

## Air Masses and Fronts

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## 1 Introduction

It is important for forecasters to be able to identify air masses, as they form the basis on which a forecast is constructed. For the majority of time air mass weather affects the UK, with fronts occasionally crossing the country. Most of our significant precipitation is associated with fronts. However, at times air masses can bring large amounts of precipitation too. By interpreting and understanding the air mass, regions that are likely to be affected by precipitation can be identified.

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

## 2 What is an air mass?

An air mass is a huge body of air where temperature and humidity (and hence subsequent weather) are reasonably consistent. For example, the small and almost evenly spaced clouds in this picture are indicative of an air mass known as "Polar". The clouds are similar in size, shape, type, etc. For this to happen, the values of temperature and humidity must be fairly similar anywhere within the area shown.

It is this uniformity and lack of variation that identifies an air mass type.

## 3 Where do air masses come from?

Air masses develop in the major high-pressure areas around the world, and gain their distinctive temperature and humidity characteristics from prolonged contact with their underlying surface. The atmosphere is heated and cooled almost entirely by contact with the earth's surface.

## 4 Air mass types

There are 4 main divisions of air mass commonly recognised. These are

- Polar (cold).
- Tropical (warm).
- Maritime (moist), and
- Continental (dry).

These can be combined to give specific air mass types as follows:

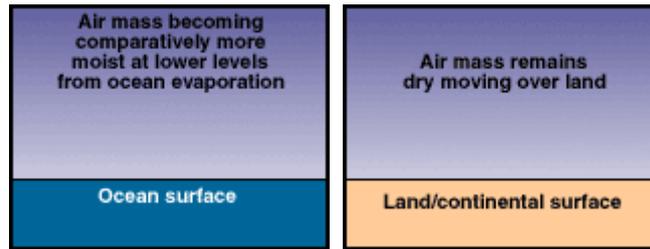
Tropical Maritime	-Warm and moist
Tropical Continental	-Warm and dry
Polar Maritime	-Cold and (fairly) moist
Polar Continental	-Cold and dry

The two main air masses affecting the UK are Tropical Maritime and Polar Maritime. There are also two further classifications known as Returning Polar Maritime and Arctic Maritime.

## 5 Modification

An air mass attains its characteristics from its source region, the area from which it originates.

However, if an air mass moves away from its source region, it will modify or change its properties of temperature and moisture content. A Continental air mass, for example, will pick up moisture if it travels over the sea, but if it travels across land it will stay dry. Cold air travelling over a warm surface will rise (convection), possibly forming shower clouds. Understanding how the air mass has been modified is crucial to forecasting the weather that it will eventually bring. So, to positively define an air mass we need to know both the region of origin and the course travelled before arrival.



## 6 UK Air masses

Six air masses affect the UK and the direction they approach the UK from. When the weather is 'unsettled' we may experience two or three different air masses during the course of a day.

### 6.1 Tropical maritime

This south-westerly air mass originates from the subtropical Atlantic Ocean, typically the Azores area, as a hot, moist air mass. As it approaches the UK though, its temperature lowers over increasingly cooler water to become warm or mild while the long sea track keeps the moisture content high.

Wind facing coasts and hills may experience fog, low cloud and drizzle in this air mass. Bodmin Moor, Dartmoor, Dyfed, western Ireland and western Scotland can be shrouded in mild, damp conditions whether it be winter or summer. Further inland, particularly to the lee of high ground, the cloud may break up bringing a lot of sunshine. Favoured locations like Northumberland and the Moray Firth can bask in spring-like weather on a January day.

### 6.2 Tropical Continental

Chiefly in the summer.

When UK residents talk of "heat waves", this is the air mass that generally provides it. It begins life in North Africa, before crossing the Mediterranean into Spain and France and arriving into the UK from the south or southeast. It does pick up some moisture in crossing the Mediterranean Sea, but loses much of this over the mountains of Southern Europe. However, it can produce widespread thunderstorms (day or night), heavy precipitation and flooding. This is known as the 'Spanish Plume'. Summer weather is hot or very hot, and dry. It is also quite hazy and it is common for this air mass to deposit Saharan dust over parts of the UK.

### 6.3 Polar Maritime

This air mass develops over cold source regions such as Greenland or Canada, to the northwest of the UK. As the cold air travels over the relatively warm sea it is warmed from below, making the air rise (convection) and it also picks up moisture. This means shower clouds (and possibly thunderstorms) develop.

This air mass is very common in winter, with frequent showers of rain, sleet and snow and occasional thunderstorms. The showers tend to be concentrated near the west coast, although they can penetrate inland, particularly through northwest facing openings such as the Cheshire Gap to reach Birmingham and London. Many eastern areas in winter usually stay clear and dry, sheltering behind hills and mountains.

In summer however, hot temperatures over the land allows showers and perhaps thunderstorms to develop anywhere in the UK. These showers tend to disperse overnight however.

Another feature of note is the very good visibility experienced in this air mass, both winter and summer — although visibility can fall to almost nil in winter snow showers.

### 6.4 Returning Polar maritime

This air mass has exactly the same source regions as Polar Maritime, but travels southwards, instead of southeast, before turning north towards the UK.

This more southerly track allows it to become warmer than Polar Maritime, before it curves back towards the UK. This re-curving brings it back over cooler water again. Therefore, at low levels of the atmosphere this air mass appears warm and moist – similar to Tropical Maritime. Higher up, the air remains unchanged from its source region, and behaves more like the Polar Maritime air mass.

On exposed coasts and hills this may lead to low cloud and hill fog. However, like Polar Maritime, showers or possibly thunderstorms are also a feature. To the lee of high ground, in the north and east, skies may be clearer and it can be quite warm.

## 6.5 Polar Continental

A Polar Continental air mass originates from high pressure areas over Scandinavia or Russia and reaches the UK on Easterly or Northeasterly winds.

UK meteorologists sub-divide this air mass type, depending upon how long the air has taken to cross the North Sea and season. If the air has a short crossing, for example from Holland to East Anglia, it is likely to remain dry and relatively cloud-free. If the sea journey is long, from Scandinavia to London for example, the air will pick up moisture en route.

Polar Continental air is associated with very low temperatures and bitterly cold winds in winter, and wind chill can be significant.

The moisture obtained from the sea brings wintry showers of snow or hail, while the west benefits from shelter of hills and mountains, staying clear, dry and very cold.

In summer, Continental air from the east is cooled as it crosses the North Sea. This leads to another common feature of East Coast weather — the North Sea “haar” or “fret” as shown in this satellite picture. If the air crossing the sea cools enough, it condenses into low cloud or sea fog. The fog is generally confined to the coastal strip, evaporating as it tries to move over the warm land, although it may be brought further inland upon the easterly wind.

As the land cools at night, the fog is able to penetrate well inland (possibly feeding through natural ‘gaps’, the Forth/Clyde valley for example) and it may persist through much of the morning before the sun is able to burn it back to the coast.

Occasionally, the additional moisture and warm temperatures inland in summer and mountain uplift can combine to produce showers or possibly thunderstorms over the Pennines.

## 6.6 Arctic Maritime

This is similar to Polar Maritime air, but colder. As with Polar Maritime, convection (cold air heated by relatively warm seas) occurs. Consequently, showers of rain, snow, sleet and hail affect windward facing coasts and high ground. The Highlands of Scotland usually take the brunt of a ‘screaming Northerly’, with blizzards on low and high ground. Parts of eastern England, North York Moors, North Norfolk, North Wales and Western Cornwall are also susceptible to wintry showers. Elsewhere there tends to be clear skies.

## 7 Final Thoughts on air masses

Air mass considerations can help predict future weather, but local effects such as proximity to coasts and topography may be as important. The actual weather depends on the detailed history of the air, the speed of movement and the surface over which it flows.

Where two different types of air mass meet is known as a front. Fronts are explained in section 9.

## 8 Fronts and Frontal Depressions

Definition of a Front: The boundary between two contrasting air masses.

In the UK fronts are often formed when Tropical Maritime air meets Polar Maritime air.

Differences in temperature (resulting in differences in density), means that air masses do not mix easily when they come together. The less dense air mass will tend to rise up over the other, creating a three-dimensional boundary called the frontal zone.

A front moving such that warm air replaces cold air on the earth's surface is termed a warm front. One that moves so that cold air replaces warm air is called a cold front.

Meteorologists often mark the position of the cold front on operational weather maps with a blue line, and use red for a warm front. In the UK the cold front is drawn as shown here, with triangles pointing the way the front is moving - northeast in this example.



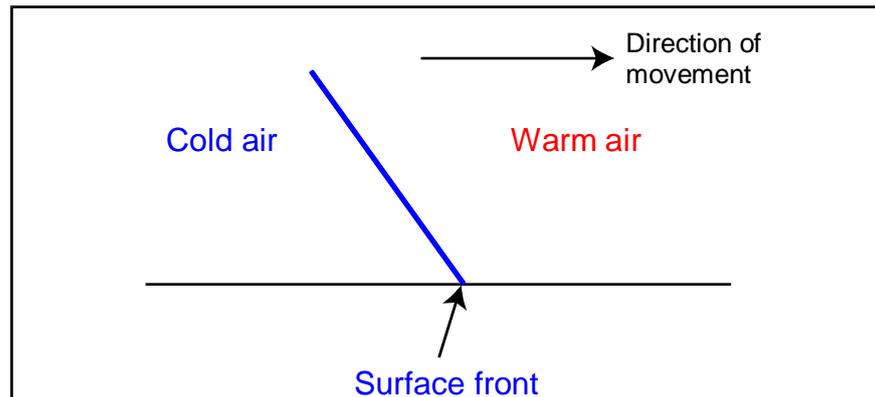
Similarly, warm fronts have semi-circles drawn in the direction of movement – this warm front too would be moving towards the northeast. A simple way to remember the difference is to think of the triangles on the cold front as icicles, and the semi-circles on the warm front as the sun on the horizon, bringing warmer weather.



## 8.1 Cold fronts

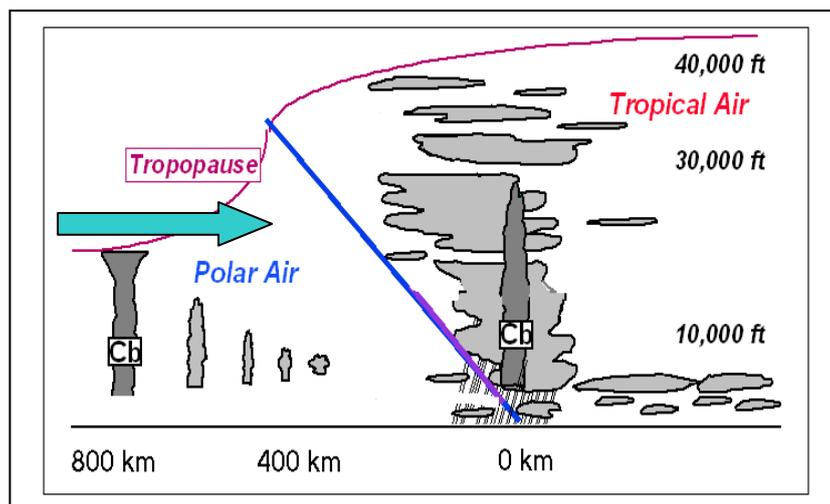
On a cold front the cold polar air undercuts the warmer tropical air (usually tropical maritime). See diagram below.

This causes the ascent and cooling of air on the front resulting in thick cloud layers and precipitation. A cold front can be an active feature with heavy rain and strong winds or weak with little or no rain.



*Diagrammatic cross-section through a cold front*

A more detailed cross section through a cold front is given below showing the cloud and dimensions.



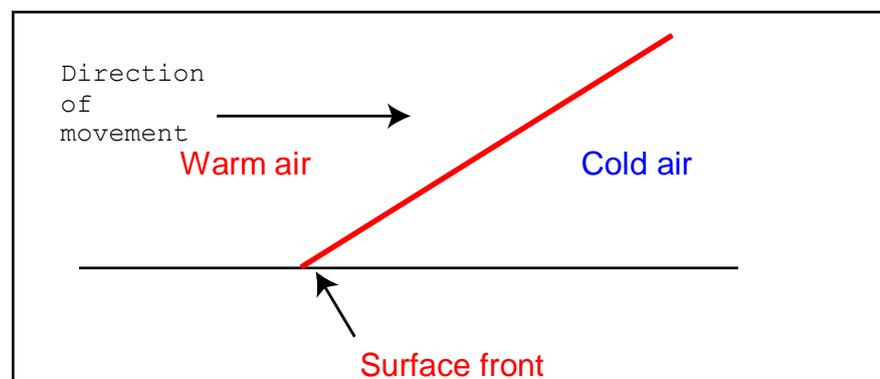
*Vertical cross section through a cold front.*

Potential hazards associated with a cold front:

- THUNDERSTORMS AND HEAVY RAIN
  - Lightning and heavy rain from embedded cumulonimbus (Cb) on an active cold front can lead to a risk of flooding/landslides. Salt wash-off is a high probability.
- STRONG WINDS
  - Strong winds are possible due to down draughts from any Cb. Perhaps gusty, squally winds behind the front.
- SNOW
  - Rain may turn to sleet then snow during the passage of a cold front. The rain may also turn to snow if the front is associated with heavy and prolonged rainfall.
- BEHIND A COLD FRONT
  - Rapid clearance of front (cloud) could result in RST falling quickly.
  - Possible wash-off on front or showers following front giving ice hazard.

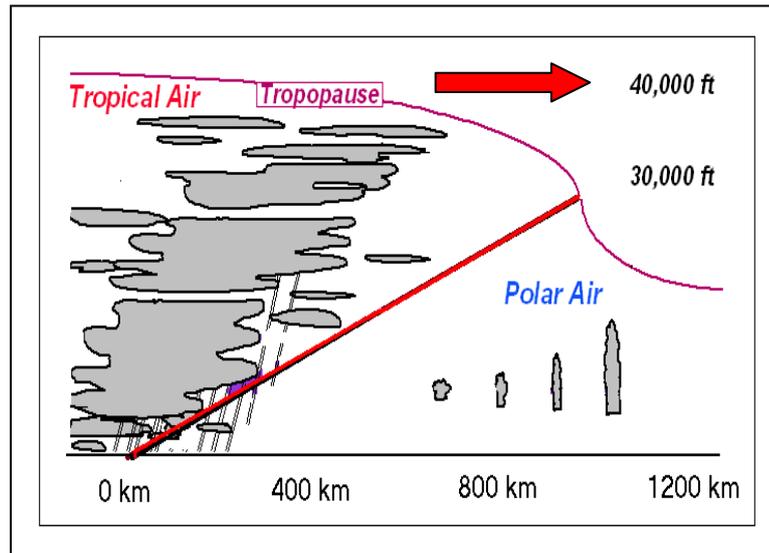
## 8.2 Warm Fronts

A warm front is where warm air is overriding cold air so that at the surface, warm air replaces cold air. See fig. 2.



**Figure 2.** Diagrammatic cross-section through a warm front

A more detailed cross section through a cold front is given below showing the cloud and dimensions.



*Vertical cross-section of a warm front*

Potential hazards associated with a warm front:

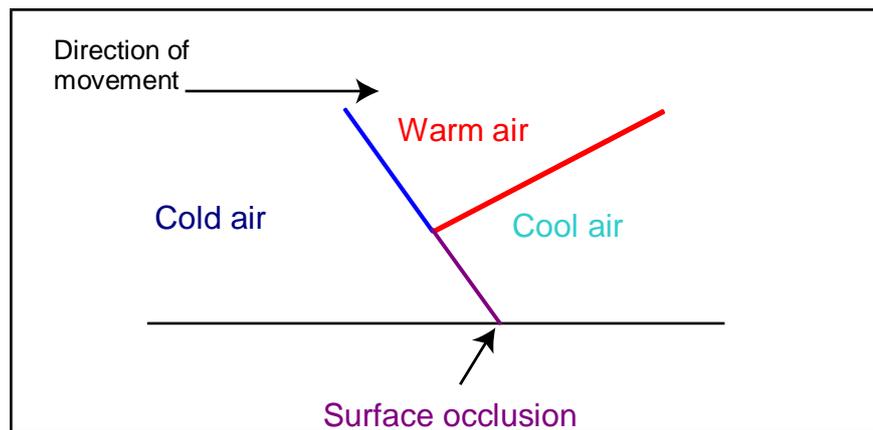
- SNOW
  - Snow may occur ahead of the front as precipitation falls through cold air. On most occasions it will turn to rain as warmer air pushes across the area.
- FREEZING RAIN
  - On very rare occasions there is a risk of freezing rain in the cold air ahead of the front producing a glaze on any surface it falls.
- HEAVY RAIN
  - An active warm front may produce prolonged and heavy rainfall with a risk of flooding.
- BEHIND A WARM FRONT
  - Widespread fog may well develop as warm air passes over a cold surface.
- RAPID THAW
  - If there is lying snow the introduction of warmer air may cause it to thaw, giving a risk of flooding.

### 8.3 Occluded Fronts

An occluded front is symbolised as on a weather map.



These are slightly more complex than cold or warm fronts. The word 'occluded' means 'hidden' and an occlusion occurs when the cold front 'catches up' with the warm front, the warm air is lifted up from the surface, and therefore 'hidden'. An occlusion can be thought of as having the characteristics of both warm and cold fronts. They can also be responsible for very heavy rain or snow events



*Diagrammatic cross-section through an occlusion*

Potential hazards associated with an occlusion:

- HEAVY RAIN/SNOW
  - The rain intensity may be heavy enough that it cools the air and turns to snow. If the air is cold enough behind the front then any precipitation may be of snow. The amount of rain may be enough to cause flooding.

## 8.4 Warm front

- Cloud: Increasing amounts of upper cloud, thickening and lowering with approach of front. Leading edge of upper cloud about 800 km ahead of surface front.
- Weather: Slight rain approximately 200–400 km ahead of surface front becomes moderate close to surface front, ceasing after passage. Scattered outbreaks of slight rain or drizzle may occur in warm sector.
- Temperature: May rise on passage of front, but not necessarily as rain depresses temperature.

## 8.5 Cold front

- Cloud: Thick layers of stratiform cloud. Some active cold fronts have occasional embedded cumulonimbus, and some are composed principally of convective cloud, though this tends to be more a feature of cold fronts at lower latitudes than the UK. Cloud becoming convective and well-broken behind front
- Weather: A fairly narrow band of rain around the surface frontal position, some heavy, especially on the front. Risk of hail and thunder if cumulonimbus is present.
- Temperature: Usually falls, but may rise due to the suns heating in clearer air behind front.