

Background Information

The atmosphere stretches for more than 100Km above our heads and most of it (99%) is calm. However the lowest 10Km – the **troposphere** is constantly moving. Everything we call weather occurs in the troposphere, because this layer contains the most water vapour. Water vapour means we have clouds, giving us rain and snow and so weather.

Weather describes the atmospheric conditions at a particular place and time. What is happening right now?

Climate describes the weather conditions over a long period of time. Climate reflects weather observations over a long period (30 years).

Climate is affected by several factors: latitude, altitude, distance from the sea, ocean currents, winds, geography.

Clouds are visible masses of water droplets or ice crystals. They form whenever there is enough moisture in the air and that moist air is high enough to cool and condense. Not all clouds are natural- GLOBE asks students to look at **contrails** too, the vapour trails from aeroplanes. Once you begin to read the clouds you will be able to forecast the weather.

Precipitation is the deposition of moisture from the atmosphere as rain, drizzle, hail, snow, fog or dew. The atmosphere contains water vapour; if the air cools sufficiently then water droplets form.

Air Temperature varies during the day in response to heating from the sun and changing weather systems. It varies with latitude, elevation and season.

Air Pressure is the weight of the atmosphere at the Earth's surface. It varies with

- Temperature: warmer, lighter air is made to rise, creating areas of low pressure behind them. Colder, heavier air falls and creates areas of higher pressure.
- Height: higher in the atmosphere the pressure becomes lower.

Wind is the horizontal movement of air across the Earth's surface. Wind is caused by differences in air pressure, with wind flowing from high pressure (sinking) to low pressure (rising). The greater the difference in pressure, the stronger the wind blows.

Relative Humidity is the amount of water vapour in the air. Warmer air holds more water vapour than cold air. If warm air rises, it will cool, the humidity will increase until the air becomes saturated and dewpoint is reached- then we get rain.

GLOBE activities

Although there are many aspects to the weather the GLOBE scientists concentrate on clouds (type and amount), contrails, air pressure, relative humidity, precipitation and air temperature. All the weather activities should be carried out at the same time each day and as close as possible to noon GMT. You can do all the activities or just one. It would be great if you took the measurements every day but if you can only do them once that's fine.

Practice measurement skills with pupils before setting up the weather station.

Activity 1: Setting up your weather station and defining your site

You must ensure that the weather station is installed correctly so that the measurements you take are accurate and comparable against readings from around the world.

You need to calibrate your equipment, see the pupil guide.

You then need to tell the GLOBE database where your weather station is and describe its surroundings.

The GLOBE web site refers to the weather station as the 'Atmosphere Study Site'.

You can complete a site definition sheet (in the Pupil Guide) then fill in the details onto the database at www.globe.org.uk.

Give your Atmospheric Study Site a name you will remember.

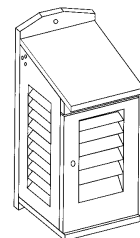
You will need measurements for latitude, longitude and elevation at the site for the Stevenson Screen from the GPS. Remember to take 5 readings over 5 minutes and then average them. Notice any obstacles or buildings in the area. Notice the ground cover.

This is the instrument shelter more commonly known as the **Stevenson Screen** where the thermometers are placed so that they are protected from sunlight, vibration and other external factors that could influence the readings.

The shelter must be properly assembled and positioned before any readings are taken.

It should be painted white to reflect the sun light.

- The ideal position for the shelter is out in the open on a flat, natural surface. Avoid areas on steep slopes, in sheltered hollows or near buildings or concrete surfaces, as these become hotter than their surroundings. Notice the ground cover too.
- Ideally the shelter should be four times as far from an object as the object is high, so if a wall is 3m high, the shelter should be 12m away.
- The door should face North.
- The instruments in the shelter should be 1.5m off the ground.



Activity 2: Cloud and Contrails

Pupils examine the cloud cover to identify the type/s of cloud in the sky using the GLOBE cloud chart and the percentage of the sky that is covered with clouds.

The chart should be placed in a convenient position where pupils may use it for comparisons.

Activity 3: Precipitation: rain and snow fall

Pupils measure rainfall collected in a rain gauge and empty it each day.

They may also record the pH of the rainfall.

Pupils may also measure snow depth and the amount of liquid contained in the snow. The standard rain gauge consists of an inner measuring tube, a funnel and an outer overflow tube. The inner tube is marked in mm and stands inside the overflow tube. The gauge should be placed in an open area away from overhanging trees but not in a place where strong winds could blow the rain across the top of the tube. It should be on a post which lifts it 50cm off the ground (it could be on the post with the Stevenson Screen).

Activity 4: Temperature

Pupils record maximum, minimum and current temperature each day.

For this study your pupils can use a “**U-tube**” **maximum/minimum thermometer** with a magnet for resetting the indicators. Alternatively you could use a **digital thermometer** which reads and displays temperature in 0.1°C increments. Both thermometers can be kept inside the screen along with the calibration thermometer.

Pupils will need to take three readings each day - minimum temperature, maximum and current temperature. The data must be recorded as near as possible to noon GMT and it must be done at the same time each day.

You will need a **calibration thermometer** for calibrating / checking the thermometers at regular intervals. This second thermometer is a single tube, liquid filled type that can record temperatures as low as -5°C. The thermometers should be calibrated every three months (see Pupil Guide for method).

Thermometers are kept in the Stevenson Screen.

Temperature is measured in °C.

Activity 5: Barometric Pressure

Measure air pressure using an **Aneroid Barometer** and **Altimeter**

For schools at elevation 500m or less use an aneroid barometer. For schools at a higher elevation an altimeter that also provides barometric pressure readings is recommended.

The barometer/altimeter can be mounted on a classroom wall, since the air pressure is the same inside and outside the building. The instruments should be calibrated every six months.

Activity 6: Relative Humidity

Measure relative humidity using either a digital hygrometer or a sling psychrometer

The **Digital Hygrometer** must not be exposed to condensation, if yours is - then record a reading of 100% and comment that 'condensation occurred'.

It is therefore best not to leave the hygrometer in the instrument shelter overnight. The ideal situation is to place the hygrometer in the instrument shelter 30 minutes before local solar noon. For calibration instructions check the individual certificate, it may need to be sent to manufacturers to be calibrated.

A **Sling Psychrometer** consists of two thermometers in a sturdy housing, which can be whirled by hand. Check that the columns of fluid in each thermometer, are continuous (no breaks in the column). If there are gaps, give it a one vertical shake. Calibrate each thermometer every three months.

Activity 7: Data loggers

Using an automated data logger you can collect weather data every 15 minutes, download to your computer and then email it to GLOBE. This means you are monitoring the weather closely and collecting much more data.

There are many on the market and if the installation instructions are followed carefully they collect very accurate weather data. Weather information from the data logger can usually be displayed in real time via a computer so everyone can see it.

Davis Instruments (<http://davisnet.com>) have several data-logging weather stations which download data in a format which can be immediately attached to an email and sent to GLOBE. Davis Instruments produce many different data logging stations. The most comprehensive in terms of variety of data collected is the Vantage Pro range – collecting temperature, humidity, barometric pressure, wind speed and direction and rainfall. The stations come wireless or cabled.

If you are interested in finding out more about the data loggers please contact the GLOBE-UK office as we have arranged for GLOBE registered schools to get a good deal and help from the distributors.

Wireless v Cabled

For many automated stations you will have a choice – wireless or cabled. Cabled means that the sensors are connected to the console by cables, which will need installing. This may limit the placement of your station. If you opt for a wireless version you may save time and money on the installation and in some cases you will find that you can move the sensors around, even taking them on field trips with you.



Installation

These are general guidelines, please do also follow the manufacturer's instructions.

1. Find a good location to place your shelter. If you are using an anemometer (to measure wind) it can sometimes be placed separately. If the sensors have to be close together, choose the site which is best for the thermometers.
If you are using a wireless station make sure that the sensors will be close enough to the console to allow good communication (this is often a 100m and will be stated in your manual).
2. If possible mount the sensors so that the thermometers are 1.5m above the ground in a flat open area (10m from the nearest building).
3. If possible mount the anemometer above trees and buildings. If you mount it on the roof try to place 1.2m above the roof line to avoid wind changes around it.
4. Calibrate the thermometers and the rain gauge using the instructions in the pupil guide.
5. Set the weather station to log data every 15 minutes, on the hour, quarter past, half past and quarter to.
6. Download data to a computer following the manufacturer's guidelines (some stations will download automatically). Check to see how much data can be collected, this will vary with different data loggers: some can collect data for months before they need to be downloaded.
7. Export a text file of your data and save the file to your computer (If you have a Davis machine and it has the GLOBE software then you will export a file in the *GLOBE email data entry format* – this means you will not need to do the next step).
8. Use a spreadsheet to manipulate the data into the *GLOBE email data entry format* and save the spreadsheet.
9. Copy and paste the *GLOBE email data entry format* into the body of an email to GLOBE – unfortunately at the time of going to press the address for email entries is changing – check www.globe.gov under data entry and email entry to find the current email address for data entry.

GLOBE equipment

- Liquid mercury U-tube max/min thermometer OR digital thermometer
- Calibration thermometer
- Weather station (Stevenson Screen)
- Rain gauge
- Snow board (Piece of board 40cm x 40cm min.)
- GLOBE cloud chart
- Aneroid Barometer or Altimeter
- Digital Hygrometer or Sling Psychrometer
- Automated weather station (optional)

Weather bytes

- The lowest temperature ever recorded on Earth was -89.2°C at Vostock, Antarctica on 21st July 1983.
- In August 1846, a hailstorm in London destroyed 7,000 panes of glass in the Houses of Parliament. The temperature was approximately 32°C .
- The coldest air temperature ever recorded in Britain was -27°C (10 January 1982 in Grampian).
- A raindrop is neither spherical or tear-drop shaped. It is in fact shaped like a burger bun and it falls flat side down.
- The temperature of lightning is approximately $7,760^{\circ}\text{C}$
- In Antofagasta, Chile, the average rainfall is less than 0.1mm a year.
- One billion tons of rain falls on the earth every minute.
- Eighty four percent of the people struck by lightning are male.

Useful contacts and publications

www.bbc.co.uk/weather/

BBC Weather Centre provides UK and World-wide weather services. Detailed maps for temperature, wind, satellite, pressure and radar.

www.met-office.gov.uk/

The latest UK and international weather forecast.

www.education.noaa.gov/

A site for teachers from the National Oceanographic and Atmospheric Administration in the US.

www.royal-met-soc.org.uk/wweb.html

A site to help British schoolteachers find meteorological information on the Web.

www.barometerworld.co.uk

A museum and website dedicated to weather monitoring instruments.

'Weather' An Eye Witness Guide by Brian Cosgrove

A book explaining weather in simple easy to follow chapters.

Extra activities

Making a cloud percentage chart

Aim: to understand the meaning of *clear*, *scattered*, *broken* and *overcast* when applied to cloud cover. See worksheet in the Pupil Guide.

Cloud elevation line

Aim: to know the names of the different cloud types and their relative positions in the troposphere. See worksheet in the Pupil Guide.

Cloud Quiz

Aim: to know the names of the different cloud types.

An interactive cloud quiz available on the GLOBE website

Natural signs

Find out about the ways people have learnt to predict the weather and make a display to show some of the country weather lore.

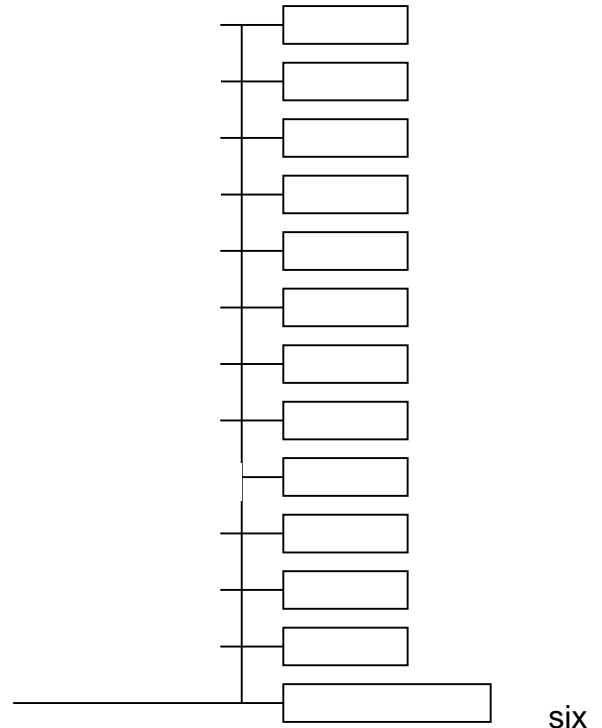
For example:

Groundhog day USA – if you see the groundhogs shadow at noon on the 2nd February, the weather will be cold for another weeks. Records do not back up the theory.

'Red sky at night shepherd's delight, red sky in the morning shepherd's warning' – meaning that a red sunset will be followed by a fine morning and a red sunrise forecasts a stormy day. Experts are doubtful.

Cows lying down – if you see cows lying in a field people say that rain is on the way. It's thought that cows can sense the dampness in the air and ensure that they have somewhere dry to sit before it starts raining.

Crickets – if you want to know the temperature, count the number of chirps a cricket makes in 15 seconds add 37 and that will be the temperature in °Fahrenheit. First find your cricket!



Reading a u-tube thermometer

Aim: to read and understand the scale on a u-tube thermometer. See worksheet in the Pupil Guide.

Answers

For u-tube 2	For u-tube 3	For u-tube 4
maximum temp = -12°C	maximum temp = 8 °C	maximum temp = 4 °C
minimum temp = -12°C	minimum temp = 4 °C	minimum temp = -1 °C
current temp = -12°C	current temp = 4 °C	current temp = 4 °C

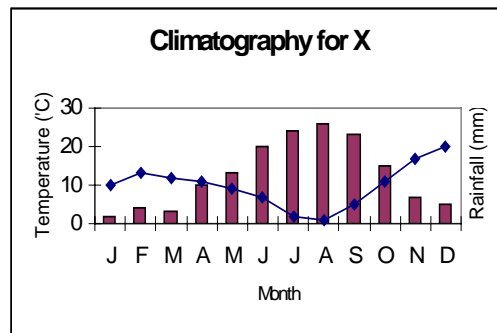
Further Weather Investigations

Microclimates

A 'Microclimate' refers to small areas that have slightly different weather than the surrounding area. For example, forests, mountains, lakes, and built-up areas can all affect temperature, and rainfall. Buildings and roads generally absorb more heat during the daytime than natural surfaces. To test this, try comparing your temperature figures with a school in a **contrasting** location. Compare your data with nearby urban school if you live in a rural area or nearby rural school if you live in an urban area.

Climate study

Compare rainfall in your area with rainfall at weather stations around the world. Construct a climate graph using both temperature and precipitation figures. Use this information to compare your results at weather stations in different places.



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Effect of rainfall upon the pH of water

Does rainfall amount and pH affect the pH of a water body? This study would be most effective using data from a period of changing weather, e.g. spring or autumn. What else might cause changes in water pH over short periods?

Effect of air temperature upon the temperature of a water body

How quickly does the temperature of water change in response to air temperature? Look at data over a year from a single school. What is the temperature difference? Can you predict the weekly temperature of water given the air temperature data from the previous week or month?

Is pH of rainfall constant?

Monitor pH of rainfall throughout the year or obtain data from another school. Does pH vary?

Study seasons

Describe the seasons and agree a class characterisation of seasonal weather. Create graphs of seasonal weather, a set of graphs for each season. Data may be drawn from one year or from longer-term data. Can you see an emerging pattern of seasonal changes? Did your data agree with your class predictions of seasonal weather?

Clouds and rain

From your own recordings, can you identify which clouds lead to precipitation, and which point towards dry weather?

GLOBE curriculum links

Geography Weather studies help with the understanding of locality both locally and in contrasting locations. A starting point for many geographical enquiries.

Key stage 2	1(a-e)	2(a-g)	3(a-g)	4(a,b)	5(a,b)	6(a-e)	7(a-c)
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Year 3 Unit 7: Weather around the world

Key Stage 3	1(a-f)	2(a-g)	4(a,b)	5(a,b)	6(a-k)	7(a-d)
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Science Uses own knowledge and understanding to interpret familiar phenomena such as temperature and the water cycle; gives opportunities to use standard measures to obtain information through direct experience.

Key Stage 2	1.1(a,b)	1.2(a-l,m)	2.3(a)	3.2(e)	4.3(a,b)	4.4(b,c)
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Key Stage 3	1.1(b,c)	1.2(a-p)	2.5(a)	3.3(e-g)
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ICT Uses computer technology to convey information; to interpret, analyse and check data required for specific purposes. Purposeful use of data-logging equipment.

Key Stage 2	1(a)	1(b)	2(b)	3(a)	4(a-c)
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Key Stage 3	1(a)	1(c)	2(b)	3(a)
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Mathematics Uses appropriate measuring instruments to observe, record and interpret numbers and scales with a high degree of accuracy. Opportunity for data handling skills.

Key Stage 2	2.1(a-k)	2.2(a,f,i)	2.3(k)	3.4(a,b)	4.1(a,c-h)	4.2(a-d)
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Key Stage 3	2.1(g,h)	2.2(e)	3.4(a)	4.1(a)	4.2(d)	4.3(a-c)
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English Finding and selecting information from various sources; use electronic communication to describe observations.

Key Stage 2	2.5(f,g)	3.1(e)	3.2(a-f)
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