clouds are often said to look like lumps of cotton wool. With a stiff breeze, they march steadily across the sky; their speed of movement gives a clue to their low altitude. Cumulus clouds occasionally produce light showers of rain or snow.

Typically, the base of cumulus clouds will be about 2,000 feet (600 metres) above ground in winter, and perhaps 4,000 feet (1,200 metres) or more on a summer afternoon. Individual clouds are often short-lived, lasting only about 15 minutes. They tend to form as the ground heats up during the day and become less frequent as the sun's heat wanes towards evening.

The cause of small cumulus clouds is usually convection. Heat from the sun warms the ground, which in turn warms the air above. If a 'parcel' of warm air is less dense than the cooler air around it or above it, the 'parcel' of air starts to rise - this is known as a 'thermal'. As it rises it expands and cools, and, if cooled sufficiently, the water vapour condenses out as tiny cloud droplets. A cumulus cloud is born.

The air within the cloud will continue to rise until it ceases to be buoyant. On some sunny days there is insufficient moisture or instability for moisture to form.

In hilly regions, a high, south-facing slope acts as a good source of thermals, and therefore of cumulus. Occasionally, a power station or factory will produce a cloud of its own.

When air rises in thermals there must be compensating downdraughts nearby. These create the clear areas between cumulus clouds and make it easier for glider pilots to find the thermals that they can use to gain height.

## Stratus

Stratus is a low-level layer cloud (not to be confused with altostratus and cirrostratus, which are much higher). In appearance, it is usually a featureless grey layer. Sometimes, when a sheet of stratus is affecting an area, the cloud base will be right down to the ground and the visibility will be below fog limits. However, the usual base will be between the ground and 1,000 feet (300 metres), which means that hilltops may be obscured by cloud. Sometimes stratus will produce drizzle, snow or snow grains, particularly over hills.

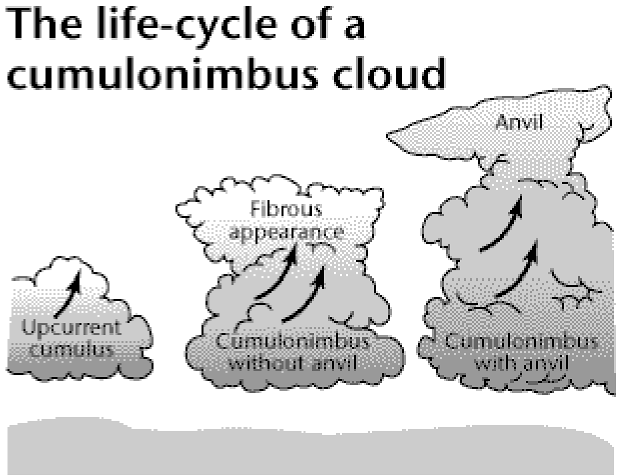
Perhaps the most important indication of its low altitude is its apparent rapid movement across the sky in any wind stronger than a flat calm. For example, a stratus cloud at 500 feet (150 metres) moving at 20 miles per hour will appear to move much faster than altostratus with its base at 10,000 feet (3,000 metres) moving at 60 miles per hour.

An approximate guide to the height of stratus may be gained by measuring the relative humidity and subtracting it from 100. The resulting number gives some idea of the height of the low cloud in hundreds of feet. For example, 94% relative humidity would indicate that the stratus is about 600 feet (180 metres) above the ground.

Inland, the base of any stratus will tend to lift slightly during the daytime and, in summer, will usually disperse completely unless associated with rain. On the coast, when a moist south-westerly airstream persists, there may be no such respite. The highest frequency of stratus occurs in the western parts of the British Isles where moist south-westerly airstreams are forced to rise over various ranges of hills.

## *Cumulonimbus*

Just as cumulus is heaped cloud, so cumulonimbus is a heaped rain cloud (nimbus means rain). In many ways the rain-bearing variety can be considered as a bigger, better-organised version of the cumulus. A cumulonimbus may be 10 km across and extend 10 km above the ground. This compares with a cumulus cloud which is typically a few hundred metres across and reaches a height of only a few kilometres. Instead of a ball of cotton wool, a cumulonimbus will resemble a huge cauliflower of sprouting towers and bulging turrets.



*The cumulonimbus cloud starts as a humble cumulus and, if the upcurrent is sufficiently powerful, will grow into a deep cumulonimbus before decaying*

But there is one important structural difference in that the uppermost levels of the cumulonimbus have turned to ice and become fibrous in appearance, whereas cumulus clouds are composed entirely of water droplets. This icy section at the top may flatten out into an 'anvil' shape when the cloud is fully developed. When it reaches this stage, the base is usually dark, with showers of rain, hail or snow falling. Ice or snow, however, will often melt before reaching the ground. Often the showers are quite heavy for short periods. Also, lightning and thunder sometimes occur.

Sometimes cumulonimbus will be 'embedded' or half hidden among other clouds. On other occasions they will be well separated and the 'anvil' may well be visible many miles away. Cumulonimbus clouds may be seen at any time of the day, but are most common inland during the afternoon in spring and summer. At these times, convection is at its strongest and most organised.

The lifetime of a cumulonimbus is usually less than one hour.

There are exceptions though. The 'Hampstead storm' of 14 August 1975 was an example of a cumulonimbus cloud that managed to keep regenerating itself over one small area of London. About 170 mm of rain fell in three hours, causing severe flooding.

## *Cirriform clouds*

Cirriform clouds (i.e. clouds from the cirrus family) are found at high altitude, usually above 20,000 feet (6,000 metres). They are composed of ice crystals. Three types of cloud make up the group: cirrus, cirrostratus and cirrocumulus.

Cirrus itself is very common in the British Isles and throughout most of the world. It is thin, wispy and white in appearance, and its name, coming from the Latin word for 'tuft of hair', gives a good description of the cloud. Another name for the cloud, 'mares tails', also conjures up an accurate image. Cirrus may be hooked or straight depending on the airflow aloft. Sometimes it comes as a very dense patch which is left over from the 'anvil' cloud of a cumulonimbus that has disappeared. On other occasions, cirrus may be quite extensive when associated with a jet stream - the cloud can then be seen moving across the sky, despite its great altitude. Aircraft condensation trails are a form of man-made cirrus. They can sometimes be seen in 'historical' films, to the delight of film buffs who enjoy spotting technical inaccuracies.

Cirrostratus is a fairly uniform sheet of thin cloud through which the sun or moon can be seen. Sometimes, if the cloud is thin, a bright ring of light (called a halo) surrounds the sun or moon. A layer of cirrostratus is often an indication of a deterioration in the weather.

Cirrocumulus is often present in small amounts along with cirrus, but rarely does it dominate the sky. On those occasions when it is widespread, a beautiful spectacle is created, especially at sunset. The individual clouds appear very small - often tiny rows of roughly spherical pear-like cloud elements. Sometimes they occur in undulating patterns like tiny ripples.

## *Stratocumulus and altocumulus*

Stratocumulus clouds usually form between 1,000 and 6,500 feet (300 and 2,000 metres), whereas altocumulus clouds form between 6,500 and 23,000 feet (2,000 and 7,000 metres). Clouds at these levels are referred to as low cloud and medium cloud, respectively.

There is no great difference in the properties of stratocumulus and altocumulus, since both are composed of water droplets and are normally limited in vertical extent, so the distinction is rather an arbitrary one. Stratocumulus will often give a sheet of almost total cloud cover, with perhaps one or two breaks. The cloud elements are rounded and almost join up. Occasionally, the sheet is composed of a series of more or less parallel rolls, which often, but not always, lie 'across the wind'. Also, stratocumulus sometimes produces light falls of rain or snow.

Altocumulus also provides a sort of dappled pattern, but, since it is at a greater altitude, the cloud elements look smaller. There are many variations on the theme, including altocumulus castellanus, which is like a vigorous medium-level cumulus (this type of cloud is sometimes an indication that thunderstorms will follow).

Both stratocumulus and altocumulus are formed by weak convection currents, perhaps triggered by turbulent airflows aloft. The convection affects a shallow zone because dry, stable air above the cloud sheet prevents further upward development.

Sometimes there are huge sheets of stratocumulus covering thousands of square kilometres around the flanks of a high pressure system, especially over the oceans. The weather below such sheets tends to be dry, but it may be rather dull if the cloud is two or three thousand feet thick.

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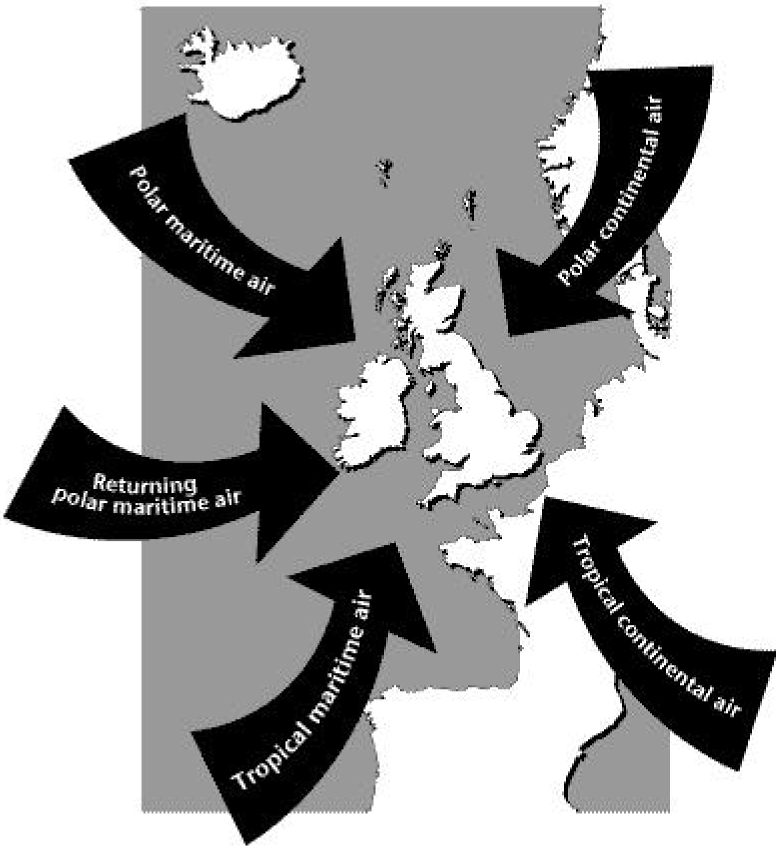
## Air Masses




### *Air masses*

The idea that northerly winds (i.e. winds from the north) are cold, and southerly winds (those from the south) are warm (at least in the northern hemisphere) is quite common. Similarly, air that has travelled over the sea picks up moisture, while air travelling over the land is relatively dry. These simple concepts help in the understanding of air masses.

In polar and subtropical regions there are large semi-permanent anticyclones (high pressure areas). The air resides in these systems for a long time and is gradually influenced by the underlying surface - air at the poles is cooled and air in the tropics is warmed. The result is a large body of air with little horizontal variation in temperature and moisture content.

Sometimes there is a large outflow of air from the anticyclones, and these air masses may approach the British Isles (usually polar air from the north and tropical air from the south). However, on their journey they may be modified by contact with the underlying surface. Air that travels over the sea (maritime air) is moistened, whereas there is little change in moisture content of air that travels over the land (continental air). For example, air that has been trapped in an anticyclone over the Sahara in June slowly heats up and dries. After a while, the air moves out of the anticyclone and may head for the British Isles. On its way it may collect moisture over the Mediterranean Sea, but the journey over Spain and France has little effect on its properties. The air then arrives here as a hot, dry air mass.

Air masses affecting the British Isles can be broadly categorised in terms of their source and their path. This leads to four possible types.

Tropical maritime - warm and moist
Tropical continental - warm and dry
Polar maritime - cold and (fairly) moist
Polar continental - cold and dry

To these must be added another air mass - returning polar maritime - which consists of polar air that has moved southwards over the sea and then turns northwards and approaches the British Isles from the south.

In reality, the type of air mass affecting the British Isles only gives an indication of the type of weather that may occur. The actual weather depends upon the detailed history of the air, the speed of movement and the surface over which it flows.

The boundary between two different types of air mass is referred to as a front. It is common for the British Isles to be affected by sequences of fronts; these usually separating polar maritime and tropical maritime air

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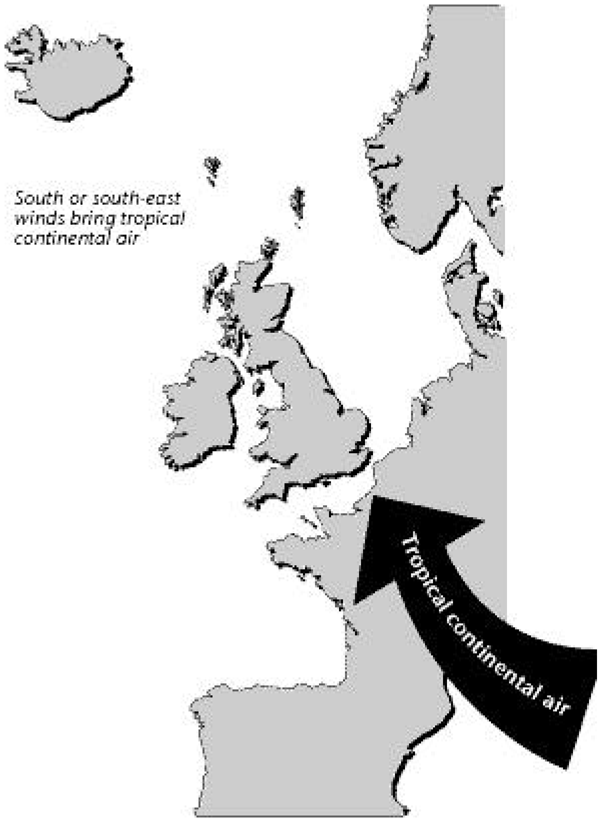


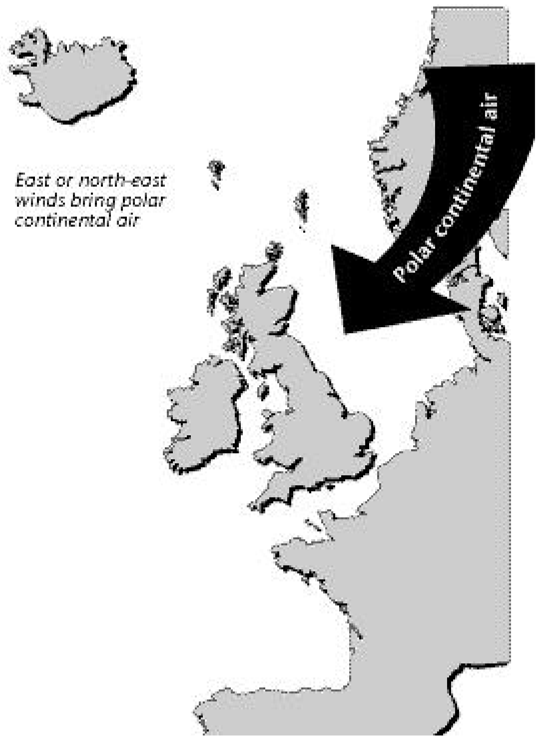

## *Tropical continental*

Tropical continental air usually comes with south-easterly or southerly airstreams. It originates in North Africa and often travels over the Mediterranean Sea, Spain and France before reaching the British Isles. In summer, even easterly winds from central Europe or the Ukraine could be included in this category, as the continent becomes so hot at this time of year. The air picks up some moisture over the Mediterranean (and perhaps the Bay of Biscay), but overall the air tends to be quite dry and the skies are typically cloudless.

Strictly speaking, an air mass cooled from below on its northward journey should be stable. Sometimes, however, moisture may have found its way to medium levels in the atmosphere. Then, if there is a layer of unstable air and a trigger to set off convection, altocumulus castellanus clouds can develop, looking like turrets. These are often the forerunner to tremendous thunderstorms, which can occur by day or night.

The majority of tropical continental airstreams give a marvellous heat wave (in summer), although plants and animals tend to be less appreciative of this type of weather. The lack of moisture usually causes the visibility to be good. However, in the air there may be desert dust, fine soil or pollution particles, which can lead to moderate visibility (often described as 'heat haze'). Also, the cloudless sky sometimes looks milky because of pollutants.

## *Polar continental*

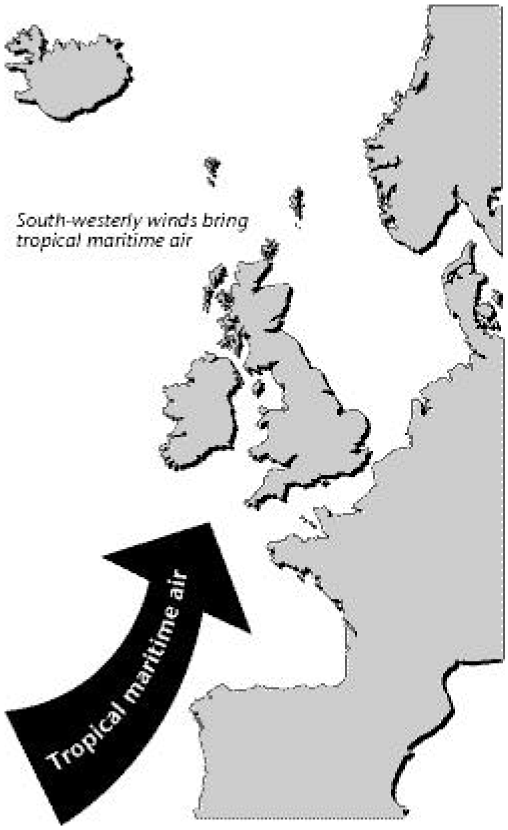



A polar continental air mass originates in Scandinavia or Russia, and the air mass reaches the British Isles when north-easterly or easterly winds become established. This tends to occur when there is a high pressure area somewhere to the north of the British Isles, often over Scandinavia itself. Polar continental air masses mainly affect the British Isles during the winter half of the year.

Temperatures in polar continental air masses are below average in winter, except perhaps to the lee of mountains. In summer, however, the temperatures tend to be above average.

The moisture content is low in these air masses, especially when they take the short sea track in the Calais/Dover region. This leads to clouds being generally well broken, and so the weather is fine and sunny. Air that has crossed the North Sea between Denmark and Scotland is said to have taken a long sea track. It therefore collects more moisture and clouds tend to form during its journey over the sea. Consequently, it is cloudy in eastern districts (with perhaps drizzle or snow flurries), but further inland there tends to be a mixture of cloud and sunshine. Visibility varies, generally being very good when air comes from Scandinavia, but moderate or poor when the air originates in the industrialised regions of central or eastern Europe. Even in April or May, the North Sea is cold and does little to modify the air mass, apart from adding a little unwelcome moisture. Southern England is particularly chilled by polar continental air masses. Further north the airstream is less cold and the wind is less strong.

## *Tropical maritime*




Tropical maritime air usually approaches the British Isles from the south-west. Its source region is the subtropical Atlantic Ocean, typically the Azores area, although occasionally it may come almost directly from the Caribbean. During its passage across the Atlantic, the air is cooled from below as it passes over a progressively cooler ocean, and so it becomes more stable. While it cools down, little of its moisture is lost. It therefore reaches south-west England or western Ireland almost saturated, giving dull, warm, overcast weather.

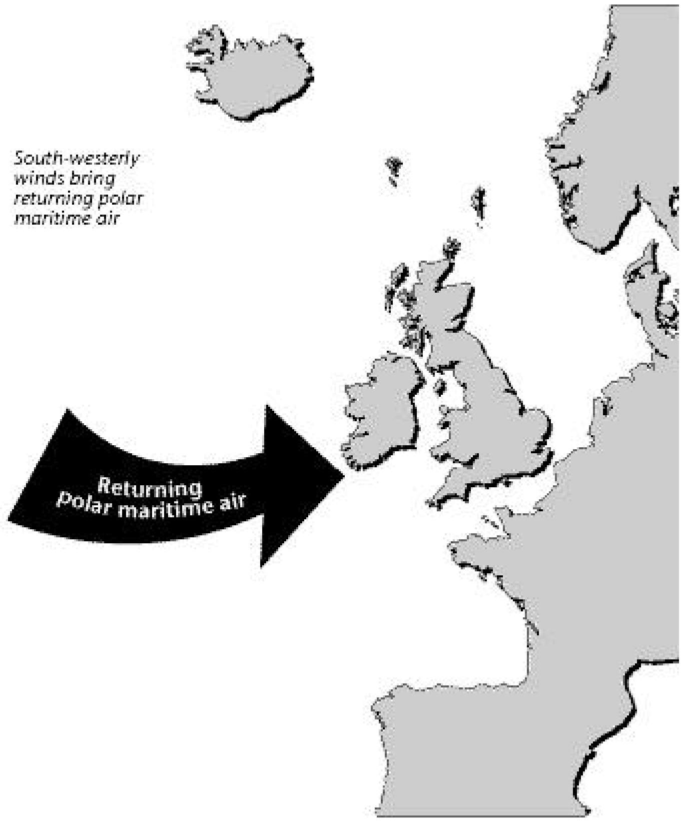
On the coasts, sea fog is common in these tropical maritime south-westerlies. However, if the cloud base of the stratus or stratocumulus is several hundred feet, sea-level sites may be saved from the fog, but on rising ground and hills there may be fog and drizzle. Bodmin Moor, Dartmoor, Dyfed, western Ireland and western Scotland can be shrouded in mild, damp conditions whether it be winter or summer.

Further inland, in the summer half of the year at least, the low stratus may be burnt off by the sun and it could turn out to be quite warm, though still humid. In the lee of hills or mountain ranges, the clouds sometimes break up and there is a lot of sunshine. Favoured locations like north Somerset, North Wales, Northumberland and the Moray Firth can bask in spring-like weather on a January day.

In a tropical maritime air mass, the nights are mild and damp, especially in mid-winter. In December and January the overcast skies result in there being little variation in temperature between day and night. However, if there are light winds and clear skies, fog may form inland overnight.

## *Returning polar maritime*

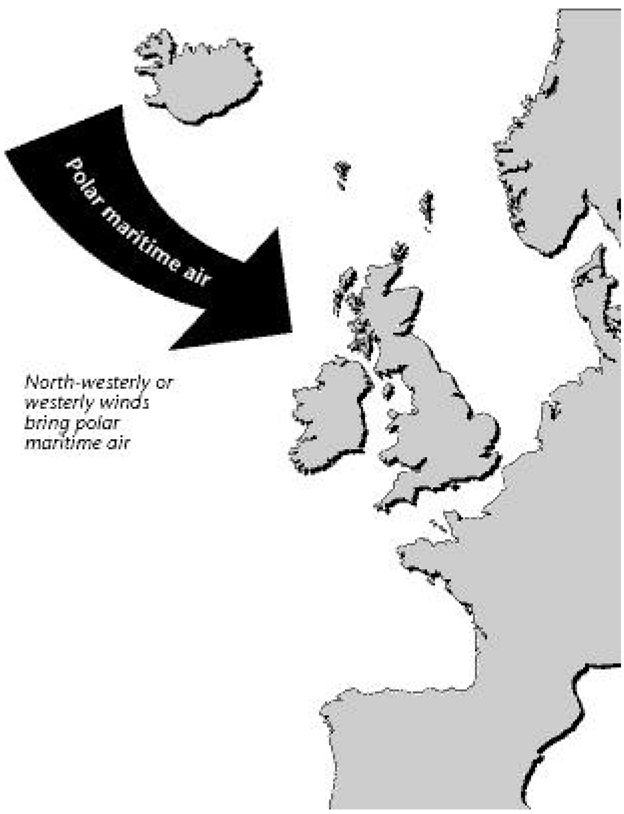
Returning polar maritime air, like polar maritime air, originates in polar regions, but travels southwards before turning north towards the British Isles. The classic returning polar maritime airstream occurs when a large depression is situated somewhere to the north-west of the British Isles. Normally, once the associated weather fronts have passed through, the British Isles are left in a north-westerly polar maritime airstream. However, if the air reaching the British Isles has travelled around the southern edge of the depression and the winds are between south and south-west, the air is designated as returning polar maritime.




The air is originally cold, but as it takes a long sea track southwards across the Atlantic, the lower layers become warmer, more moist and more unstable. However, as it returns northwards, the lower layers are cooled and become more stable. This mixture of a stable layer near the surface and an unstable layer aloft can lead to a wide variety of weather. On exposed coasts and hills, the combination of high moisture content and low-level stability can lead to stratus clouds and hill fog. Sometimes, however, the unstable layer leads to the formation of cumulonimbus clouds and showers (and occasionally thunderstorms). Further inland a mixture of weather can occur - stratus lifts and disperses and then suddenly gives way to a heavy shower.

South-west England and Wales usually have the first taste of a returning polar maritime airstream; such airstreams are especially common in autumn. Further north and east, with some shelter from the mountains, conditions tend to be better. East coast areas may well be quite warm, with only broken convection clouds. At night, these areas are usually clear, dry and cool. Moisture contents are quite high, especially near southern coasts, but the clean air usually means good visibility. Only if the wind becomes very light can inland fog form, where evening showers have moistened the ground.

## *Polar maritime*




Polar maritime air is the most common type of air mass affecting the British Isles. The air has its source in the Canadian Arctic or the Greenland area. It reaches the British Isles from the west or north-west after having swung around the western side of a depression. As the cold air travels over the relatively warm sea, it is warmed from below and becomes unstable. Unstable airstreams tend to produce convection, and so cumulus clouds, cumulonimbus clouds and showers are likely in polar maritime air. Other characteristics of the air are that it is cool (especially in summer), fairly moist and associated with good visibility.

In winter, most of the convection is initiated over the Atlantic, and showers hit the coasts, spreading inland if the winds are strong. The Scottish and Welsh mountains often shelter the eastern side of Britain, although, with a north-westerly wind, some showers sneak through the Cheshire Gap to reach Birmingham and perhaps London. With a westerly wind the winter showers can cross Glasgow and central Scotland to reach Edinburgh and Fife; others travel up the Bristol Channel to affect Cardiff and Bristol.

In spring and summer, convection clouds tend to be set off inland by daytime heating. Now, the shelter of the western mountains is less important, and showers or short-lived thunderstorms can occur almost anywhere. At night the clouds disperse.

After a low has crossed eastwards over the British Isles, winds 'veer' (a clockwise change in wind direction) to a northerly point, and true arctic air may reach us. This is sometimes referred to as arctic maritime air. It is similar to polar maritime air but tends to be more unstable, colder and drier. Consequently, showers of rain, snow, sleet or hail often occur on northern coasts and over high ground. The Highlands of Scotland usually take the brunt of a 'screaming northerly', with blizzards on low and high ground. Elsewhere there tend to be clear skies.

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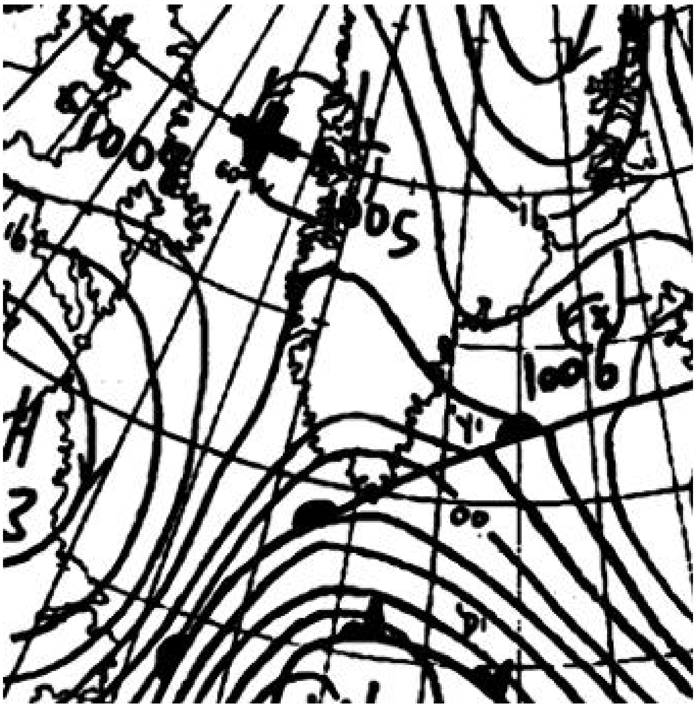
## Interpreting weather maps




### *Isobars*

The lines shown on a weather map are isobars - they join points of equal atmospheric pressure.

The pressure is measured by a barometer, with a correction then being made to give the equivalent pressure at sea level. Meteorologists measure pressure in units of millibars (mb), though instruments sometimes give pressures in terms of inches of mercury. The term hectopascal (hPa) is often used instead of millibar, where 1 millibar equals 1 hectopascal. In the British Isles the average sea-level pressure is about 1013 mb (about 30 inches of mercury), and it is rare for pressure to rise above 1050 mb or fall below 950 mb.

Charts showing isobars are useful because they identify features such as anticyclones and ridges (areas of high pressure) and depressions and troughs (areas of low pressure), which are associated with particular kinds of weather. These features move in an essentially predictable way.

There are three important relationships between isobars and winds.

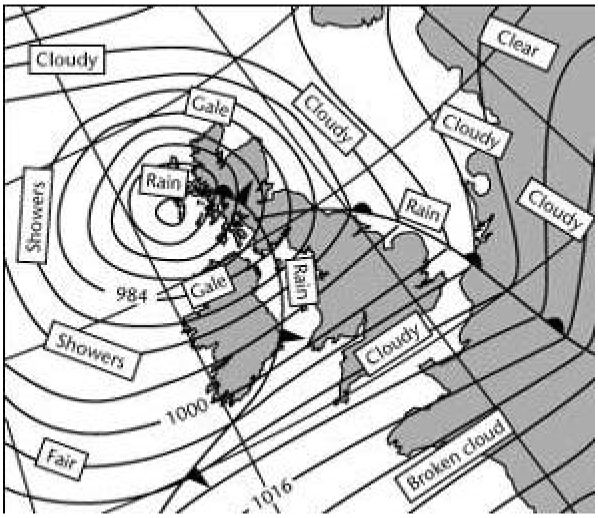
- The closer the isobars, the stronger the wind.
- The wind blows almost parallel to the isobars.
- The direction of the wind is such that if you stand with your back to the wind in the northern hemisphere, the pressure is lower on the left than on the right.

| Speed (knots) | Symbol | Speed (knots) | Symbol |
|---|---|---|---|
| Less than 1 | | 33–37 | |
| 1–2 | | 38–42 | |
| 3–7 | | 43–47 | |
| 8–12 | | 48–52 | |
| 13–17 | | 53–57 | |
| 18–22 | | 58–62 | |
| 23–27 | | 98–102 | |
| 28–32 | | 103–107 | |

### *Wind Speed & Direction*

The direction given for the wind refers to the direction from which it comes. For example, a westerly wind is blowing from the west towards the east. Measurements of wind strength are made at 10 metres (33 feet) above the ground. A specified height has to be used because the wind speed decreases towards the ground. In this country winds are measured in knots (nautical miles per hour). However, forecast winds are often given in miles per hour (where 1 knot is equivalent to 1.15 m.p.h.) or in terms of the Beaufort Scale. There are rapid variations in the wind - these are referred to as gusts. Gusts are higher inland than over the sea or windward coasts, although the mean wind speeds tend to be lower inland. Typically, gusts can be 60% higher than the mean speed, although in the middle of cities this can reach 100%. Northerly winds tend to be gustier than southerly ones.

## *Relationship between wind direction and weather*

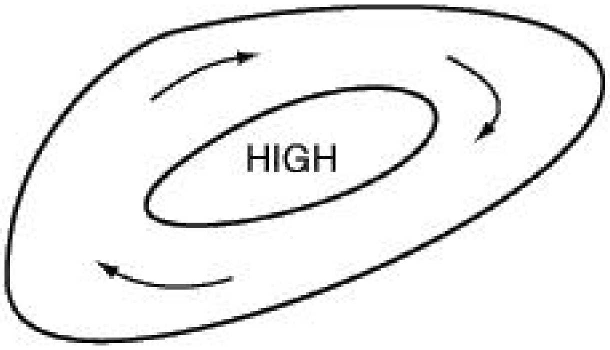


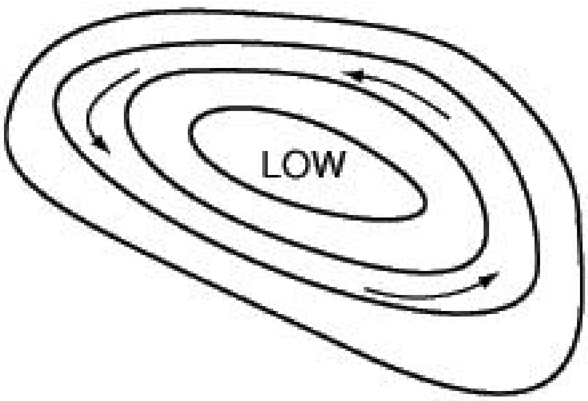

In general, the weather is strongly influenced by the wind direction, so information about the wind provides an indication of the type of weather likely to be experienced. However, this approach is effective only if the wind is blowing from the same direction for some time. A marked change in wind direction usually indicates a change in the weather. Northerly winds tend to bring relatively cold air from polar regions to the British Isles. Similarly, southerly winds tend to bring relatively warm air from the tropics. The characteristics of the air are also affected by its approach to the British Isles. Air picks up moisture if it travels across the sea, but remains relatively dry if it comes across the land.

As cold polar air moves southwards over an increasingly warm sea, the heating of the air by the sea causes cumulus clouds to form. These clouds may grow sufficiently for showers to develop and, consequently, winds from the north-west, north or north-east usually bring cold, showery weather to the British Isles. Warm air from the tropics moving northwards over the sea is cooled from below. Sometimes the cooling is sufficient for sea fog or a thin layer of stratus to form. The cloud can become thick enough for drizzle, especially on windward coasts and over high ground. In general, winds from the west or south-west are associated with overcast, wet weather.

Winds from the south and south-east mainly occur in summer and these bring warm, dry weather. However, southerly winds can sometimes bring hot, thundery weather. Easterly winds in winter bring very cold air to the British Isles. The characteristics and path of the air determine whether it is cloudy (with perhaps rain, sleet or snow) or fine and sunny. In summer, an easterly wind will mean it is cool on the east coast but warm elsewhere, usually with clear skies.

## *Depressions and anticyclones*





In a depression (also referred to as a 'low'), air is rising. As it rises and cools, water vapour condenses to form clouds and perhaps precipitation. Consequently, the weather in a depression is often cloudy, wet and windy (with winds blowing in an anticlockwise direction around the depression). There are usually fronts associated with depressions.

In an anticyclone (also referred to as a 'high') the winds tend to be light and blow in a clockwise direction. Also the air is descending, which inhibits the formation of cloud. The light winds and clear skies can lead to overnight fog or frost. If an anticyclone persists over northern Europe in winter, then much of the British Isles can be affected by very cold east winds from Siberia. However, in summer an anticyclone in the vicinity of the British Isles often brings fine, warm weather.

A trough has characteristics similar to those of a depression, and in a ridge the weather is similar to that in an anticyclone. The changeable weather in the British Isles is caused by a succession of depressions with their associated fronts and anticyclones (or ridges) running across the country from the Atlantic Ocean.

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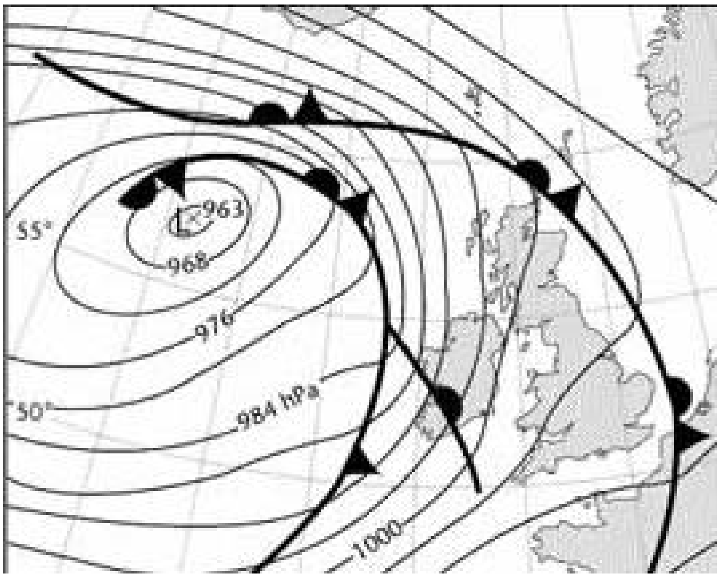
## *Fronts*

The boundary between two different types of air mass is called a front. In our latitudes a front usually separates warm, moist air from the tropics and cold, relatively dry air from polar regions. On a weather chart, the round (warm front) or pointed (cold front) symbols on the front point in the direction of the front's movement. Fronts move with the wind, so they usually travel from the west to the east. At a front, the heavier cold air undercuts the less dense warm air, causing the warm air to rise over the wedge of cold air. As the air rises there is cooling and condensation, thus leading to the formation of clouds. If the cloud becomes sufficiently thick, rain will form. Consequently, fronts tend to be associated with cloud and rain. In winter, there can be sleet or snow if the temperature near the ground is close to freezing.

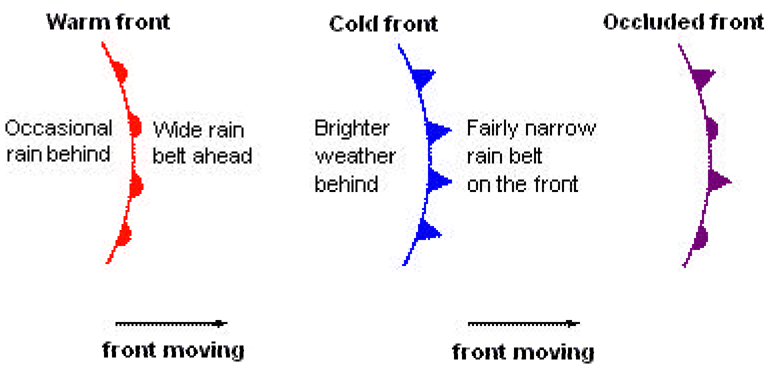
It is convenient to distinguish between warm fronts, cold fronts and occluded fronts.




A front which is moving in such a way that the warm air is advancing to replace the cold air is called a **warm front**. As the warm front approaches, there is thickening cloud and eventually it starts to rain. The belt of rain extends 100-200 miles ahead of the front. Behind the front the rain usually becomes lighter, or ceases, but it remains cloudy. As a warm front passes, the air changes from being fairly cold and cloudy to being warm and overcast (typical of warm air from the tropics travelling over the sea). Also there is a clockwise change in wind direction, and the wind is said to 'veer'.

A **cold front** moves so that the cold air is advancing to replace the warm air. This means that as a cold front passes, the weather changes from being mild and overcast to being cold and bright, possibly with showers (typical of cold polar air travelling over the sea). The passage of the front is often marked by a narrow band of rain and a veer in the wind direction.

An **occluded front** can be thought of as being a result of the warm and cold fronts meeting. Consequently, ahead of an occlusion the weather is similar to that ahead of a warm front, whereas behind the occlusion it is similar to that behind a cold front.




The characteristics given for the fronts apply to active fronts. If the front is weak, the rain associated with it is light or non-existent, and the changes across the front are less marked.

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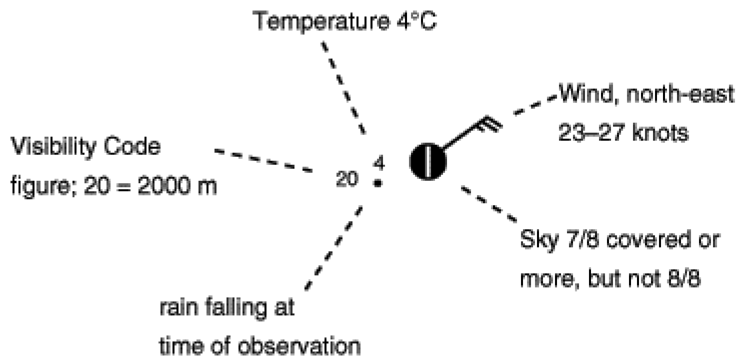
## *Other Weather Symbols*

| | Symbol | | Symbol |
|---|---|---|---|
| Clear sky | ○ | 5/8 covered | |
| covered 1/8 or less, but not zero | ⦶ | 6/8 covered | ◕ |
| 2/8 covered | ◔ | 7/8 covered | |
| 3/8 covered | | sky completely covered | ● |
| 4/8 covered | ◑ | sky obscured, e.g. by fog | ⊗ |




| | Symbol | | Symbol |
|---|---|---|---|
| Rain | ● | Fog | ≡ |
| Drizzle | | Thunderstorm | |
| Shower | ▽ | Hail | ▲ |
| Snow | | | |

combinations of these can be made,
e.g. rain shower, snow shower

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| Name | Air Masses | Clouds | Instruments | Observations | Maps | Charts | Weather Record | Human Body | Make an instrument | Passed? |
|---|---|---|---|---|---|---|---|---|---|---|
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