



Atmosphere, Climate & Environment

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WEATHER & CLIMATE

Teaching Pack for Key Stage 3

Sue Hare

2001



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Introductory Notes For Teachers

This teachers' resource pack on Weather and Climate is designed for use with Key Stage 3 pupils, primarily within the geography curriculum.

The resource consists of 7 sections on Weather and 2 sections on Climate. Each section is followed by a number of exercises for pupils. These can be used by the teacher as follow up work during the lesson or for homework. It is not necessarily intended that all exercises be completed, but to be used by the teacher as time (and facilities) allow.

It is hoped that this Teaching Pack will be useful and informative. If you have any criticisms, comments or ideas on how the pack could be improved, we would be pleased to hear from you. Our contact details are below:

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Section 1: Weather & Climate

1.1 What is the difference between weather and climate?

WEATHER describes conditions in the atmosphere at any time or short period of time. Weather conditions can change suddenly. Today may be warm and sunny, tomorrow may be cool and cloudy. Weather conditions include rain, snow, sleet, hail, fog, mist, sunshine, wind, temperature and thunderstorms.

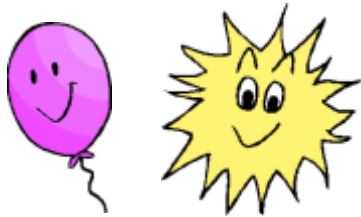
CLIMATE describes surface and atmospheric conditions over a longer time period or over a large geographical area. The climate of an area is concerned with the **AVERAGE** weather conditions which are taken over a year or more. Climate changes slowly, usually over decades, centuries and thousands of years. The Earth has many climate regions; Britain is in the Temperate Climate Belt, with winters that are not too cold and summers that are not too hot.

1.2 The effect of weather on our lives

The weather affects us in many different ways. For example, it affects our moods, what we wear, our leisure activities and our mode of travel. To highlight the



importance of the effect that weather has on our lives, simple



observation and recording work can be

done. Weather conditions can be recorded over a period of time and at the same time

the effects the weather has on factors

such as our mood can also be noted.

EXERCISES

1. If you have computer access to the Internet (world wide web), try doing a search to find other definitions of Weather and Climate. You could try using key search words such as weather, climate, definition.

If you do not have access to the Internet, look up weather and climate in a dictionary.

Copy the definitions that you have found on the Internet or in a dictionary below.

Internet Address:

http:// _____

Weather.....
.....
.....
.....
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Climate.....
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2. Which is the correct word in the following sentences, WEATHER or CLIMATE? Fill in the spaces.



I hope the is sunny tomorrow.

Britain is in the Temperate Belt.

Global warming is a change in the world's

Last month the was so wet!

The TV forecast is on after the news.

Satellite photographs help us to predict tomorrow's

3. Collect and cut out newspaper headings which show how the weather affects our lives.



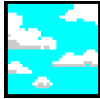



**RAIN STOPS
PLAY**

**PARK FIRES
BLAZE IN
SCORCHING SUN**

4. Think of some songs (e.g. pop. music, nursery rhymes) which relate to the weather. Write a couple of lines from each song that you have thought of.
5. Record the general weather conditions every day for one week on the chart below. Try and fill in the chart at around the same time each day (e.g. lunchtime). Tick the weather conditions for each day or write in the space provided.

My Weather Chart:

Week beginning Sunday (date) (month) (year)

<u>Day</u>	Sunshine 	Rain 	Cloud 	Wind 	Snow, mist or fog 	Temperature 
Sunday						
Monday						
Tuesday						
Wednesday						
Thursday						
Friday						
Saturday						

6. Did the weather affect your life this week? Write a few details about whether or not your activities were affected by the weather for the week that you filled in the weather chart above. For example did rain stop football or did a boiling hot day make you decide to go swimming?



Section 2: Measuring Weather

2.1 Why do we measure the weather?

Weather can be described using terms such as wet or fine, warm or cold, windy or calm, so why is there a need to measure the weather? For most people, a description of the weather is adequate but for many businesses more detailed and accurate measurements are required. The science of studying weather is called **meteorology**. Weather scientists or meteorologists measure temperature, rainfall, pressure, humidity, sunshine and cloudiness and they make predictions and forecasts about what the weather will do in the future. This is important for giving people advance notice of severe weather such as floods and hurricanes.



2.2 Measuring temperature



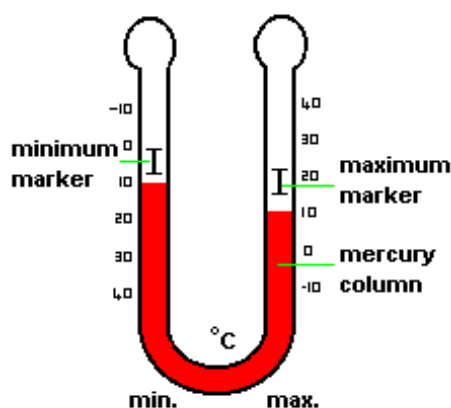
Temperature, or the hotness or coldness of a substance, is measured with a thermometer. A thermometer is usually made from a tube of hollow glass with a bulb shaped base. The bulb is filled with a liquid, usually mercury which expands as temperatures rise and falls as temperatures drop. A scale on the thermometer can be read to find out what the temperature is. Celsius ($^{\circ}\text{C}$) is the most common scale for thermometers.

To make sure that the thermometer is measuring the temperature of the surrounding air, it must be shaded from direct sunlight and should have sufficient air circulating around it. The **Stevenson Screen** was designed by Thomas Stevenson (father of Robert Louis Stevenson) to create an enclosure with as near as possible temperature as the air outside.

The Stevenson Screen is a wooden box with slatted sides, a sloping roof and legs to keep the screen off the ground. It is painted white to reflect the sun and it has opening doors which can be locked for security.

Figure 2.1 shows a **maximum-minimum** thermometer. This type of thermometer measures both the highest (maximum) and lowest (minimum) temperature over a period of time, usually one day (24 hours).

Figure 2.1: A maximum-minimum thermometer



2.3 Recording temperature with a maximum-minimum thermometer

Figure 2.1 shows that a maximum-minimum thermometer is U-shaped. There are two markers one for the maximum temperature and one for the minimum. The mercury in the tube pushes the markers as temperatures go up or down.

The maximum-minimum thermometer should be placed in a Stevenson screen shelter for the most accurate recording of temperature.

Instructions

1. Around 1200 hours (mid-day), set the thermometer by using a small magnet to drag the markers so that they are both on top of the mercury column. Hang the thermometer in the shelter.
2. At mid-day the following day record the maximum and minimum temperature. The maximum temperature is read at the level of the bottom of the maximum marker, the minimum temperature is read at the bottom of the minimum marker.
3. Record the present temperature by reading at the top of the mercury column on either side (they read the same on the maximum or the minimum side).
4. Reset the indicators with the magnet so that the markers are on top of the mercury column.

5. Repeat instructions 2 to 4 each day for the next week.
6. Record all of your results in table form (*e.g.* Figure 2.2).

Figure 2 .2 Sample recording chart.

Day	Maximum temperature °C	Minimum temperature °C	Temperature at time of reading (mid-day)
Sunday			
Monday			
Tuesday			
Wednesday			
Thursday			
Friday			
Saturday			

2.4 Temperature readings

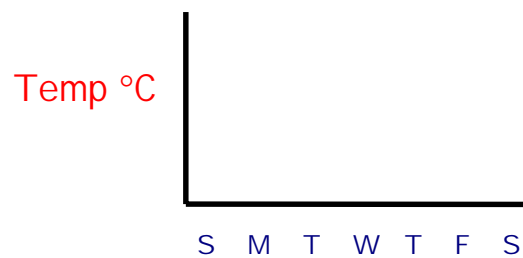
The temperature of air measured using a maximum-minimum thermometer can be used to show the difference in temperature over a period of time, usually one day. The difference between the daily maximum and the daily minimum is called the **diurnal range**. Figure 2.1 shows a maximum temperature of 15°C and a minimum temperature of 8°C. The diurnal range for this example is 7°C ($15 - 8 = 7$).

The difference between the daily maximum and the daily minimum temperature is the diurnal range.

EXERCISES

1. If you have access to a computer with a graphics package, try and produce two graphs, one of the maximum temperatures and one of the minimum temperatures, that you recorded in Figure 2.2.

Alternatively, use graph paper to plot your results.

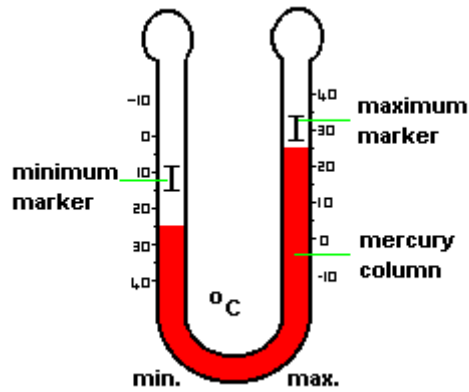


2. What was the diurnal range (daily range) for each of the days that you recorded the temperatures in Figure 2.2? Fill in the table below.

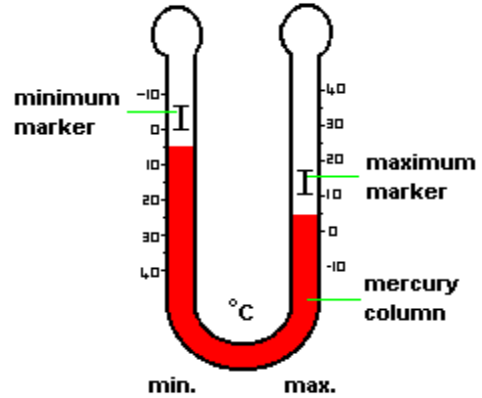
	Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
Diurnal range °C							

3. Study the maximum-minimum thermometers below. Imagine that each thermometer has been measuring the temperature of the air at your school at different times of the year.

Max/Min Thermometer A







Max/Min Thermometer B



Fill in the correct temperatures for both thermometers:

	Thermometer A	Thermometer B
Present temperature		
Maximum temperature		
Minimum temperature		

Tick which season you think thermometers A & B represent?

Season	Thermometer A	Thermometer B
 SPRING		
 SUMMER		
 AUTUMN		
 WINTER		

Section 3: Movement of Air

3.1 Wind speed



Wind is moving air. Wind can be measured by its speed and the direction from which it has come. The speed of the wind can be measured using a weather instrument called an **anemometer**. The speed can be recorded in many different units, including for example:

- miles per hour;
- kilometres per hour;
- metres per second;
- knots;
- the Beaufort Scale.

3.2 The Beaufort Scale

The Beaufort scale describes various conditions associated with different wind strengths. These descriptions help us to imagine how windy it is at a particular time. The Beaufort scale measures wind speed on a scale between Force 0 (no wind) and Force 12 (hurricane).

Force	Description	Conditions	Wind speed (mph)
0	Calm	Smoke rises vertically	0
1	Light air	Smoke drifts	1-3
2	Light breeze	Leaves rustle; vane moved by wind	4-7
3	Gentle breeze	Leaves in constant motion; light flag extended	8-12
4	Moderate breeze	Raises dust and loose paper; small branches move	13-18
5	Fresh breeze	Small trees sway; crested wavelets on inland water	19-24
6	Strong breeze	Large branches in motion; whistling in telegraph	25-31
7	Moderate gale	Whole trees in motion	32-38
8	Gale	Breaks twigs off trees; impedes walking	39-46
9	Strong gale	Slight structural damage to buildings	47-54
10	Whole gale	Large branches broken: some trees uprooted	55-63
11	Storm	Large trees uprooted	64-72
12	Hurricane	Widespread damage occurs	73+

3.3 Wind direction

The direction of the wind is expressed as the point on the compass from where the wind is blowing. If a wind is blowing from the south, it is travelling northwards but is called a



southerly wind. Knowledge of wind direction is important for many people and activities. For example aircraft take off from the end of the runway which is going into the wind for extra

lift at take-off, and wind direction is of course very important for leisure activities such as yachting. Wind direction can be measured in many different ways; using a weather vane or simply holding a light object such as a flag or ribbon.

3.4 Air temperature and wind

When the sun heats the ground on a warm sunny day, heat from the surface warms the air just above it. This causes the air to expand and rise. When air cools it contracts and sinks. The movement of air upwards or downwards by temperature changes causes winds known as vertical winds or **convection currents**. Winds that develop through heating processes sometimes move horizontally; these are known as **advection** winds, for example a sea breeze.

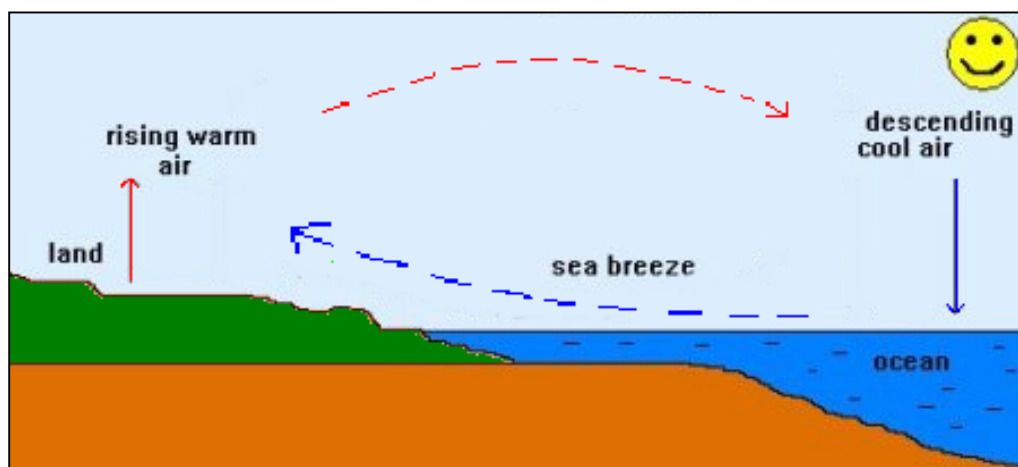
3.5 Pressure and wind

An instrument called a **barometer** is used to measure the pressure of air. Although air is very light, because the atmosphere is so thick (many kilometres in altitude above the Earth's surface), air exerts a force or pressure. When air is cooled it sinks towards the ground, the pressure increases and a **high pressure** is measured. When the air warms up it rises, the pressure is reduced and **low pressure** is measured.

Sinking air which leads to a high-pressure system is called an **anticyclone**. When there is high pressure over an area, the winds are usually gentle. The opposite happens for a low-pressure system, also known as a **cyclone** or a **depression**. Stronger wind speeds are usually experienced with low pressures compared to the gentle wind speeds often associated with high-pressure systems.

3.6 Sea breezes

Land near the sea warms up quicker than the surface of the sea. This makes the air above the land warmer than the air above the sea. The warm air above the land rises, this is called **convection**. As the warm air rises, cooler air is drawn in from the sea. This horizontal wind or **advection** is known as a sea breeze which provides a cooling influence at seaside locations on a hot sunny day. The full sea breeze circulation is shown in the diagram below.





At night however, the land cools faster than the sea. This may cause a land breeze which is the opposite of a sea breeze. Warm air from the surface of the water rises and draws in cooler air from the land surface.

EXERCISES

1. You will need a calculator for this exercise. Below is a table of wind speeds for seven UK cities. The wind speeds were measured in knots at midday during January 1999.

Date Jan '99	Birmingham	Cardiff	Edinburgh	London	Manchester	Norwich	Plymouth
1st	15	20	10	10	20	10	25
2nd	15	20	15	15	20	15	25
3rd	20	10	15	25	5	20	15
4th	15	20	30	15	15	20	15
5th	15	15	10	15	15	15	30
6th	10	10	10	15	5	10	20
7th	10	10	2.5	10	5	10	25
8th	5	5	5	10	0	15	20
9th	10	5	2.5	5	2.5	10	10
10th	5	10	5	5	5	5	10
11th	5	5	2.5	5	5	10	10
12th	20	5	10	15	5	20	15
13th	10	10	10	10	10	10	20
14th	10	15	15	10	10	25	10
15th	20	20	25	20	20	25	30
16th	15	10	20	10	20	15	15
17th	15	10	15	10	15	15	20
18th	15	15	15	15	15	15	30
19th	20	15	15	20	15	20	25
20th	15	10	5	5	15	15	15
21st	5	0	15	2.5	5	5	0
22nd	5	0	15	2.5	5	2.5	0
23rd	10	15	10	10	10	10	20
24th	10	10	20	5	10	5	15
25th	15	20	2.5	15	5	25	20
26th	10	15	5	10	10	20	20
27th	5	2.5	5	5	5	15	10
28th	20	5	5	10	15	25	15
29th	5	0	0	5	2.5	5	5
30th	5	0	10	10	2.5	10	0
31st	5	0	5	5	2.5	10	5

Using a calculator, work out the average wind speed for each city and fill in the table below with your answers.

City 	<i>Average Wind Speed (knots)</i> 
Birmingham	360 (total wind speeds for January) ÷ 31 (days) = 11.6
Cardiff	
Edinburgh	
London	
Manchester	
Norwich	
Plymouth	

Which city was the windiest during January 1999?

Which city was the least windy during January 1999?

Look at the table of wind speeds for the seven UK cities.

Which date in January 1999 was the calmest for all cities (where all cities recorded a wind speed of less than 10 knots)? _____



Which date in January 1999 was the windiest for all cities (where all cities recorded a wind speed of 20 knots or more)? _____

2. To compare the wind speeds for January 1999 to the Beaufort Scale, the wind speeds need to be in the same units of measurement. To change a wind speed from knots to miles per hour, the wind speed in knots is multiplied by 1.15.

To convert a wind speed from knots to miles per hour, multiply by 1.15

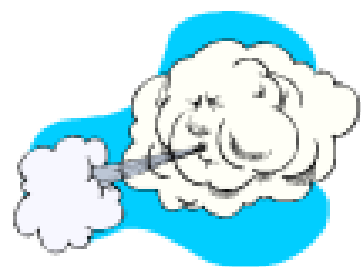
e.g. Birmingham mean wind speed (knots) = 11.6
Birmingham mean wind speed in miles per hour (mph)
is $11.6 \times 1.15 = 13.3$


Use a calculator and the average wind speed figures from Exercise 1 to fill in the table below:

City 	<i>Mean Wind Speed (miles per hour)</i> 
Birmingham	11.6 x 1.15 = 13.3 (mph)
Cardiff	
Edinburgh	
London	
Manchester	
Norwich	
Plymouth	

3. Refer to the Beaufort scale.

Fill in the following table with the wind speed data for the seven cities that you have converted to miles per hour in Exercise 2. Also fill in details of the Beaufort scale for each city.



City 	Average wind speed (miles per hour) January 1999	Beaufort Scale Force	Beaufort Scale description
Birmingham	13.3	4	moderate breeze
Cardiff			
Edinburgh			
London			
Manchester			
Norwich			
Plymouth			

4. Read the text below and fill in the missing words in the correct places using the words underneath. Use each word once only.

Wind can be described as the _____ of air. A weather instrument called an anemometer measures wind _____ and a weather vane can be used to measure wind _____.

wind is blowing from the south it is called a _____ wind. Such a wind will be blowing towards the north. When air is moving upwards or downwards, it is know as a _____ current. An example of an advection wind is a _____ breeze.

sea

direction

convection

speed

movement

southerly

Section 4: Moisture in Air

4.1 The water cycle



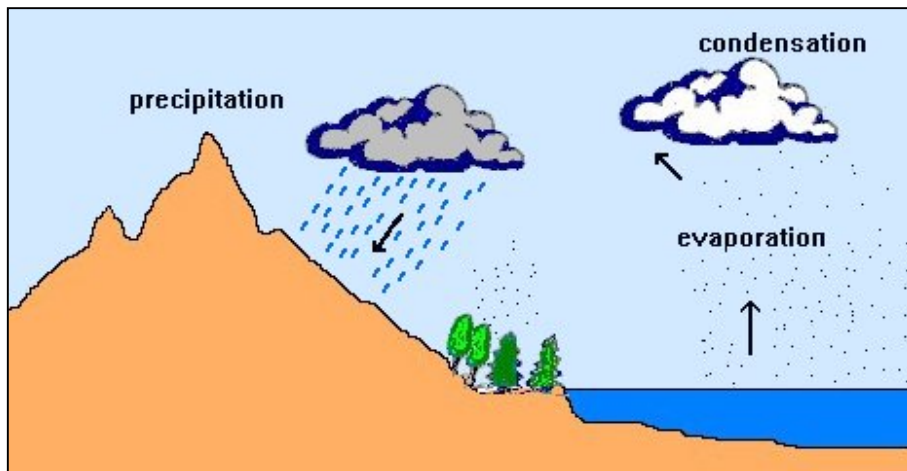
Water vapour - water in the form of a gas - is ever present in the atmosphere. The **water cycle** is the movement of moisture around the Earth and atmosphere. Water vapour enters the atmosphere by

evaporation from areas of water (for example puddles, rivers, lakes and seas) and from evapotranspiration from plants and trees. When warm air rises it can hold on to moisture for a while but when the air cools, it becomes saturated and **condenses** into



water droplets. [Colder air cannot hold as much water vapour as warmer air.] Clouds are made up of water droplets and they return water back to the surface of the Earth as **precipitation** (rain, snow, hail *etc*). The water cycle is therefore a pattern of evaporation, condensation and precipitation. The diagram below shows the water cycle.

The Water Cycle



4.2 Evaporation

Evaporation of water from the surface of the Earth forms one part of the water cycle. Evaporation is the movement of water from land or surface water (e.g. sea, rivers, ponds) into the air. You have probably noticed the effect of evaporation on the beach on a hot, sunny day when wet sand dries out. Water from the wet sand evaporates into the air. How much evaporation occurs, depends on several conditions including:



- **temperature** - evaporation increases as temperatures rise (an increase of 10°C approximately doubles the rate of evaporation);
- **humidity** - dry air 'picks up' water vapour much more than humid moist air.

- **wind** - if there is some wind, the air is usually kept dry and evaporation is more likely. When the air is very still, air usually becomes moist or humid, slowing down further evaporation.

4.3 Condensation

Condensation occurs when water vapour turns back into a liquid. It occurs when the temperature of air is cooled to its dew point (this varies according to the moisture content or humidity of the air). Condensation may be in the form of clouds, fog and mist, dew and frost.



4.4 Rainfall

Clouds are made up of very small water droplets which are suspended in the air. If the air continues to cool, the small droplets will join together to form larger droplets or ice crystals. Eventually the weight of the water drops or ice crystals may be heavy enough to make them fall as **precipitation** (rain, snow, hail or ice).

4.5 Cloud types

There are three main ways in which rising air is cooled to form clouds;

- convection;
- fronts; or
- relief (mountains).

These will be looked at in Section 5. There are however, many types of cloud that can be formed in the sky. Different types of cloud can be described as they are viewed from the ground using the following terms, derived from the Latin words:

<u>DESCRIBING CLOUDS</u>		
Cloud type	Meaning	Example
Cumulus	Heap	Alto cumulus
Stratus	Layer	Strato cumulus
Cirrus	Curl of hair	Cirrostratus
Nimbus	Rain	Cumulonimbus

The examples in the box above show how cloud type names can be combined together to describe typical examples of clouds. Cirrostratus, for example, looks like a layer of wispy thin cloud that makes the sky look hazy.

High Level Clouds

Characteristics: *High level clouds are generally thin and wispy and are usually made up of ice crystals because they are so high above the earth's surface.*

Examples:



- **Cirrus** clouds are thin and wispy. They are usually seen on sunny days as white curly, wispy, feather like clouds, high in the sky.

- **Cirrocumulus** clouds are thin white patches of cloud which may look like waves.



- **Cirrostratus** clouds are very thin layers of whitish cloud which cover the sky. The sun and moon can usually be seen shining through these clouds.

Middle Level Clouds

Characteristics: *Middle clouds may be made up of ice crystals and/or water droplets. They can be associated with light precipitation.*

- **Alto cumulus** clouds are ripple-like clouds which appear like bands in the sky. One part of the cloud may be darker than the rest.

- **Altostratus** clouds cover the sky, appearing bluish or grayish. The light of the sun may shine through but without the halo or 'ring around the sun' effect.

Low Clouds

Characteristics: *Low clouds are mostly made up of water droplets. Some low-level clouds can develop into multi-level clouds.*



- **Stratus** clouds are gray and often cover the sky giving an overcast sky but they can be in patches. They rarely produce any rainfall.
- **Nimbostratus** clouds are very dark gray and blot out sunlight. They usually produce heavy rainfall.

Other types of clouds

There are a variety of clouds which are not classified as high, mid or low level cloud. These include:

- **Fog**, which is cloud at ground level;
- **Vertically developed cumulus** clouds are the fluffy white clouds with definite edges and flat bases. Usually they are fairly restricted in height, but can sometimes extend

upwards to much higher altitudes when they become known as **cumulonimbus** clouds.

These are very large and can extend to 12000

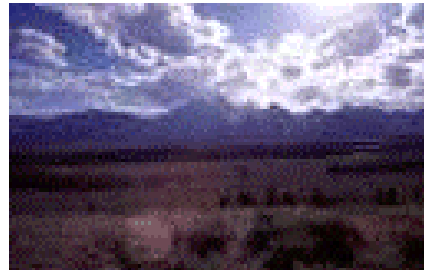
metres or higher. At base level, the cloud is made up of

water droplets but the top of the cloud is made up of ice crystals.

Cumulonimbus produce severe weather such as heavy rain, thunderstorms and tornadoes.



- **Orographic cloud** is cloud which is formed when air is forced to rise over mountains.



- **Vapour trails or contrails** are small clouds which form as vapour from a jet aeroplane condenses into ice crystals. The vapour trails look like lines high in the sky.

EXERCISES

1. Unscramble the following words to determine the names of certain clouds and classify then the cloud as high, medium or low level cloud.

Cloud name + Level of cloud

stoustaltar _____

usstart _____

msntuaribso _____

lmucusu _____

sircur _____

uslumctoal _____

csirtarrosut _____

2. Write true or false after each of the following statements:

The water cycle is the circular movement of water down the plug-hole when you empty the bath.

Condensation means the same as evaporation.

Snow and rain are both types of precipitation.

Clouds are always white and fluffy.

Water vapour enters the atmosphere by evaporation of water surfaces such as lakes and rivers.

Evaporation causes a puddle to dry up quicker if it is a warm day.

Clouds are usually made up of water droplets and sometimes they contain ice crystals.

3. If you have access to the Internet, try and find some pictures of clouds of different types. If you also have access to a printer, print them out and arrange them in a scrapbook style, labelling each cloud type (low, medium or

high level cloud) and the name of the cloud (*e.g.* cirrus, cumulus).

You can start by trying the following websites or use the search facility to find your own:

Spacious Skies

<http://www.fox8wqhp.com/spacious.htm>

Cloud Boutique

<http://vortex.plymouth.edu/clouds.html>

If you do not have access to the Internet, collect some old magazines and find some pictures with clouds on them. Try and identify what types of clouds you have found. Cut the pictures out and arrange them in a scrapbook style, labelling each picture with the cloud type and cloud name that you think they are.

Section 5: Rain

5.1 Introduction



Condensation, as we have seen in Section 4, involves the cooling of air which causes water vapour to turn into water droplets (such as dew, frost and fog). As air is uplifted, it also cools. There are three main ways that air can rise:

- Convection
- Fronts
- Relief (mountain) cooling.

5.2 Convection Rainfall

The most powerful force which causes air to rise and cool is the Sun. When the Sun heats the surface of the Earth, warming of the air above the ground takes place. This warm air rises and cools as it goes higher. At a certain point, condensation will occur and clouds will form. If the air is



humid, the cloud base will be low. The size and shape of convection clouds depends on the humidity of the rising air and the strength of the convection.

Convection clouds are made up of millions of suspended water droplets that have condensed from water vapour. But not all convection clouds release rain. Convection clouds are cumulus clouds which can range from the 'fluffy white cotton wool ball' clouds to the towering cumulonimbus thunder clouds. The fluffy cumulus clouds are known as fair weather clouds. These rarely produce any rainfall. Larger 'cauliflower-like' cumulus clouds may produce light showers, whilst the cumulonimbus clouds can produce heavy downpours and thunderstorms.

Key points of convection rainfall

- Sun shines on land and warms the air above it;
- Warm air rises;
- Warm air can pick up moisture from water sources (seas, lakes etc.);
- Warm air cools as it rises;
- Water vapour condenses to form clouds;
- Rainfall may occur.

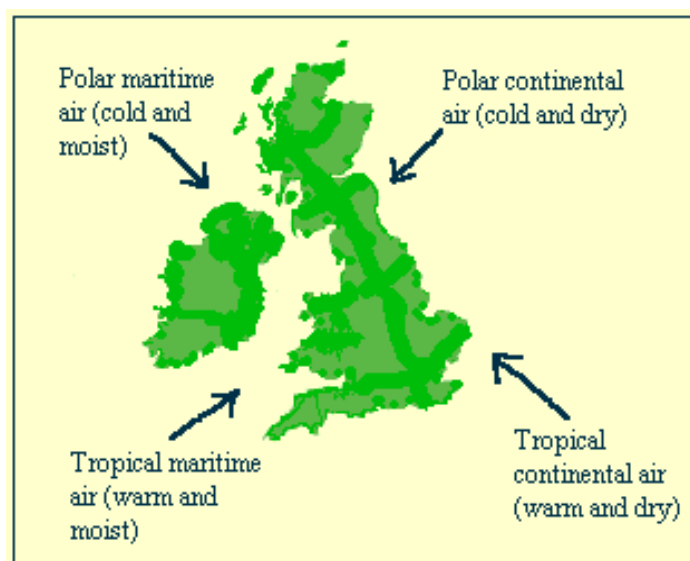
5.3 Frontal Rainfall

When huge air masses come together from different directions, air may be uplifted and cooled if there are differences in the temperature and humidity of the two air masses. They cannot mix immediately. The lighter warmer air mass begins to rise above the other cooler denser air mass. The boundary between the two is called a FRONT. Fronts are usually several hundred

kilometres long and there are three types; warm fronts, cold fronts and occluded fronts.

Types of air masses

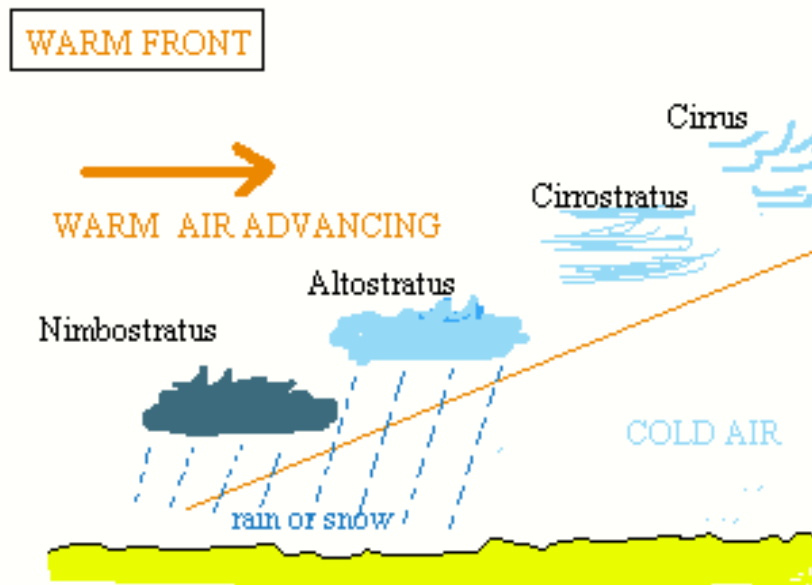
Air masses may be cold or warm, humid or dry depending on where they originated and from which direction they have come. The British Isles are located at the meeting point of air from many parts of the world.



Warm Fronts

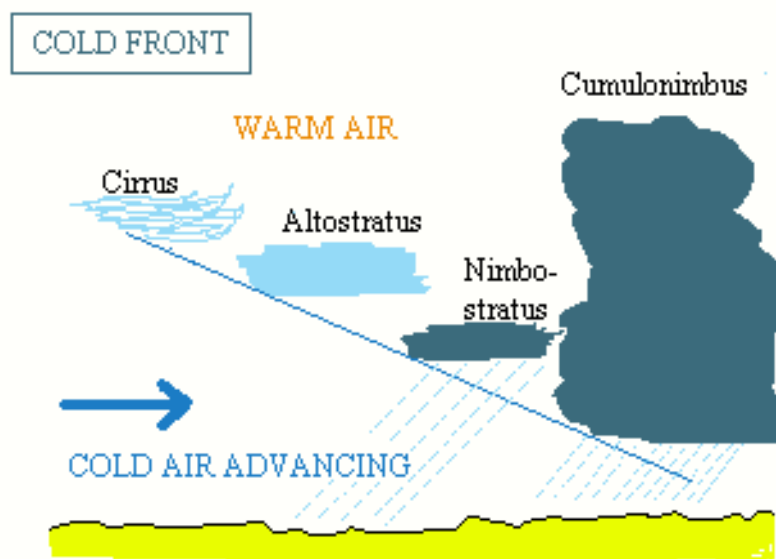
Warm fronts occur when light, warm air meets cold air. The warm air rises gradually over the cold air as they meet. As the warm air rises it cools and condenses to form clouds. Rain falls along the front as long periods of drizzle or steady rain. The symbol on a weather map for a warm front is made up of red semi-circles along a line.





Cold Fronts

Cold fronts form when cold air advances towards warm air. The cold air undercuts the warmer air in front of it, forcing the warm air to rise above it more vigorously than at a warm front. As the warm air rises much faster it may cool more rapidly and may form large cumulonimbus clouds. Heavy rainfall may result and the air temperature may



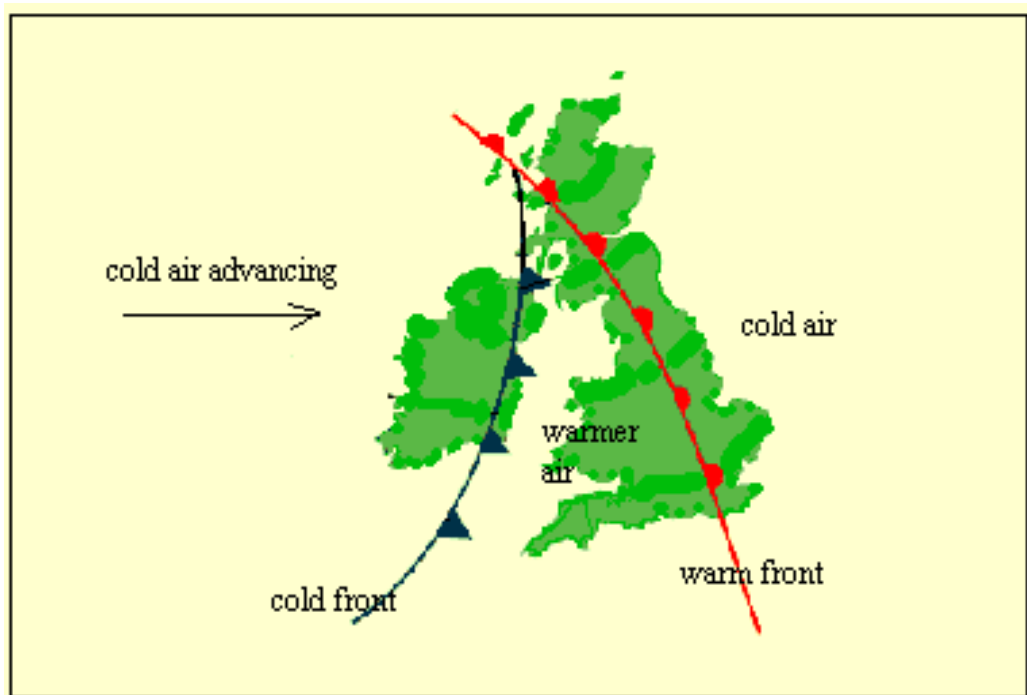
become noticeably cooler as the cold front passes by. A cold front is symbolised on a weather map by blue triangles along a line.

Occluded Fronts

Sometimes a cold front catches up with a warm front to form an occluded front. Here the warm air is totally lifted off the ground by the cold air in front and behind. Occluded fronts are usually associated with heavy rainfall and strong wind speeds. An occluded front symbol on a weather map is a line with triangles and semi-circles.



Below is an example of a weather map showing a warm and a cold front for the British Isles.

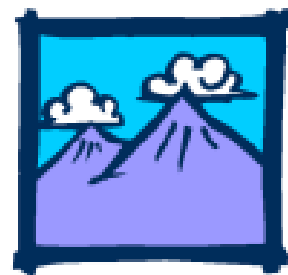


In the above example, cold air is advancing across Ireland towards Great Britain. When it meets warmer air a cold front forms and clouds will appear as the warm air rises and then cools. This may lead to heavy rain along the cold front.

A warm front forms when warm air advances and meets cold air. In the above example, the air temperature near the ground between the warm and cold fronts (the warm sector) will be warmer than that of the air advancing behind the cold front. Cloud will also form along the warm front but it will usually be stratiform in nature, beginning with altostratus, and later stratus and nimbostratus (rain-bearing layer cloud).

5.4 Relief Rainfall

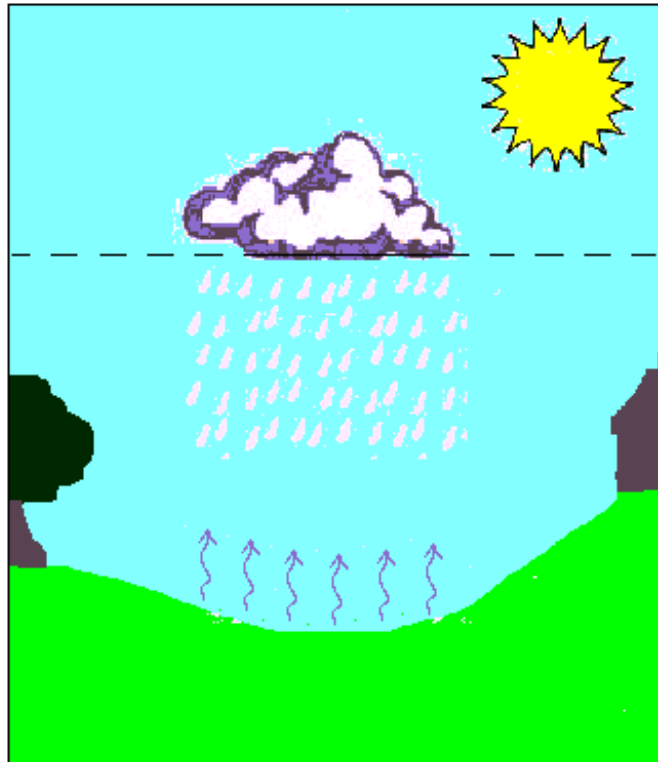
The third type of uplift of air is caused by relief or mountains. As air moves forward and reaches large obstacles such as hills and mountains, the air is forced to rise over the top. On a fine day, the air rising



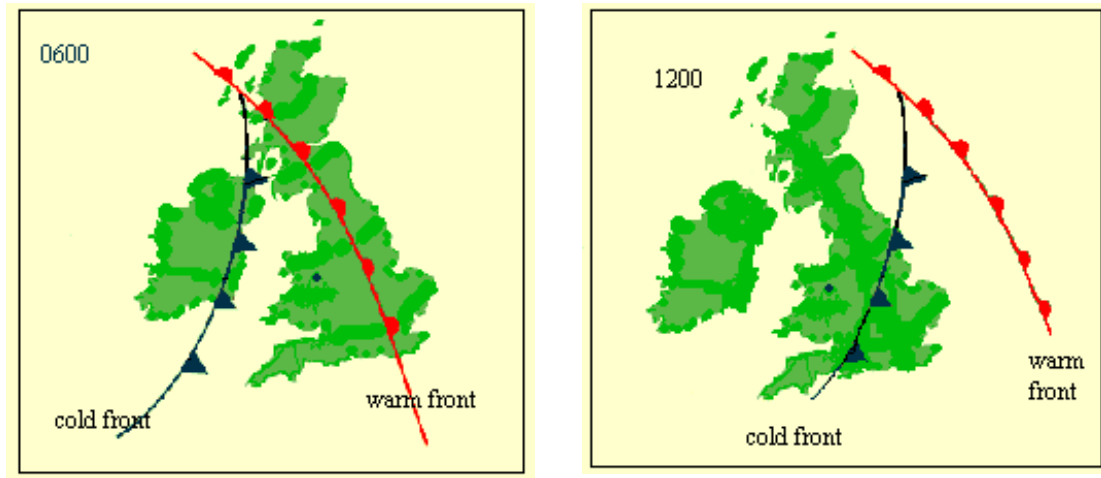
over high land may cause some thin cloud to form over the tops, as the rising air cools. If however, the air is fairly humid, many clouds may form over the mountain tops and produce rainfall. As the air moves over the high ground, it may warm up and descend over the hills. Moisture may evaporate to give generally dry weather conditions on the other side of the mountain. This dry side is called the rain shadow.

EXERCISES

1. Use the statements below to label this diagram about convection rainfall.

**COLD AIR****WARM AIR****HEAVY RAIN FALLS****LAND HEATS UP DURING THE DAY****HEATED AIR RISES****SUN BEATS DOWN ON LAND****CLOUDS FORM AS CONDENSATION OCCURS**

2. Below are some weather maps showing how a cold and warm front have moved over a few hours.

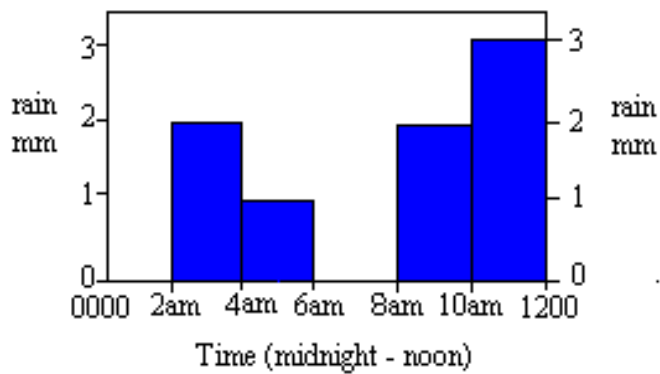


Which weather front was closest to the Welsh site marked on the map?

at 0600 hours

at 1200 hours

This is the rainfall chart for the Welsh site above, for the same morning:



How much rain fell between midnight and noon on this day?

How much rain fell between 6am and 12 noon?

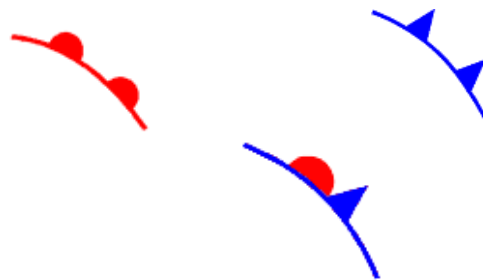
Describe what you think the weather was like at the Welsh site using the evidence from the maps and rain chart.

3. Draw lines to join up the correct weather symbols.

A cold front

A warm front

An occluded front.



Section 6: Pressure Systems

6.1 Introduction

Air in the atmosphere, as we have seen, moves both up and down and from side to side. This vertical and horizontal movement of air causes changes in air pressure. Rising air, as discussed in section 5 gives rise to cloudy and rainy weather and is described by the terms **low pressure**, a cyclone or a depression. The opposite is descending air which is accompanied by **high pressure** or an anticyclone and gives rise to more stable weather conditions such as long dry periods with little or no wind.

6.2 Low Pressure Systems

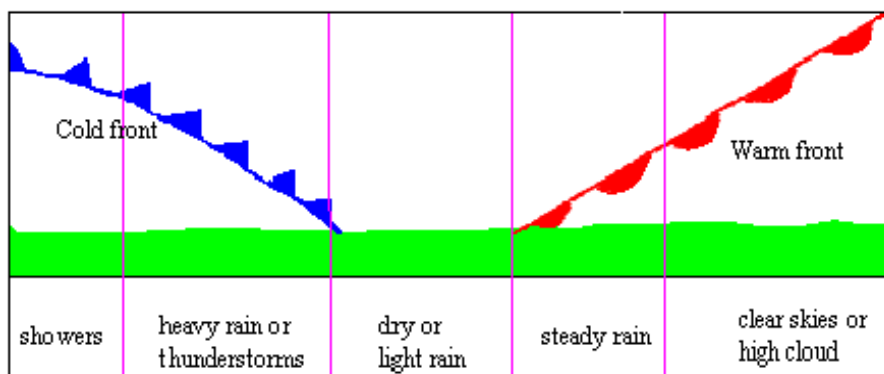
Low-pressure systems or **depressions** develop when air masses with different temperatures meet. The air does not mix well and the warmer air mass moves up and over the other causing a front to form. As we have seen in Section 5, fronts generally give rain, cloud and increased wind speeds.



The main (**prevailing**) wind direction for the British Isles is south westerly. This brings tropical maritime air masses from the Atlantic Ocean which often form

depressions over the British Isles when they meet cold air masses from the polar regions. Depressions bring changeable weather and this is why the weather in Britain can be so different from one day to the next.

As a depression moves over an area, there are noticeable changes in the weather conditions. Below is a diagram of a cross section of a depression which shows the changes of weather that occur as a typical depression passes over a place.





6.3 High Pressure Systems

Sinking air leads to areas of high pressure or **anticyclones**.

When high pressure occurs, winds become very gentle and the descending air warms up. Anticyclones usually lead to warm, dry weather which usually lasts for several days or even weeks.

There are some differences between anticyclones in summer and winter as shown below:

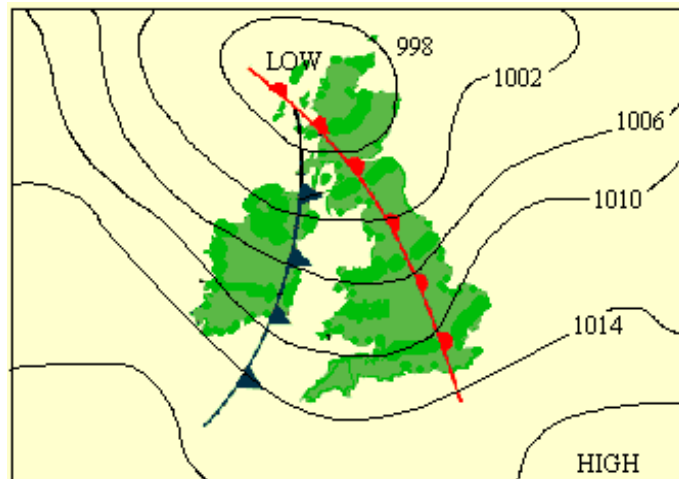
 ANTICYCLONES	 ANTICYCLONES
Hot days, blue skies, few clouds	Clear skies, cold because sun is low in the sky and there is no cloud cover
Light winds.	Light winds
Morning mist due to cooling of the ground at night.	Fog and frost forming at night. Sometimes the fog remains all day
Warm, moist air rising may lead to anticyclone breakdown and to thunderstorms.	Very cold nights due to no cloud cover
Cloud over Eastern coastal areas because of cool coastal winds blowing over the North Sea.	If an easterly wind, may bring snow showers.

Anticyclones are much larger than depressions and may block the path of a depression, forcing it to travel elsewhere. An anticyclone that persists for a long period is known as a **blocking high** and may lead to long hot spells of weather and even droughts during the summer months.

6.4 Isobars

Air pressure changes are recorded on weather maps using lines called **isobars** which link areas with the same pressure. Isobars are usually drawn at 4 millibar intervals, e.g. 998, 1002, 1006. If the isobar lines on a weather map are very close together, this indicates that wind speeds will be high and if well spaced out, that wind speeds will be light.

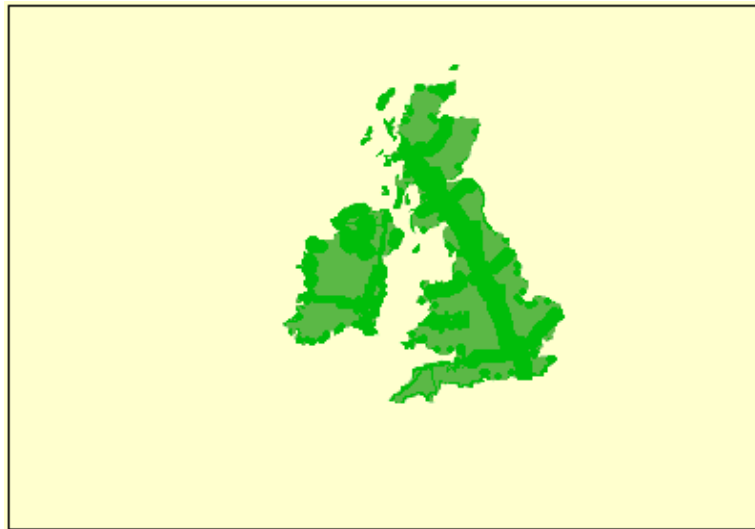
Below is a typical chart of British weather showing isobar lines.



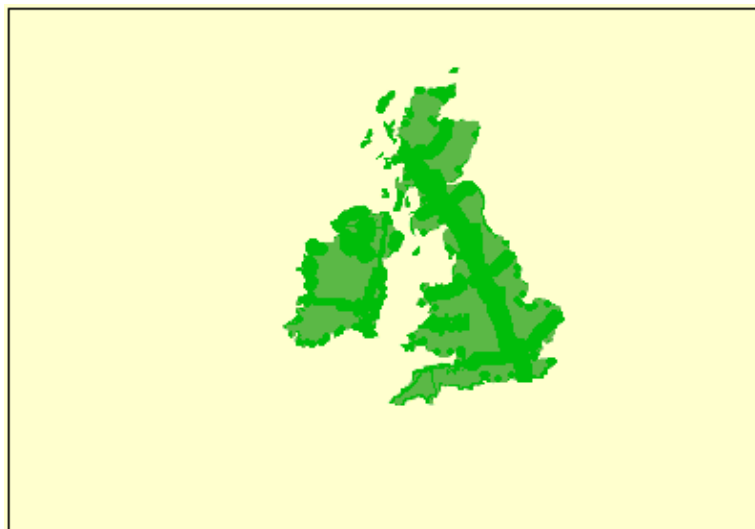
The isobar lines show that the low-pressure system is centred over northern Scotland.

EXERCISES

1. Below are two maps of the British Isles. Create your own weather maps by drawing isobars onto each map, one for a depression and one for an anticyclone. Include example isobar readings (at 4 millibar intervals). Identify which map is which.



This is an example of a _____ pressure system.



This is an example of a _____ pressure system.

2. Which of the following statements describe a low-pressure system and which describe a high-pressure systems? Write the correct answer, HIGH or LOW, after each statement.

This pressure system usually results in fine, dry weather.....

Cloud and rain are associated with this pressure system.....

Low wind speeds or still conditions often occur.....

This pressure system may remain in place for several weeks.....

This pressure system brings changeable weather.....

This pressure system is also called a depression.....

Another name for this pressure system is an anticyclone.....

3. Answer part a) or b).

a) If you have access to the Internet, visit the following UK weather sites and find out what the current weather is for where you live. Explore the sites and find out as much as you can about today's weather in the region where you live.

<http://www.metoffice.com/>

<http://www.bbc.co.uk/weather/>

Make a few notes on the table below to compare the information that you found on both Internet sites.

The Met Office Internet Site	The BBC Weather Site
Weather conditions for (region where you live) for today..... (date)	Weather conditions for (region where you live) for today.....(date)

Did the weather conditions match for both sites? If not, which one of the sites best described today's weather for where you live?

b) If you do not have access to the Internet, look at other sources of weather information such as a newspaper or TV weather forecast or TV Teletext to find out what the current weather is for where you live.

Make a few notes on the table below to compare the information that you found from two sources.

Source (e.g. newspaper)	Source (e.g. Teletext)
Weather conditions for (region where you live) for today..... (date)	Weather conditions for (region where you live) for today.....(date)

Did the weather conditions match for both sites? If not, which one of the sites best described today's weather for where you live?

Section 7: Forecasts & Charts

7.1 Introduction

In previous sections we have seen how air moves and how clouds and rain form. By observing the sky and general weather conditions such as wind speed and direction, we can guess what the weather will be like tomorrow. But, to be able to predict and

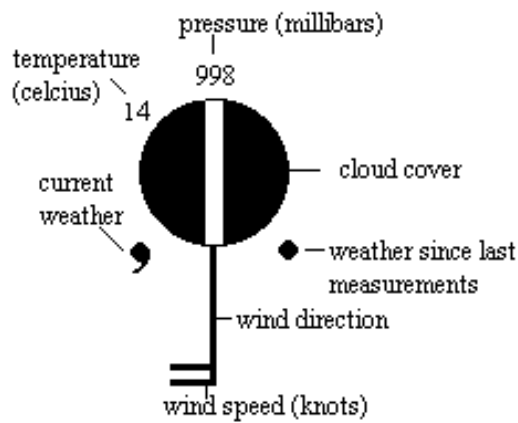


forecast the weather more accurately, scientists called **meteorologists** understand the isobar patterns associated with fronts, depressions and anticyclones and they plot these on **synoptic charts**.

7.2 Weather charts

The first stage in preparing a synoptic chart is to plot the position of weather recording stations. This is marked on the chart by a small circle in the correct position on the map. The weather station for Manchester is therefore positioned in northwest England. Other details of wind speed and direction, cloud cover and so on are marked on and around the circle. By studying the codes carefully, you can soon learn what all the symbols mean.



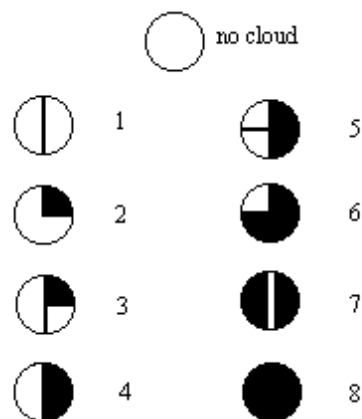


This example tells us what the weather conditions were like at a certain place and time. The wind direction was southerly and the wind speed was 20 knots. The sky was almost completely covered in cloud and it was drizzling with rain at the time of weather recording. The air temperature was 14 degrees Celsius and the pressure was 998mb. There had been rain since the last weather recording.

7.3 Weather symbols











Cloud cover is recorded on weather charts by shading in parts of the circle. If there are no clouds, the circle is left white and if the sky is completely covered in cloud, the circle is filled in. The sky is divided into eighths; if half of the sky is covered in cloud, then 4 eighths would be recorded on the weather chart.

Cloud cover (in eighths of sky)



Air pressure is recorded on the weather chart. Air pressure is normally in the range of 950 – 1050 millibars.

Current weather symbols are as follows:

	drizzle
	rain
	continuous light rain
	continuous heavy rain
	sleet
	snow
	thunderstorm
	shower
	hail
	fog

Weather since the last recording is also noted, using the same symbols as above.

Wind speed and **wind direction** are recorded by the addition of a 'tail' to the circle. The direction of the wind is marked in the compass position from which the wind is coming from. The speed of the wind is noted by the addition of small lines to the 'tail'. Each full line equals 10 knots; a smaller half line is 5 knots.



Examples:



A westerly wind direction (20 knots)

An easterly wind direction (15 knots)



A northerly wind direction (25 knots).

If there is no wind at all, there is no 'tail' and an extra circle is drawn around the cloud cover circle.



Temperature is recorded at the time of reading in degrees Celsius (°C).

7.4 Satellite recording and weather radars

Satellites are able to provide photographs of weather across a wide area (e.g. a whole continent) at a given time. Weather radars use microwaves to scan for raindrops.



Wherever it is raining, the radar can work out the location and intensity of the rain. Satellites allow meteorologists to track the path and development of weather systems. Satellites can also measure the temperature of the ground and the clouds by "seeing" in infrared. Some satellites even measure the amount of water vapour in the atmosphere.

The Internet is now able to provide public access to weather satellites for different parts of the world.

EXERCISES

1. These are the recordings made at two weather stations. Use weather symbols to record these details (on the circle to the right of the information), as they would be recorded on a weather map.

Site A: Edinburgh

Temperature 12°C

Air pressure 1005mb

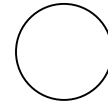
Cloud cover 3/8

Current weather: none

Weather since last recording – shower

Wind direction southerly

Wind speed 10 knots

**Site B: Luton**

Temperature 14°C

Air pressure 1012.5mb

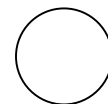
Cloud cover 4/8

Current weather: shower

Weather since last recording – shower

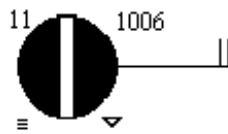
Wind direction south easterly

Wind speed 15 knots



2. Here are several weather details for a selection of UK sites. Use a map or atlas to label the location of these sites on the map below. Just mark A, B, C and D on the map in the appropriate place.

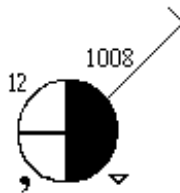
Site A: Cardiff



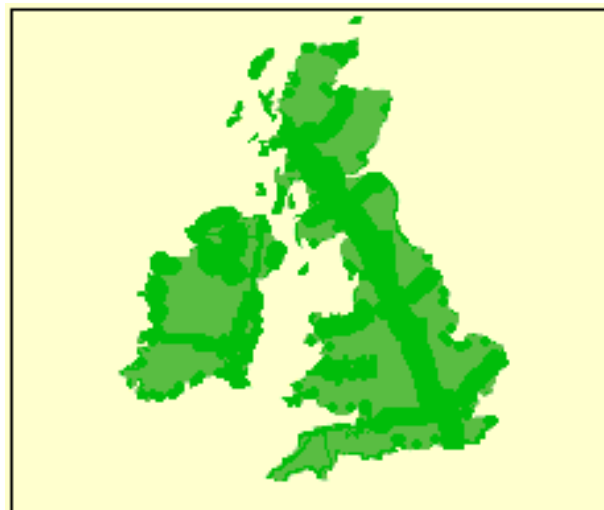
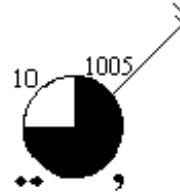
Site B: Aberdeen



Site C: Birmingham



Site D: London



Using your skills of reading weather symbols, answer the following questions.

QUESTION	ANSWER
Which site recorded the coldest temperature?	
Which 2 sites recorded a north easterly wind direction?	
Which site recorded continuous light rain as the weather since last measurements?	
Which site recorded the warmest temperature?	
Which site recorded the sky as 7/8 covered with cloud?	
Which site recorded the highest wind speed?	
Which site recorded the highest air pressure?	

3. (Access to the Internet required). There are many satellite weather pictures to observe on the Internet. Use search facilities to explore some of the satellite pictures available. Try and find a satellite picture of Europe for today. You may also find a series of satellite

pictures which are used to show a dramatic weather event such as a hurricane.

Some website addresses to try include:

The Meteorological Office:

<http://www.metoffice.com/>

The BBC Weather Centre:

<http://www.bbc.co.uk/weather>

Washington Post:

<http://www.washingtonpost.com/wp-srv/weather/>

Write a short summary of what you found on your Internet search. Include the website addresses of any interesting sites that you visited.

Write down the Internet addresses of any others that you find.

Section 8: Climate Variations

8.1 Introduction

In section 1, the differences between weather and climate were highlighted.

CLIMATE describes the average weather over a longer time period, over many years, or over a large area. In this section we will look at climatic variations in temperature and precipitation.



8.2 Average weather



To find out what the climate of a place is like, averages of weather readings need to be calculated. This can be done for a period of months or years. Sometimes it is also useful to know the climate varies seasonally throughout the year. For example, two cities such as Manchester (UK) and Warsaw (Poland) may have similar yearly average temperatures but the yearly temperature range for Warsaw is nearly twice as large as that for Manchester, as it has much colder winters and much warmer summers.





8.3 Climate differences around the world



There are differences in climate around the world because of differing amounts of radiation received from the Sun at different parts of the Earth at different times of the year. More heat from the Sun is received near the equator than near the north and south poles where the angle of the Sun's rays is lower. This is why tropical climates differ so much from polar climates.

Types of climate found at different locations around the Earth can be grouped into zones or regions to identify the particular weather features experienced. The main types of climate are as outlined in the Table below:

Climate Pattern	Characteristics
<p>Desert</p> 	<p>Low rainfall, little or no vegetation due to lack of water. Cloudless skies associated with anticyclones. High daytime temps. of 40°C are common.</p> <p><u>Examples:</u> Saharan Desert, Arabian Desert.</p>
<p>Tropical</p> 	<p>Located around the equator. Hot, humid weather (daytime max. temp 30-35°C). Convection produces daily rainstorms. Little seasonal difference. Further away from the equator a wet season and a dry season occur.</p> <p><u>Examples:</u> Amazon Basin, Brazil; the Congo Basin, W.Africa and Indonesia.</p>

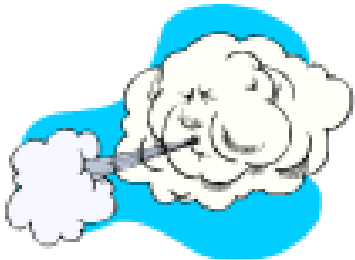
<p>Savannah</p> 	<p>Located between the wet equator belt and sub tropical belt. Savannahs have one short rainy season, rest of year is dry. Vegetation is mostly scrub and grassland.</p> <p><u>Examples:</u> Sahel in N. Africa, large parts of India, parts of N. Australia.</p>
<p>Temperate</p> 	<p>Temperate climates are maritime or continental. Maritime climates are strongly affected by the oceans with a fairly steady temperature across the seasons, whilst continental climates are more inland with warmer summers and colder winters.</p> <p><u>Examples:</u> UK (maritime), central Europe (continental).</p>
<p>Mediterranean</p> 	<p>Mid latitude. Hot, dry summers and mild winter rain.</p> <p><u>Examples:</u> Regions around the Mediterranean, S Africa, South East Australia</p>
<p>Polar</p> 	<p>Covered by snow and ice throughout the year. Sun is never high enough in the sky to cause widespread melting. Temperatures usually below freezing.</p> <p><u>Examples:</u> Greenland, northern Siberia, Arctic (north pole); Antarctic (south pole).</p>

8.4 Seasons

It takes a year for the Earth to orbit around the Sun. As the Earth moves, the angle at which sunlight strikes different places on the Earth at the same time of day changes because the Earth is tilted.



When a particular location is tilted towards the Sun, warmer temperatures occur (summer); when the same place is tilted away from the Sun, colder temperature occur (winter). These seasons are at opposite times of the year for the Northern and Southern Hemispheres. Near the equator the angle of the Sun remains high throughout the year so seasonal changes in temperature are not evident at these locations.



Winds also affect the temperature of different places on the Earth. The average worldwide wind system is called the general circulation of the atmosphere. Heat energy from places near the equator is transported to colder temperate and polar regions. If this heat transfer by winds did not occur, then equatorial places would continue to heat up and polar regions would continue to cool down.

8.5 Temperature and rainfall around the Earth

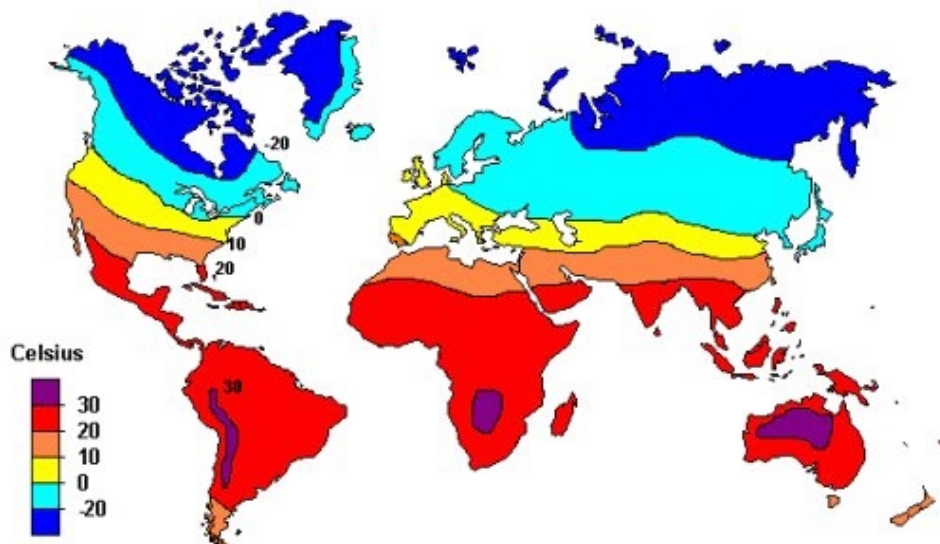
Seasonal variations in temperature and precipitation occur around the world because of the effect of the Earth orbiting around the Sun. There are wide differences in temperature if we look at average temperatures around the world in January and July. In January, lowest temperatures occur over the northern continents. The warmest areas are the landmasses of the Southern Hemisphere, particularly South Africa and Australia.

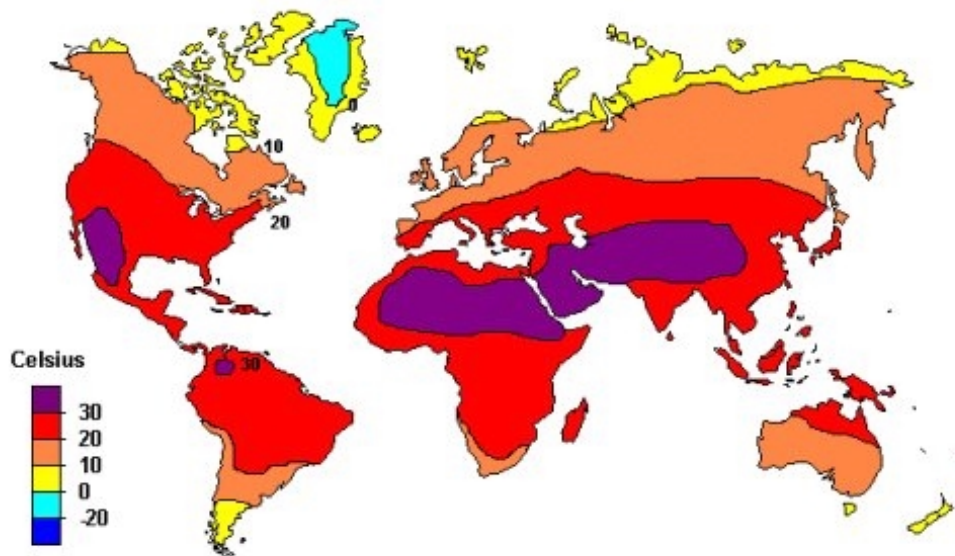


In July, the northern continents are strongly heated by the Sun. The hottest areas are the desert areas (Saharan, Arabian, Californian and northwest Indian) with average temperatures well above 30°C.

Countries near the equator are cooler than the desert areas because much of the heat energy is used in evaporating the large volumes of precipitation that fall there.

Global average temperatures for January



Global average temperatures for July

Rainfall also varies with the seasons. The highest rainfall totals occur near the equator where warm air rises and falls again due to convection. Tropical countries typically have prolonged heavy showers and thunderstorms in the afternoons. At very high latitudes (e.g. Greenland), precipitation is very low because the air is too cold to contain much water vapour. Sub tropical high-pressure regions also have low rainfall, as they experience generally stable conditions of descending air. The northern temperate mid latitudes (e.g. Britain) have moderate amounts of rainfall, mostly associated with fronts and depressions.



EXERCISES

1. Which is the correct statement in each of the following sets of statements about climate?

a) Countries which have a Savannah climate are located:

- in the Mediterranean region ;
- between the equator and the tropical belt or
- at the north & south poles.

b) Climate is different from weather because:

- it concerns average weather over time;
- of the greenhouse effect or
- it concerns only short-term weather measurements.

c) There are different seasons at most places around the earth because:

- the Earth is tilted and receives different amounts of radiation as it moves around the Sun;
- the temperature of the Sun changes all the time or
- other planets block out sunlight.

d) An example of a desert climate is:

- the equator;
- the Amazon Basin or
- the Sahara.

e) A tropical climate typically has:

- cold winters and hot summers;
- hot, humid conditions with little seasonal differences or
- drought conditions all year.

f) Polar climates are characterised by:

- cold temperatures throughout the year;
- hot, dry conditions or
- hot, windy conditions throughout the year.

2. See if you can find the underlined words in the wordsearch below.

The climate of an area concerns the average weather conditions. Different parts of the Earth have different climates because of different amounts of heat received from the Sun. The main types of climate are desert, tropical, Savannah, temperate, Mediterranean and polar. The UK has a temperate maritime climate whilst many western European countries have a more continental climate. Some climates have different seasons and there may be little or much variation in precipitation and temperature.

X	E	Q	M	U	T	J	C	H	D	E	F	G	P	S
Z	T	L	A	C	I	P	O	R	T	B	S	I	E	N
S	A	F	R	H	J	K	N	U	G	E	D	A	P	A
N	R	V	I	S	T	A	T	E	J	H	S	C	Y	E
W	E	A	T	H	E	R	I	G	X	O	Y	E	E	N
G	P	W	I	E	M	L	N	O	N	S	I	Q	R	A
T	M	Q	M	I	P	D	E	S	E	R	T	S	V	R
R	E	E	E	H	E	T	N	K	H	A	R	E	T	R
E	T	T	R	L	R	O	T	C	B	L	R	K	O	E
Y	H	A	N	N	A	V	A	S	D	A	E	T	L	T
R	R	M	Q	R	T	O	L	O	G	K	O	P	H	I
A	F	I	A	S	U	D	U	E	S	L	J	N	S	D
L	Y	L	K	S	R	O	T	E	D	U	H	S	C	E
O	O	C	O	G	E	S	O	G	Y	D	G	U	M	M
P	R	E	C	I	P	I	T	A	T	I	O	N	O	A

Answers overleaf

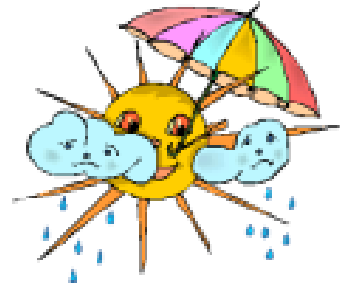
Answers to wordsearch

	E		M				C						S
	T	L	A	C	I	P	O	R	T				N
	A		R				N					O	A
	R		I		T		T				S		E
W	E	A	T	H	E	R	I			A			N
	P		I		M		N		E				A
	M		M		P	D	E	S	E	R	T		V
	E	E	E		E		N			A		E	R
	T	T			R		T				R		E
	H	A	N	N	A	V	A	S		A		T	T
R		M			T		L		G				H
A		I			U			E					D
L		L			R							S	E
O		C			E							U	M
P	R	E	C	I	P	I	T	A	T	I	O	N	

Section 9: Climate of Britain

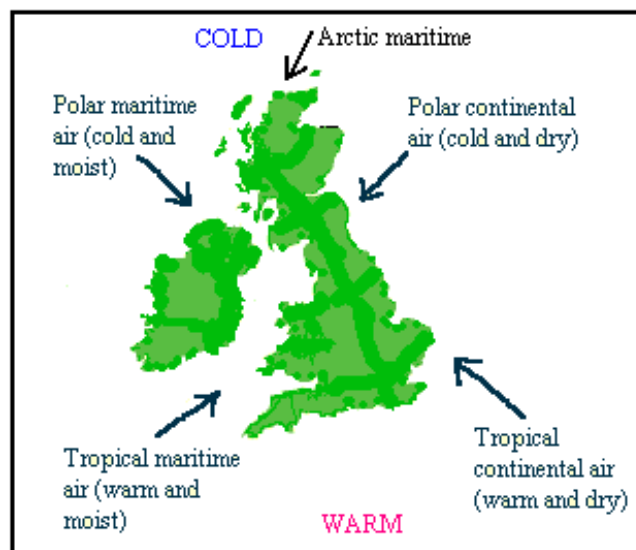
9.1 Introduction

Britain is in the temperate climate zone and does not have extremes of temperature or rainfall. The Gulf Stream, a large Atlantic Ocean current of warm water from the Gulf of Mexico, keeps winters quite mild whilst during summertime, warm but not excessively hot temperatures are experienced. The average annual temperature in Britain is about 10°C, with the summer average temperature being around 15°C and the winter average being around 5°C (day and night). As we have seen in previous sections, the British weather is dominated by frontal depressions which form in the Mid-Atlantic and pass across into Europe, bringing changeable weather.



9.2 Air Masses

The main air masses that affect Britain are those that form over the Mid-Atlantic but there are several other air masses that bring particular weather conditions. The air masses are defined



according to where they originated and their course of travel. For example air from Arctic regions is classified as *Arctic maritime* as it originates in the Arctic and travels across the North Sea. Another example is *Tropical maritime* air which originates near the Gulf of Mexico and travels across the warm Atlantic Ocean before arriving in Britain. Other air masses include the *Polar maritime*, *Polar continental* and *Tropical continental*. Examples of air masses which affect British weather are shown on the diagram:

9.3 Maritime climates

Most of the airflow across Britain throughout a year is maritime, including tropical and polar air masses. Tropical maritime air is mild in winter and warm and humid in summer. If these air masses are associated with frontal depressions, there is usually plenty of rainfall, but when associated with anticyclones, settled weather with warm sunny spells occurs.



Polar maritime air masses usually result in cool, showery weather throughout the seasons but may bring snow during the winter months.

9.4 Continental climates



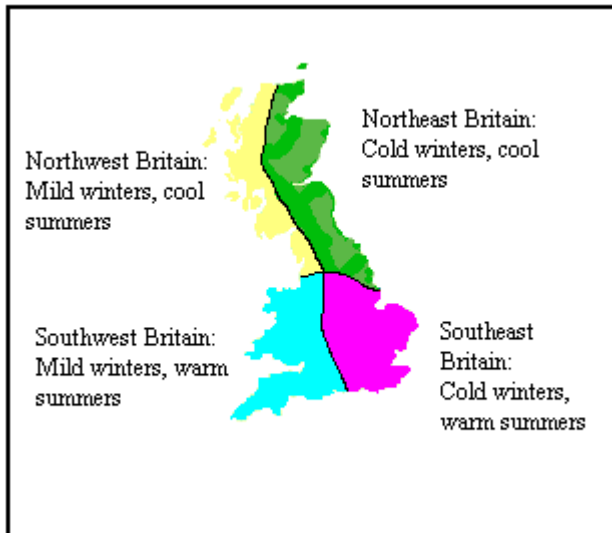
Polar continental air in winter is very cold. The air mass is usually dry and stable but as it passes over part of the North Sea, sufficient heat and moisture can lead to the formation of showers, often snow, over eastern England and Scotland. During summer, the polar air mass brings warm air as even northern parts of Europe experience high temperatures during the summer months.

Tropical continental air reaches Britain from the Saharan region of Africa. It gives dry weather in the summer and also gives pleasantly warm weather in the winter.



9.5 Geographical variation in the British climate

The general patterns of climate experienced in Britain have been identified. However, there are also noticeable differences that occur throughout Britain. The coldest winter temperatures in Britain occur in eastern Scotland and England. The western side of Britain is warmed by the influence of the tropical maritime airstream. Temperatures are therefore colder in the east than in the west during winter. During summer the south is warmer than the north. This is due to the differences in solar heat received, being greater in the south.



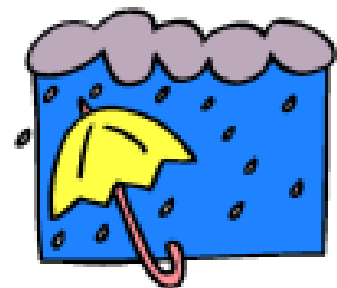
The British climate can be divided into four parts as shown on the map below.

The northwest section is characterised by mild winters and cool summers and the northeast with cold winters and cool summers. The southwest experiences mild winters

and warm summers and the southeast with cold winters and warm summers. Western parts of Britain generally experience a more maritime climate during winter whilst eastern Britain is influenced by the cold airstreams from the European continent. In summer, climate differences are more dominated by latitude.

Precipitation also varies throughout Britain.

Western Britain, particularly the parts on higher ground, receives considerable rainfall. Most of this is frontal rainfall but there is also relief rainfall due to the

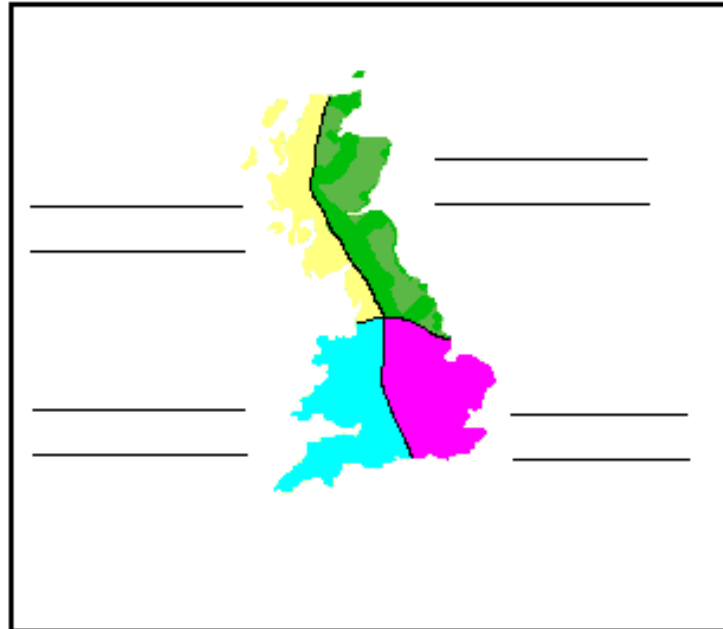


mountains such as the Lake District and the Welsh Mountains.

Parts of Scotland can receive over 250 cm or 100 inches of precipitation per year. Eastern Britain, particularly southeastern parts, receive much less rainfall. Areas of the southeast may receive only 50 cm or 20 inches of precipitation per year. Much of eastern Britain lies in the rain shadow of hills and mountains such as the Lake District, the Peak District and the Scottish Highlands.

EXERCISES

1. Label the map below with the correct climate summary for each part of Britain.



Cool summers
Cold winters

Warm Summers

Mild winters

Cool summers
Cold winters

Warm Summers

Mild winters

2. Some of the words below are mixed up. See if you can unscramble them.

Britain is in the **merteatpe** climate **noze** British **eatwher** is dominated by frontal **piodressens** which give changeable weather. The Gulf **remSat** Drift causes western Britain to have **ldmi** winters.

Eastern Britain has **lerdoc**..... winters which are influenced by continental air masses. In **mumers**..... the south of Britain is warmer than the north due to higher levels of **lrsoa**..... heat in the south.

3. Below is some climate data for several cities in Britain. Plot graphs of the data, using a computer package if possible, to show the variation in temperature and rainfall for each site .

Site	Month	J	F	M	A	M	J	J	A	S	O	N	D
A	Temp °C	5.9	8.9	8.3	8.1	13.3	14.5	15.9	16.3	13.7	9.8	5.2	4.7
	Rain mm	84	7	84	99	35	97	28	14	60	112	48	72
B	Temp °C	4.9	8.3	7.3	6.4	10.9	12.7	14.4	14.8	12.8	8.4	5.2	4.8
	Rain mm	99	41	46	84	85	76	101	48	42	124	81	53
C	Temp °C	7.1	8.1	8.8	8.5	14.2	14.3	15.5	16.0	15.0	10.3	7.0	6.2
	Rain mm	128	17	89	77	30	73	53	23	100	145	84	138

The average monthly rainfall and temperatures for the three sites above are:

Site		Annual average
A	Temperature °C	10.4
	Rainfall total mm	740
B	Temperature °C	9.2
	Rainfall total mm	880
C	Temperature °C	10.9
	Rainfall total mm	957

Using your knowledge of climate variation throughout Britain, which location do you think each set of data belongs to. Mark the map with A, B, C next to the site you think they represent. Write a few lines to explain your choice.

