



Weather Basics

Unit 1

The basics about weather, pressure systems and fronts

Changes in our climate are difficult to observe as it is a long term process, which lasts over the span of a lifetime or even generations. An unusually rainy, cool spring or a heat wave in summer does not mean that the climate is changing. What we observe everyday are weather phenomena.

The weather is observed world-wide in a dense network of meteorological stations. If average weather data change over decades we call this a climate change. In this unit we have a look at weather parameters. An important one is the pressure, as the sequence of high and low pressure systems has a strong influence on our weather. We explain how these pressure systems form, how fronts are generated and the type of weather they usually cause.



1. Weather indicator
© optikerteam.de



Part 1: Weather and climate

What is weather?

Its definition and how it is different to climate

Weather is the instantaneous state of the atmosphere, or the sequence of the states of the atmosphere as time passes. The behaviour of the atmosphere at a given place can be described by a number of different variables which characterise the physical state of the air, such as its temperature, pressure, water content, motion, etc.

There isn't a generally accepted definition of climate. Climate is usually defined as all the states of the atmosphere seen at a place over many years. The time period is not given but it should be 'sufficiently long'. This means we can choose the time period we look at. As a result, climate doesn't have a very scientific definition.



1. Source: FreeStockPhotos.



2. Source: FreeStockPhotos .



3. Source: freeimages.co.uk

Since weather is the sequence of the states of the atmosphere, it is tempting to define a "true" climate in terms of a limit as time approaches infinity, i.e. it the the total ensemble of all the states of the atmosphere which have ever occurred in the past. This is not only practically impossible but would not let us investigate how climate has changed over time.





4. Source: NatureWallpaper.net

The internationally accepted convention, as recommended by the World Meteorological Organization (WMO), is that a 30-year period is a basic climatic time scale. Climate statistics are, therefore, calculated for the consecutive 30-year time periods 1901-1930, 1931-1960 and 1961-90. These periods are known as climatological standard normals.



5. Source: www.edenpics.com

Because the climate is changing rapidly nowadays, climate characteristics are sometimes re-calculated every 10 years for the period of the recent 30 years, i.e. 1961 - 1990, 1971 - 2000, ... although the next official period would be 1991 - 2020. These fixed time intervals allow world-wide comparison of climatological events. For special purposes, however, other climatic time scales are sometimes used.



6. Source: Christoph Grandt's Homepage.

For example, the suitable climatic time scales to investigate the cultivation of a new plant or to look at glacial chronography are completely different. This means that the length of the meteorological time series we use to determine the climatic characteristics is always determined by the question we are trying to answer.



How do we measure meteorological variables?

Meteorological variables change not only over time, but also in space. Therefore a single measurement site (station) only records the weather in that particular location. To determine the weather over a large area, weather stations are organised in networks. The density of the weather stations in a particular network depends on:

- the purpose of the observations (weather conditions or climate)
- the weather elements to be measured (many more stations are needed to get good rainfall data than for the air pressure)
- other, non meteorological reasons (cost, high mountains, etc.).

To ensure that the observations at each station can be compared to each other, the instruments must be located away from the immediate influence of trees and buildings, steep slopes, cliffs or hollows. A climatological station should be located at a place which provides unchanged exposure over a long period and continued operation for at least ten years.



7. A Stevenson screen. This houses maximum and minimum and dry and wet bulb thermometers. Source: Samoa Meteorology Division.



8. An automatic weather station. This station is equipped with a solar panel and records temperature, water vapour, wind direction, wind speed and air pressure. The data are transferred by satellite. Other measurement equipment at the station provides local weather information for local aviation. Source: AWI.

These surface measurement networks provide so called '*in situ*' measurement data. 71% of the Earth's surface is covered by oceans and large parts of the continents are covered by rainforests, ice, deserts and high mountains which make regular surface observations difficult. To overcome this problem, remote sensing techniques are now used which involve measurements of meteorological variables from space using instruments aboard satellites and using radar.

Although the number of people observing the weather is falling, the number of automated weather stations (AWS) are increasing. These use technological advances to measure meteorological variables over short time intervals (the usual measurement frequency at an AWS is seconds to minutes, compared to hourly for a manual station). As a result, we now have much more data available both for weather forecasting and for climate observation. However, measurement techniques have changed and, in many cases, we no longer measure the same meteorological parameters as in the past (for example the sunshine duration).



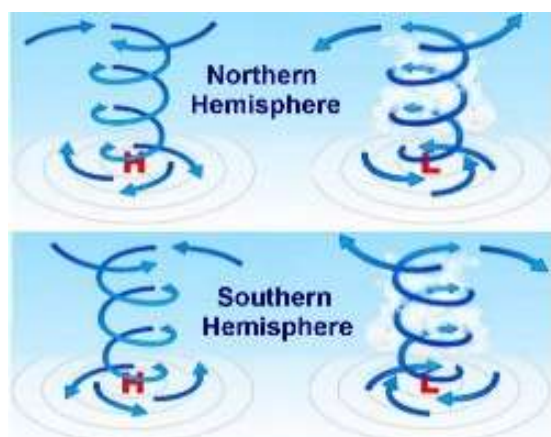
Part 2: Pressure systems

High Pressure Systems, Low Pressure Systems

Air always flows from areas of high pressure to areas of low pressure to try to reduce pressure differences and reach equilibrium. The rotation of the Earth generates a force known as the Coriolis effect and this stops the air moving in a straight line. Rather the winds move in a spiral: inwards and upwards in low pressure systems, downwards and outwards in high pressure systems.



1. Eye of the Storm, Hurricane Elena
© Dreamtime, NASA's Multimedia Partner



2. In cyclones, the winds move anti-clockwise around a low pressure centre in the northern hemisphere. In the southern hemisphere the wind direction is reversed. Figure: volvoceanadventure ©

Low pressure systems – Cyclones

Regions of rising air are called lows, low pressure systems, depressions or cyclones. These are systems of closed isobars (lines of constant pressure) surrounding a region of relatively low pressure. Cloudy conditions, windy weather, rain and snow and unsettled changeable weather often occur in these regions.

A low pressure system develops when relatively warm and moist air rises from the surface of the Earth. Air near the centre of a low pressure system is unstable. As the warm humid air spirals upwards, it cools and clouds form. These may be thick enough to give rain or snow. In these low pressure systems the air spirals inwards at the Earth's surface. If the pressure is very low, these spiralling winds may reach storm or hurricane force. This is why the term cyclone is often loosely applied to storms generated by low pressure systems.



Tropical and midlatitude cyclones

There are **two types of cyclones**, they develop in different ways and have different structures.

Tropical cyclones

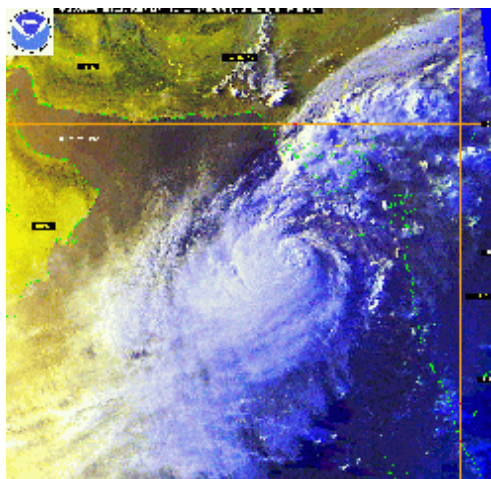


Tropical cyclones develop over the ocean in warm and moist tropical air masses at latitudes between 20° and 25° north or south of the equator. They are characterised by very low air pressure at their centre and are small in size, just 100 to 1500 km in diameter. This means that there is a very strong pressure gradient across the cyclone and this can lead to very strong hurricane strength winds.

Wind speeds in hurricanes are over 33 m s⁻¹ (120 km h⁻¹), with a record of 104 m s⁻¹ during hurricane Allen in 1980, that's a wind speed of 375 km h⁻¹!

Tropical cyclones gain their energy from the latent heat of evaporation of water from the ocean. They therefore gradually dissipate when they move across land and lose their energy source.

Please read also about tropical cyclones, hurricanes and expectations for the future in the ACCENT school magazine: **[special edition on hurricanes](#)**

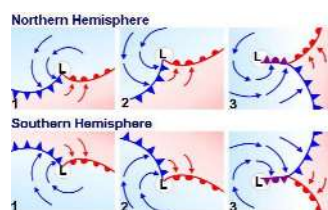


3. left: Tropical cyclone Graham in the Pacific Ocean. Source: www.gowilmington.com

4. right: NOAA satellite imagery showing strong Tropical Cyclone 03A moving northeast across the Arabian Sea toward landfall in northwest India. source: weather.ou.edu



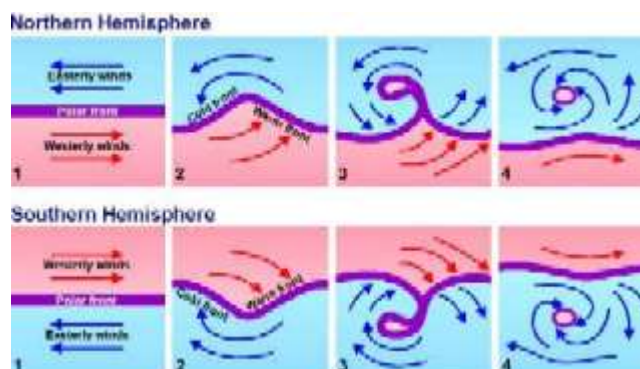
Midlatitude cyclones



5. left: The way weather fronts develop around a low pressure system.

6. right: The development of midlatitude cyclones north of the Equator (top) and south of the Equator (bottom).

Source: volvoceanadventure ©



Midlatitude cyclones are powered by large temperature differences in the atmosphere. They develop when air masses of different temperatures meet. The air masses do not mix together, rather the warmer air is forced up over the colder air. This causes a front to form (see also chapter 3).

Midlatitude cyclones are much larger than tropical cyclones. They have diameters of between 1000 and 4000 km and they also have lower wind speeds.

The maximum wind speed in a midlatitude cyclone is around 30 m s^{-1} (110 km h^{-1}).

High pressure systems - anticyclones

Regions of sinking air are called highs, high pressure regions or anticyclones. They are usually accompanied by constant, good or fair weather. High pressure systems tend to cover a greater area than lows, they move more slowly and have a longer atmospheric lifetime.

Anticyclones are produced by a large mass of descending air. As the air sinks, it warms up, the atmospheric pressure increases and the relative humidity decreases. This causes water droplets in the air to evaporate and leads to dry weather.



7. In anticyclones the winds move clockwise around a high pressure centre in the northern hemisphere. In the southern hemisphere the wind direction is reversed (see Figure 2).

Source: www.geologia.com



The warm, sinking air makes the atmosphere stable, so warm air at the surface of the Earth cannot rise far before it stops. This prevents tall clouds from forming. For this reason anticyclones usually lead to warm, dry weather and cloudless skies in the summer and cold, dry weather in the winter. These conditions usually lasts for several days or even weeks.

Anticyclones are much larger than cyclones and may block the path of depressions. This slows down the arrival of bad weather or forces it to travel elsewhere. An anticyclone that persists for a long period is known as a 'blocking high' and these lead to long hot spells and even droughts during the summer and extremely cold winters.



8. Anticyclone conditions over France and much of western Europe. The skies are cloudless and the weather is fair. Source: Passion Meteo, photograph taken from space by a NOAA satellite.

Part 3: Fronts

A weather front is defined as the boundary between two air masses of different temperatures and densities. When two air masses meet, the warmer air rises above the cooler denser air. The transition region between the two air masses is known as a front.

Weather fronts generally travel from west to east. Their direction can, however, be affected by geographic features such as mountains and large bodies of water, particularly if they form in the lower levels of the atmosphere.

Fronts are always accompanied by clouds and, very often, also by rain. When a weather front passes over an area, changes in wind speed and direction, atmospheric pressure and the moisture content of the air are also seen.

There are four types of fronts: cold fronts, warm fronts, occluded fronts and stationary fronts. The type of front depends both on the direction in which the air mass is moving and on the characteristics of the air mass.

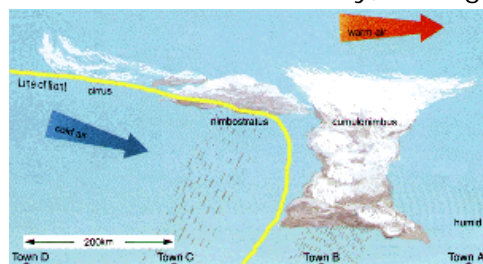


1. Front over the Findon coast. Source: http://www.abdn.ac.uk/physics/meteo/metoh12_files/frame.htm



Cold fronts

Cold fronts occur when a colder air mass replaces a warmer one. At a cold front, the cold air is behind the warm air. Because the cold air is more dense, it pushes the warm air out of its way, forcing the warm air to rise into the atmosphere.

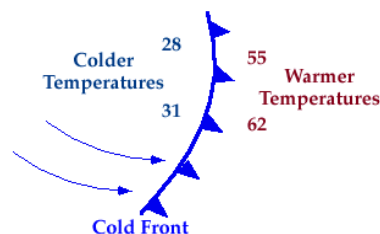


2. A cold front.

<http://www.ckkc.co.uk/html/stories/metrology.html>

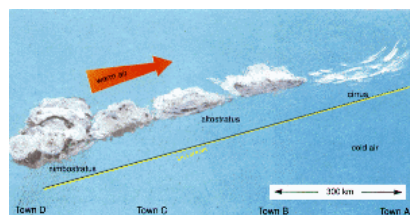
As the warm air rises, it cools, the water vapour in the air condenses out and clouds start to form. The warm air is forced to rise rapidly due to strong undercutting by the cold air. This causes towering clouds to form and thunderstorms. Rain associated with cold fronts is usually heavy but short lived and only affects a small distance (about 50 to 70 km). The air behind a cold front is noticeably colder and drier than the air ahead of it. When the cold front passes through, temperatures can drop more than 15 °C within the first hour.

3. Image right: A cold front is represented by a solid blue line with triangles along the front pointing towards the warmer air and in the direction of movement (temperature is given in Fahrenheit in the figure.) Source: University of Illinois [http://ww2010.atmos.uiuc.edu/\(Gh\)/home.rxml](http://ww2010.atmos.uiuc.edu/(Gh)/home.rxml)



Warm fronts

Warm fronts occur when a warm air mass approaches a colder one. The warmer air lifts up and over the colder air. Warm fronts generally move more slowly than cold fronts, gently settling over the cold air and moving it out of the way. Rain associated with warm fronts is less heavy but more extensive (300 to 400 km) than rain generated at cold fronts.



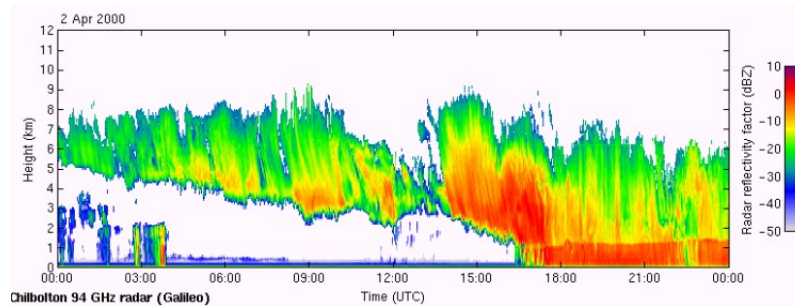
4. A warm front.

<http://www.ckkc.co.uk/html/stories/metrology.html>

The air behind a warm front is warmer and more moist than the air ahead of it. Warm fronts generate light rain or snow which can last from a few hours to several days. When a warm front passes through, the air becomes noticeably warmer and more humid than it was before.

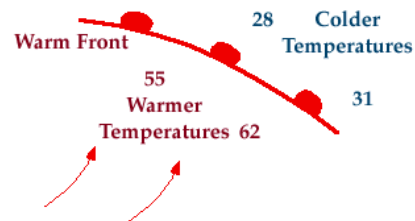
The first signs of the warm front are the cirrus clouds, followed by the cirrostratus, altostratus, nimbostratus and stratocumulus types of clouds. The cirrus clouds can be up to 1000 km away from the position of the front at the ground. These clouds are all generally horizontal in structure because the front slopes gently into the air. Clouds associated with cold fronts are mostly vertical in structure because the front rises quickly.





5. Radar image of warm front clouds. Source: http://www.abdn.ac.uk/physics/meteo/metoh12_files/frame.htm.

6. Picture on the left: A warm front is represented by a solid red line with semicircles pointing towards the colder air and in the direction of movement (temperature is given in Fahrenheit on the figure.)



Source: University of Illinois
[http://ww2010.atmos.uiuc.edu/\(Gh\)/home.rxml](http://ww2010.atmos.uiuc.edu/(Gh)/home.rxml)

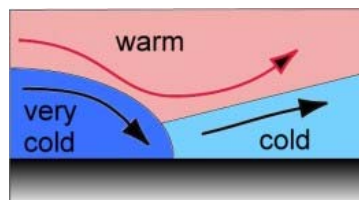
Occluded front

Occluded fronts occur when cold, warm and cool air come together. There are two main types, cold and warm occluded fronts. The difference depends on the relative states of the cold airmasses behind and in front of the warm air.

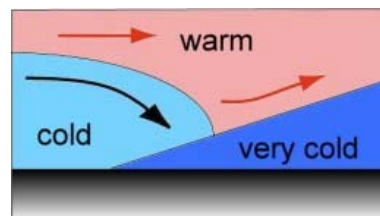
Cold occluded fronts occur when a very cold front overtakes a warm front. The cold front lifts the warm front up in to the air (both the warm air above and the cold air underneath) and the cold front creeps underneath. At the beginning the weather is similar to that seen when a warm front passes, but it then changes into typical cold front weather and heavy rain falls.

Warm occluded fronts occur when a cold front overtakes a warm front overlying a very cold front. Here the cold front and the warm front both move up and over the very cold front which stays close to the ground. The weather is similar to that when a warm front passes.

Stationary fronts form at the boundary between warm and cold air when neither airmass is moving forward. They have similar characteristics to warm fronts but are less active.



8. A cold occluded front.
 Image: Elmar Uherek.



9. A warm occluded front.
 Image: Elmar Uherek.

