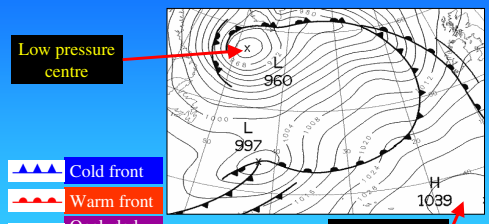
WEATHER SYSTEMS OVER THE UK

Talks in a Box

In this talk, we shall be looking primarily at mid-latitude weather systems - the highs and lows that we commonly see in the British Isles. We shall look at the basic theory behind their development, evolution and dissipation, together with the weather commonly associated with them.

A SYNOPTIC CHART



This is the classic type of weather chart (called a synoptic chart) that we see in newspapers and on some TV weather forecasts. The solid lines are isobars, i.e. lines of equal pressure. The cold, warm and occluded fronts are marked using the standard meteorological symbols. When colour is available, cold fronts are drawn in blue, warm fronts in red and occluded fronts in purple.

LOW PRESSURE SYSTEMS

- Lows (cyclones) tend to bring clouds, rain (or snow) and strong winds
- Wind rotates anti-clockwise in the northern hemisphere
- Most common system in the UK

HIGH PRESSURE SYSTEMS

- Highs (anticyclones) tend to bring:
  - in summer, clear skies and sunny weather
  - in winter, clear skies, cold nights and frosty mornings
  - BUT cloud can get trapped under anticyclonic inversions causing dull conditions
- Wind rotates clockwise in the northern hemisphere

The type of weather system we experience most commonly in the British Isles is the low pressure type. These systems, called Lows or depressions, generally form over the North Atlantic and travel with the westerly flow towards the British Isles. They last for 3 to 10 days. We will look at their formation in more detail later in the talk. Suffice to say here that each Low forms on the boundary between warm and cold air masses, a boundary known as the polar front. The Low first appears as a distortion of the boundary called a frontal wave.

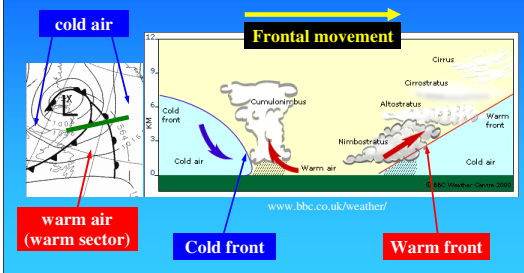
At the centre of each depression there is an area of low pressure. On average, the pressure at sea level is 1013 millibars (mb). The pressure at the centre of a deep depression can be as low as 950 mb or even less. Occasionally, indeed, pressure readings below 930 mb have been recorded in the British Isles.

In the northern hemisphere, winds blow anti-clockwise around depressions. In the southern hemisphere, they blow clockwise. In fact, the winds blow slightly inwards across isobars, the angle between wind direction and isobar orientation being typically 15° to 30°.

If there is more air being removed from the top of a Low than entering at the bottom then the Low deepens. The weather associated with the system then becomes more severe.

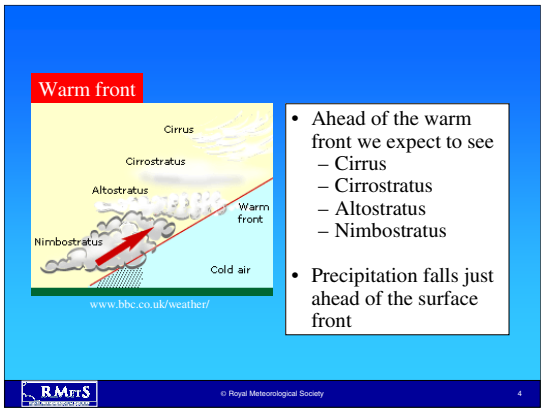
Depressions can be up to 2000km in diameter.

CROSS-SECTION THROUGH FRONTS



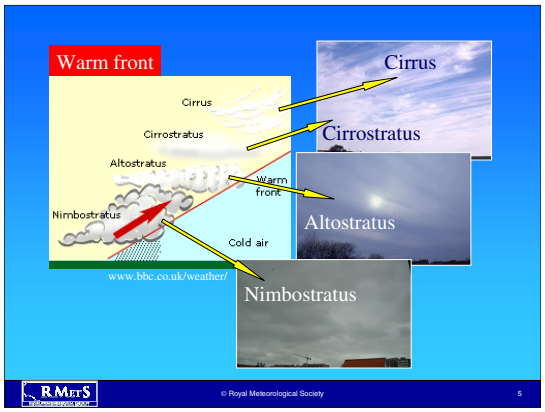
This diagram shows a cross-section through the warm and cold fronts of a low pressure system which has begun to occlude, i.e. decay. Ahead of the warm front and behind the cold front, there is cold polar air. Between the fronts, there is warmer air. Thus, this part of the depression is known as the warm sector.

In a mid-latitude system over the British Isles, the cold air will typically be polar maritime (mP) or polar continental (cP) air from the Arctic region and the warm air tropical maritime (mT) air from the tropics or sub-tropics.



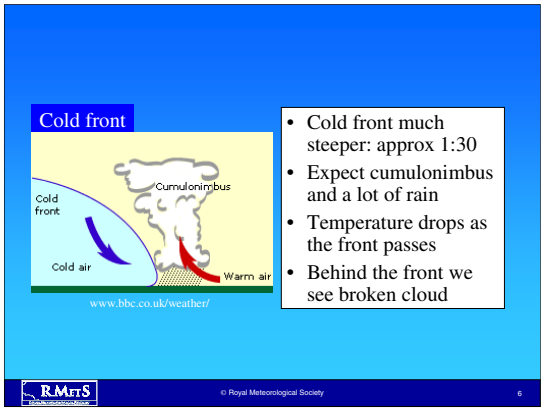
The slope of a warm or occluded front is typically 1 in 100 to 1 in 150, i.e. a vertical height of 1 km over a horizontal distance of 100-150 km. We can expect to see cirrus (wispy) cloud approximately 12 hours before the frontal precipitation arrives.

The warmer air (coloured yellow on the diagram) rises above the colder, more dense air. If the air rises high enough, the cloud can become deep enough for snowflakes or raindrops to form and precipitation to fall. Where a front is weak, as is often the case some distance from the centre of a Low, it may produce rather little precipitation or even none at all.



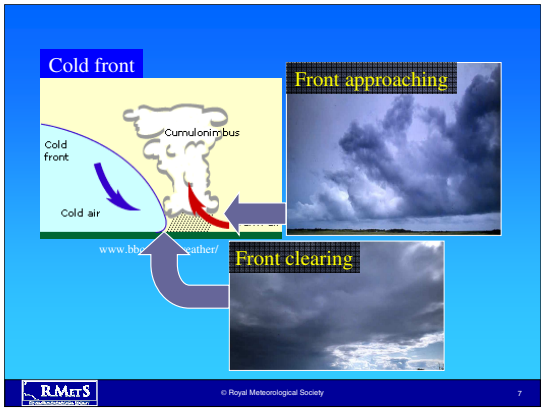
When an active warm (or occluded) front approaches, the following sequence of clouds is usually observed: cirrus uncinus (i.e. hooked cirrus), altostratus, nimbostratus. Sometimes, the sequence also includes cirrocumulus and altocumulus.

Notice that the picture of altostratus cloud shows the classic "sun as if through ground glass" characteristic. The actual position of the sun cannot be made out clearly. The appearance of the sun through cirrostratus is different. The position of the sun (or moon) can be seen clearly and optical phenomena, especially haloes and parhelia, often form. Altostratus cloud is largely formed of water droplets, whereas cirrostratus is composed of ice crystals.

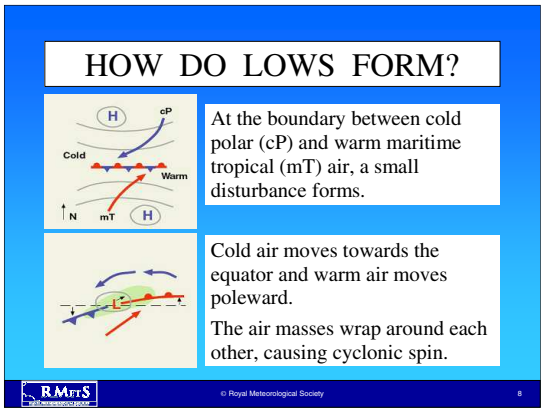


At a cold front, cold air undercuts warm air and the latter rises to middle and upper levels of troposphere. Deep cumulonimbus clouds form and heavy rain falls. When a cold front passes, the temperature generally falls.

Immediately behind a cold front, the air is generally clear, perhaps with scattered small cumulus clouds. Soon, however, larger cumulus clouds and cumulonimbus clouds develop, producing showers. The cumulonimbus clouds result from the passage of cold air over warmer surfaces, as a result of which convection occurs. For example, the surface of the Atlantic is warmer than the cold air.

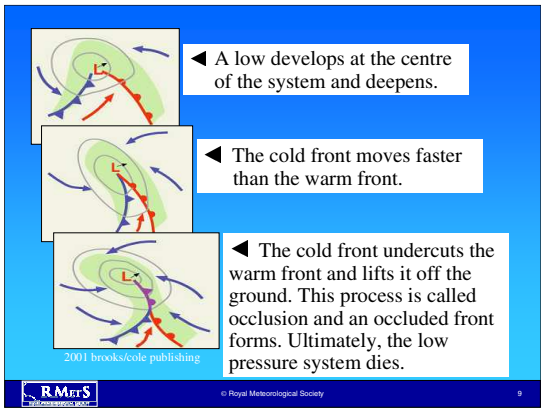


These pictures show the approach a cold front and the clearance which follows. Notice that the "snout" of undercutting cold air can be seen on the lower picture.



The development or strengthening (intensification) of a low-pressure system is called cyclogenesis.

A depression begins as a weak disturbance on the polar front, which is the boundary between cold air from high latitudes and warm air from the tropics.

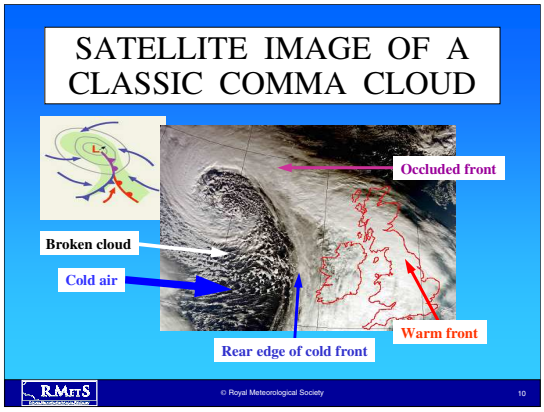


As a depression develops, distinct warm and cold fronts form. Winds blow anti-clockwise around the Low, converging towards the centre of the Low.

The closer isobars, the stronger the wind.

Where the cold front catches up with the warm front it undercuts it and lifts the warm air off the ground. An occluded front forms and the line of this front on the ground marks the boundary between two masses of cold air. When the air ahead of the front is colder than the air behind, as is typically the case in winter in the British Isles, the occluded front is known as a warm occlusion (because the air after the passage of the front is warmer than the air before). When the air ahead of the front is warmer than the air behind, as is typically the case in summer in the British Isles, the occluded front is known as a cold occlusion.

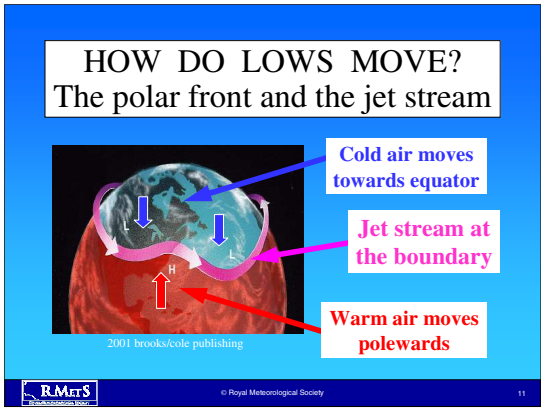
Depressions go through a life cycle of growth to maturity and subsequent decay. Occlusion marks the beginning of the decay stage and an occluding depression generally dies out within two or three days of the occlusion process beginning but may survive for longer.



This image was taken over the UK on 31 January 2002 and is reproduced by kind permission of the Dundee Satellite Receiving Station. It shows the classic comma cloud associated with a dissipating low pressure system. The image is a so-called 'visible' one, meaning that it shows the clouds as an observer in the satellite would see them if he/she were looking in black and white.

The clouds of warm, cold and occluded fronts can be seen but the positions of the fronts are difficult to locate precisely from the satellite image alone. Satellites view clouds from above and therefore see cloud tops. Forecasters use temperatures, dew-point measurements and other meteorological data to place fronts. From a visible image, cloud type is not easy to distinguish. An infra-red image shows temperature distributions and therefore allows the viewer to gauge the height of the cloud top to some extent. High clouds appear white, for example, while low clouds are grey.

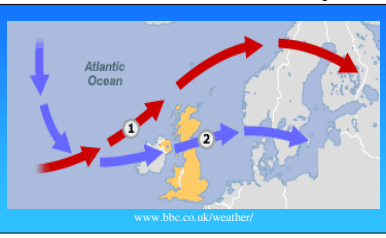
Behind the cold front is an area of cumulus and cumulonimbus clouds. In this area, cold air is warmed from beneath by passage over a warmer sea. Thus, convection occurs, manifest as cumulus and cumulonimbus clouds.



In general, warm tropical air moves polewards. As it does so, it transports water vapour and hence energy towards the pole. Cold polar air moves towards the equator. Along the boundary between the warm and cold air – the boundary known as the polar front - there is a marked temperature gradient from one side of the front to the other. At the boundary, especially in winter, the temperature gradient tends to be be steep and, hence, the winds strong. These strong winds constitute the so-called 'jet stream'.

The jet stream flows in a broadly eastward direction (i.e. from west to east) in a wavy pattern. The polar front jet stream forms at the boundary of the troposphere and stratosphere, i.e. the tropopause, at a height of approximately 9 km.

Jet streams steer weather systems



www.bbc.co.uk/weather/

Jet stream steers weather systems north of the British Isles
Jet stream steers weather systems over the British Isles

As we have seen from the previous slide, the polar front jet stream exists at the tropopause in middle latitudes and forms at the [polar front] boundary of the the warm and cold air masses. The winds of the polar front jet stream are particularly important, for they influence the tracks of mid-latitude weather systems.

Weather systems are steered by upper-level winds. If the jet stream lies to the north of the British Isles then the bad weather associated with low pressure systems will skirt around the top of Scotland and the majority of the British Isles will miss their effects. This normally allows good weather from the continent to spread over many parts of the British Isles, giving warm, sunny weather in summer.

If, however, the jet stream is over the British Isles then we can expect lows to pass right over us on their journey into Scandinavia and northern Europe. Most of them have begun to occlude by this time. The lows bring with them cloud, wind and precipitation and changeable weather - weather which is typical of the British climate.

ANTICYCLONES (HIGHS)

- The wind blows clockwise in the northern hemisphere.
- Generally light winds and very often clear, bright skies.
- Inversion of temperature 1-2 km above the ground.
- Air descends above the inversion and suppresses vertical development of clouds …
  …but extensive sheets of cloud can form under inversions.
- Pollution to be trapped beneath inversions, giving hazy conditions.
- Semi-permanent Sub-tropical High over the Azores.
- Highs not normally associated with severe weather …
  …BUT they can cause extreme heat leading to deaths
  e.g. in France in August 2003, 14,000 deaths of mainly elderly people when temperatures reached 40°C (104°F)
  …AND winds from the east on their southern flanks can bring very cold air to the UK in winter.

Highs are generally associated with fine weather.

In Highs in winter, we tend to get still, cold nights with morning frosts; and we normally have clear fine days. However, inversions of temperature occur in anticyclones and layers of stratocumulus cloud can become trapped under them, especially when the wind is blowing from a northerly direction. When this happens, the weather is gloomy (often called 'anticyclonic gloom').

In summer, we often get fine, dry and sunny conditions with little wind. Cloud formation is suppressed as air descends within the High.

In Highs, pollution can become trapped beneath the descending air, i.e. beneath the inversion. When this happens, haze becomes visible. When the air quality is poor, the incidence of respiratory illnesses such as asthma increases.

There is a semi-permanent High over the Azores. If the jet stream is north of the British Isles, this High can extend over us, giving our finest weather.

Highs are not associated with severe weather, but if they remain stationary for long enough the weather can become very hot. On the western flanks of Highs, where, in the northern hemisphere, southerly winds occur, the air may become both hot and humid and therefore unpleasant.

In 2003, most of Western Europe experienced a period of extremely dry and

OTHER TYPES OF WEATHER SYSTEM

- Severe thunderstorms in equatorial regions, that provide the rain which sustains the rainforests.
- Monsoons, that bring life-giving rain to southern Asia and other parts of the tropics.
- Tropical cyclones, sometimes called hurricanes, that bring extremely strong winds and torrential rain, causing death and destruction.
- Dry-line tornadoes in the USA, which also cause death and destruction.

There are many other types of weather system.

In the Intertropical Convergence Zone (ITCZ) around the equator, winds are generally light and variable and large cumulonimbus clouds develop, producing heavy rainfall. The clouds tend to form in groups which can be up to about 1,000km across. These groups are called 'cloud clusters'. Disturbances form on the ITCZ and some of them develop into tropical storms or even hurricanes.

Around the states of Oklahoma, Texas and Kansas in the USA, conditions are often favourable for severe thunderstorms and tornadoes to develop. Cool dry air, warm moist air and hot dry air converge along a 'dry line'. The so-called 'tornado alley' extends all the way to the Great Lakes. Each year there are, on average, 1000 tornadoes in the USA.

Monsoons occur over southern Asia, northern Australia, western Africa and parts of Central America, bringing thick cloud and heavy rain. They occur between June and September in the northern hemisphere, December and March over northern Australia. In winter, the weather over these regions is broadly consistent with the general circulation of the atmosphere, meaning that trade winds occur and skies are largely clear of cloud because of anticyclonic subsidence of air. The monsoons occur in summer and represent a reversal of the winter pattern, with monsoon winds from a westerly point and thick cloud replacing the clear skies.

SUMMARY

Talks in a Box

- At any given moment, we are always affected by a forming, mature or decaying weather system.
- The most common system over the UK is a Low, which brings cloud, wind and rain.
- Highs generally bring fine weather … but they can also give very low temperatures in winter or extreme heat in summer.
- Various other types of weather system exist around the world.

