Surface Weather Charts

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1. PRELIMINARY

1.1. Weather basics

Although a complete discussion about forecasting is far beyond the scope of this paper, a brief overview of forecasting process is warranted. The overwhelming question that most forecasters are trying to answer is: 'Where will there be clouds and precipitation?'

Obviously, the clouds and precipitation may not have formed yet, so looking for the underlying causes rather than what's there already, is the key of the forecast process.

In either case, the clouds and precipitation are caused by some sort of lift, often called *ascent* by meteorologists.

Stratiform rain is caused by slow, large-scale ascent of a very humid air mass.

On the other hand, convective (cumuliform) showers and rain depend much more on the presence of instability (warm air underlying cold air).

1.2. Various sources of ascent

Slow, large-scale (synoptic scale) ascent is one of the easiest problems for amateur forecasters, professionals and numerical weather models to tackle. It occurs over such a large area that the air mass characteristics are sampled quite well by surface and radiosonde stations. In most cases, large-scale ascent is revealed in one of the following ways:

- Upper-level forcing (dynamic): when divergence occurs in the upper atmosphere, it removes mass from the column and lowers surface pressures, air tends to rise to fill the void
- Isentropic lift: this type is most prominent when air parcels are travelling over rapidly varying air mass temperatures. The parcels must rise or sink in order to conserve their potential temperature
- Surface convergence: a clash in low-level wind direction or a low pressure area, cause ascent. Air converges and is forced to rise
- Orographic lift: air is forced to travel over ascending terrain has no other choice than to rise
- Convection: when very cold air overlies low-level warm moist air, the less dense warmer air will rise as long as its temperature is warmer than that of its environment

2. SURFACE CHART

2.1. Weather systems

On a weather chart, lines joining places with equal sea-level pressures are called **isobars**. Charts showing isobars are useful because they identify features such as anticyclones (areas of high pressure), depressions (areas of low pressure), troughs and ridges which are associated with particular kinds of weather.

2.1.1. Buys Ballot's Law

A rule in synoptic meteorology, enunciated in 1857 by Buys Ballot, states that:

"If, in the northern hemisphere, one stands with one's back to the wind, pressure is lower on one's left hand than on one's right"

In the southern hemisphere the converse is true.

This law implies that, in the northern hemisphere, the winds blow **anticlockwise** round a **depression**, and **clockwise** round an **anticyclone**; the converse is true in the southern hemisphere.

2.1.2. High pressure or anticyclone

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.

2.1.3. Low pressure or depression

In a depression (also referred to as a 'low'), air is rising. As it rises and cools, water vapour condenses to form clouds and usually 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 frontal systems associated with depressions.

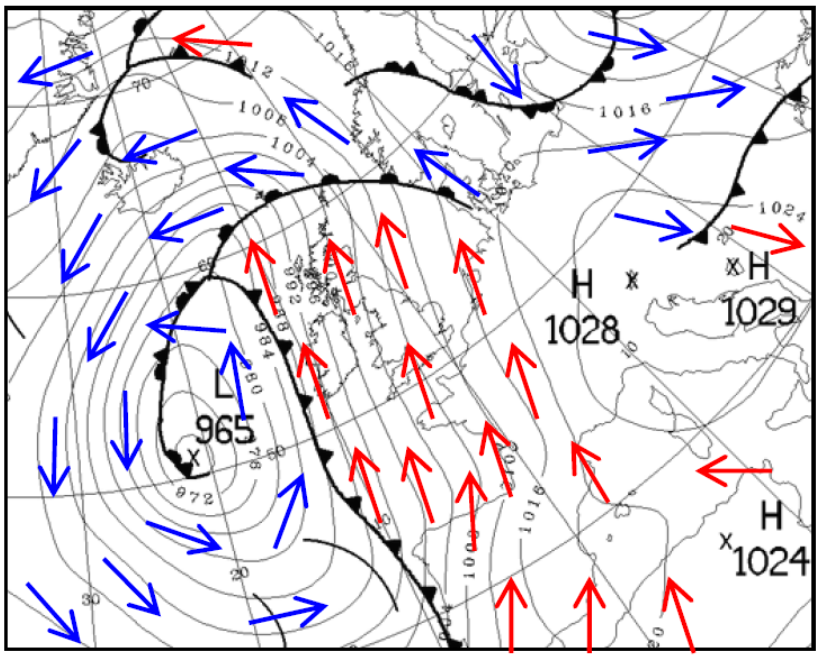


Figure 1: Surface chart showing high pressure, low pressure systems along with wind flow

2.1.4. Isobars (lines of equal atmospheric pressure)

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 millibar (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.

Also, wind speeds and directions are related to the spacing and orientation of the isobars.

2.1.5. Relationship between isobars and wind

There are two important relationships between isobars and winds:

- The closer the isobars, the stronger the wind
- The wind blows almost parallel to the isobars. It reality, because of surface friction, it blows across them by about 30 degrees on land and 10 degrees on water. It blows out of a high an into a low

These make it possible to deduce the surface wind flow from the isobars.

2.1.6. Wind speed and direction

By definition, 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 (going eastwards).

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 the UK, 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 mph) 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.

2.1.7. 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.

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.

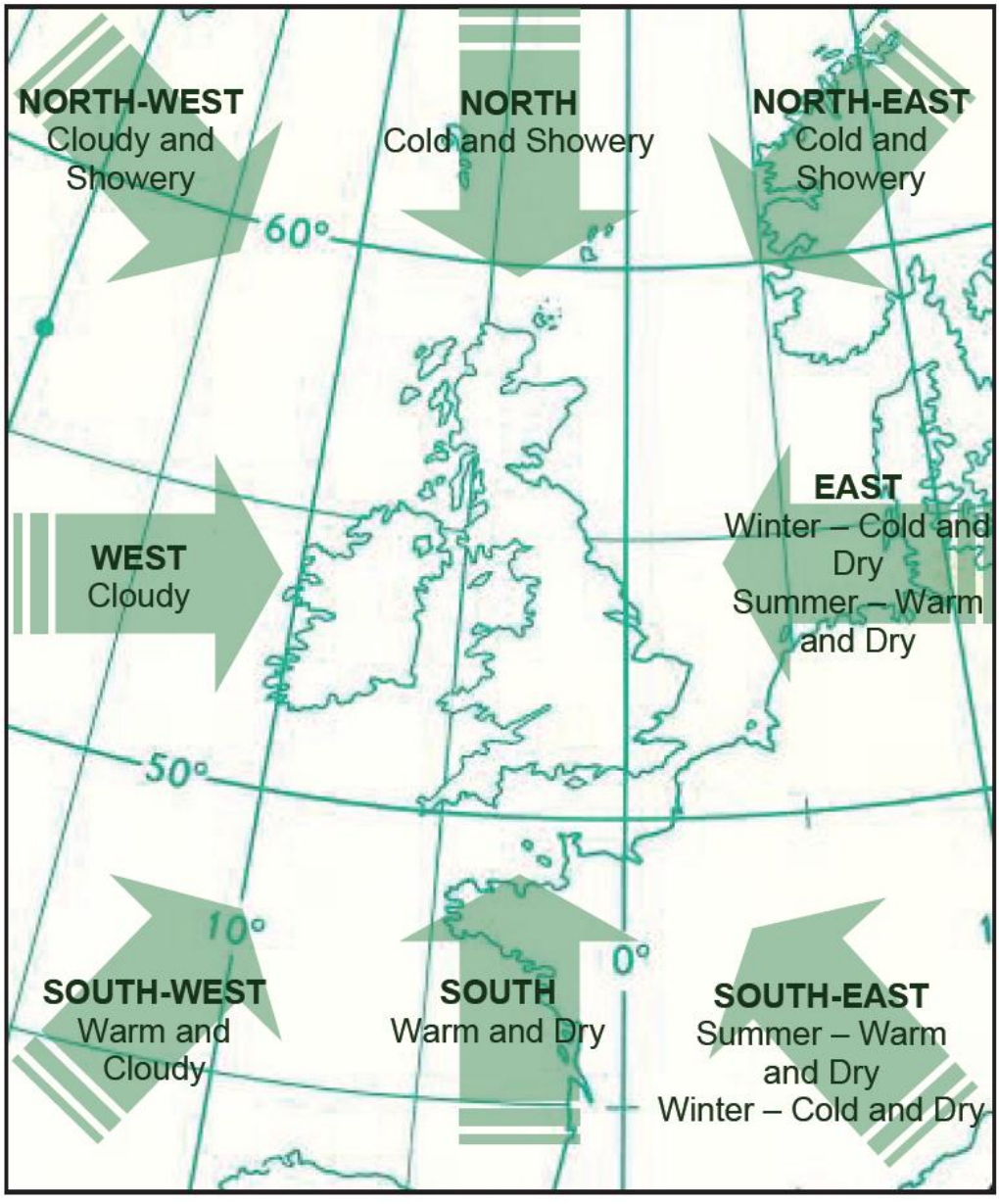


Figure 2: UK weather phenomena according to wind directions.

Northerly winds tend to bring relatively cold air from polar regions to the British Isles.

Southerly winds tend to bring relatively warm air from the tropics.

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.

2.1.8. 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.

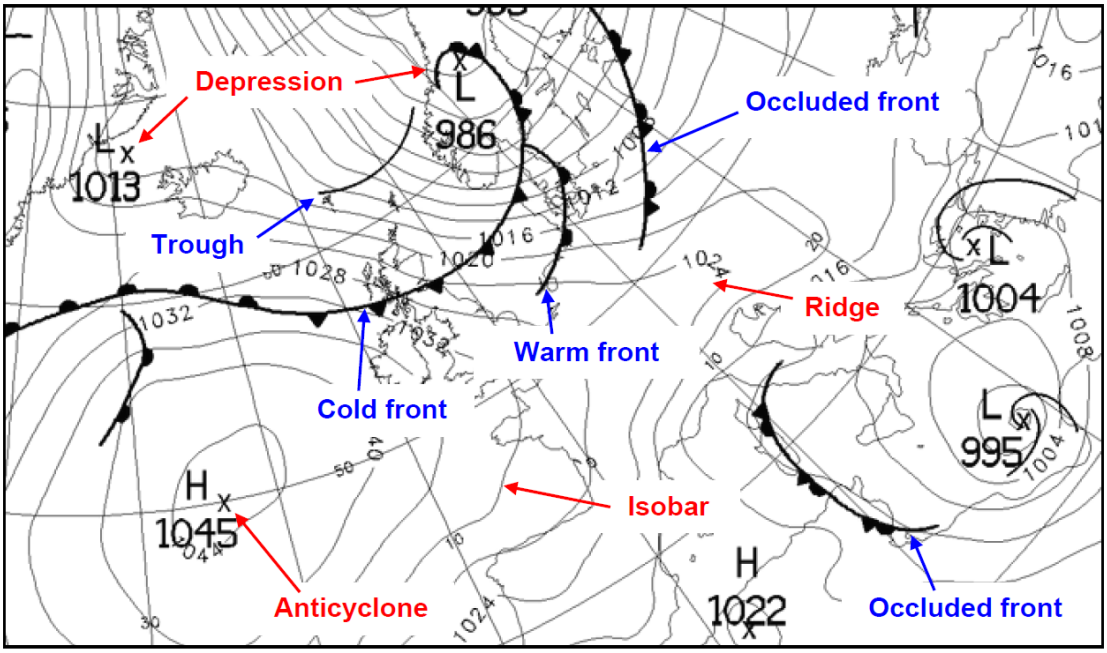


Figure 3: Depressions, anticyclones, isobars and weather fronts

2.2. Typical chart and legend

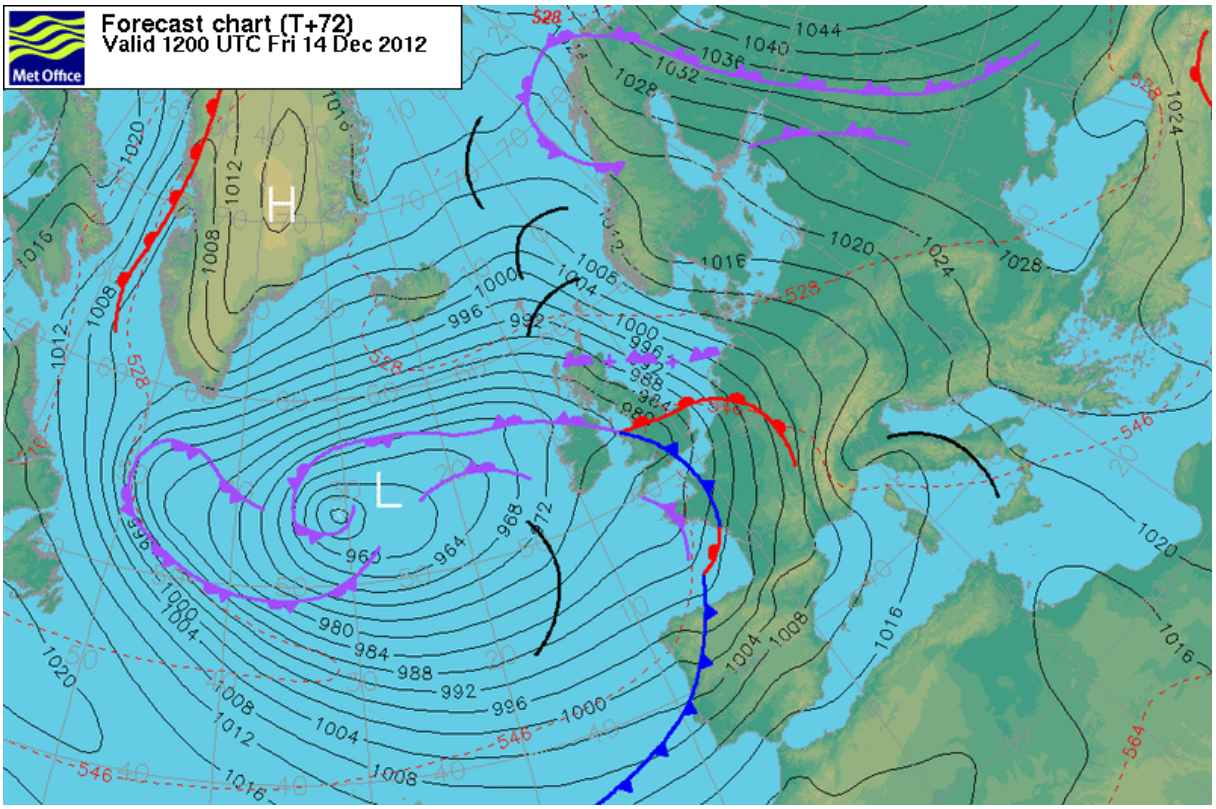
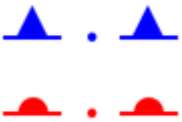
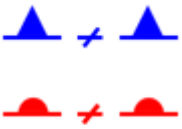
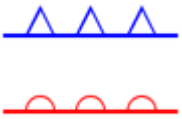
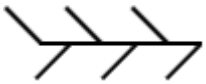


Figure 4: Typical surface chart from the Met Office site

Symbol	Meaning
	**Cold front:** The leading edge of an advancing colder air mass. Its passage is usually marked by cloud and precipitation, followed by a drop in temperature and/or humidity
	**Warm front:** The leading edge of an advancing warmer air mass, the passage of which commonly brings cloud and precipitation followed by increasing temperature and/or humidity
	**Occluded front (or 'occlusion'):** Occlusions form when the cold front of a depression catches up with the warm front, lifting the warm air between the fronts into a narrow wedge above the surface. Occluded fronts bring cloud and precipitation
	**Developing cold/warm front (frontogenesis):** Represents a front that is forming due to increase in temperature gradient at the surface
	**Weakening cold/warm front (frontolysis):** Represents a front that is losing its identity, usually due to rising pressure. Cloud and precipitation becomes increasingly fragmented
	**Upper cold/warm front:** Upper fronts represent the boundaries between air masses at levels above the surface. For instance, the passage of an upper warm front may bring warmer air at an altitude of 10,000 ft, without bringing a change of air mass at the surface
	**Quasi-stationary front:** A stationary or slow-moving boundary between two air masses. Cloud and precipitation are usually associated
	Trough: An elongated area of relatively low surface pressure. The troughs marked on weather charts may also represent an area of low thickness (thickness trough), or a perturbation in the upper troposphere (upper trough). All are associated with increasing cloud and risk of precipitation

	Thickness lines: Pressure decreases with altitude, and thickness measures the difference in height between two standard pressure levels in the atmosphere. It is proportional to the mean temperature of this layer of air, so is a useful way of describing the temperature of an air mass. Weather charts commonly show contour lines of 1,000-500 hPa thickness, which represent the depth (in decametres, where 1 dam = 10 m) of the layer between the 1,000 hPa and 500 hPa pressure levels. Cold, polar air has low thickness, and values of 528 dam or less frequently bring snow to the UK. Conversely, warm, tropical air has high thickness, and values in excess of 564 dam across the UK often indicate a heat wave
	Isobars: Contours of equal mean sea-level pressure (MSLP), measured in hectopascal (hPa). MSLP maxima (anticyclones) and minima (depressions) are marked by the letters H (High) and L (Low) on weather charts
	**Convergence line:** A slow-moving trough, which is parallel to the isobars and tends to be persistent over many hours or days. They are quite common in cold northerly outbreaks down the Irish Sea, affecting west Wales, Devon and Cornwall in particular, but can be found in other areas also. This convergence line can gives hours of persistent precipitation over very localised areas, whilst a few miles down the road it is relatively dry, leading to some heavy snowfall/rainfall. In summer the convergence lines are not as easy to forecast, but then can still occur due to sea-breeze convergence, and are over the land, whilst in winter they are over the sea

2.3. Summary: what to look for

- Advections: warm air, cold air, moisture
- Fronts: cold fronts, warm fronts, troughs, outflow boundaries, occluded fronts, stationary fronts
- Pressure: High pressure regions, low pressure regions
- Convergence, divergence
- Temperature and moisture gradients
- Influence of topography upon the weather conditions.