

Weather data can be used for lots of interesting investigations, and is also a useful addition to many investigations – the weather can affect both physical processes and human ones. Are the responses people give to surveys affected by the weather? How does this extend to other forms of behaviour – how people travel, what activities they choose to do? What impact do microclimates have on land use – and vice versa?

Weather data can be obtained directly (primary sources) using instruments – which may be simple (homemade or cheaply available) or highly precise, professional instruments. Alternatively, much weather data is now available on the web.

## Temperature



Digital thermometers are available in many forms and can be very cheap, costing just a few pounds. They are frequently incorporated in other devices (such as phones or watches). However, the same basic points remain true of all but the most expensive thermometers:

- Be careful not to touch the probe whilst using the device (where the thermometer has a probe such as in the image to the left) or to block the air inlet to the thermometer in instruments without a probe – this is usually a very small hole in the plastic casing.
- Most digital thermometers have an accuracy of  $\pm 3^{\circ}\text{C}$ . This means that, although you can easily compare measurements made by the same device in different places, to compare measurements made by different thermometers you will need to compare them with each other before you start. To do this, leave them in a dark, enclosed space overnight and record the difference in the temperature they show. Subsequently, you'll need to use that difference to adjust any readings made.
- Digital thermometers will take a while to adjust to new temperatures. You should really allow a minute per degree of temperature change – so a thermometer being taken outside on a cold day from a heated room will take at least 10 minutes to give an accurate temperature reading.
- All thermometers should be shielded from direct sunlight. Traditionally this has been done using a Stevenson Screen, which allows air flow passed the thermometer whilst reflecting much of the sun's light. Placing the thermometer in a shaded place is a good start, away from any walls.
- The temperature at the ground will be different from the temperature a metre or so from the ground – be consistent about the level you use.

Car thermometers can be very useful, particularly when looking at urban temperature patterns. The thermometer is usually located within the wheel arch, and so the car should be moving for at least 5 minutes before the temperature is recorded.



Infra-red thermometers are an affordable, robust and easy to use option which allow you to record small scale variations in temperature as well as the temperature of distant objects, such as clouds. IR thermometers show the temperature of an object by measuring the heat from it; it doesn't matter how close or far away it is, as long as it fills the field of view. Typically, this means that an object 10m from the thermometer needs to be 1m big to be able to measure its temperature. An object 10km away needs to be 1km big. To measure air temperature using an IR thermometer, hold a piece of white paper in the air for a few minutes to allow it to adjust to the local temperature, then use the thermometer to measure the temperature of the paper. IR thermometers will not need to be shielded from the Sun's light. More complete information is available at <http://www.metlink.org/wp-content/uploads/2013/06/Infrared-Thermometer-Worksheet.pdf>



Recording data over a few days for microclimate studies used to be both difficult and expensive. Affordable USB dataloggers have revolutionised this. They contain a sensor (of temperature, humidity for example), processing electronics and a logger with memory that can store many thousands of readings. They are left to record for days or weeks, then plugged into a PC USB port, and the data downloaded usually as an Excel spreadsheet and a graph. They can be weatherproofed using small waterproof containers, allowing them to be left outside for lengthy periods of time.

### Humidity

Traditionally, humidity was recorded using wet and dry bulb glass thermometers, but these are fragile and cumbersome, and tables are needed to calculate humidity. A cheaper and more practical solution is to use a digital hygrometer – these mainly come with temperature as well, such as in the right hand thermometer image above.

### Rainfall



Rainfall is easy to measure using simple, cheap manual rain gauges such as that shown above. The rainfall amount should be recorded at the same time each day, and then emptied. To avoid the gauge being blown over by the wind, it should either be placed in a slight hole in the ground, or partially buried in a flower pot or similar.

It is also possible to make a rain gauge using a large fizzy drink bottle. Cut off the top 10cm or so of the bottle, invert it and push it back into the remaining bottle. The most accurate way to use such a gauge is in conjunction with a measuring cylinder – pour any water into the cylinder on a daily basis. You'll need to account for the aperture of the bottle to convert the ml collected into mm of rainfall.

Automatic, wired or wireless, rain gauges can be purchased, either on their own or as part of a weather station (see below). These work with a tipping bucket – counting the number of times a small bucket (typically holding 0.2mm of rainfall) fills and tips.

If possible, rain gauges should be positioned in a well exposed position, away from any walls or trees.

All rain gauges should be checked for slugs, spiders' webs, leaves and other debris on a regular basis.

### Pressure

Pressure is a relatively easy weather element to record, as there are no small-scale variations. The pressure recorded inside a building will be the same as the pressure recorded outside. Many simple instruments, such as indoor thermometers and watches, now report pressure. Gadgets which display a simple weather forecast (usually a sun or rainfall symbol) make these forecasts based on pressure changes, equating a falling pressure with a likelihood of rain.

Although it is possible to make a barometer, either with liquid in a tube or a simple aneroid type barometer, such instruments invariably respond to temperature changes as well as pressure changes.

So that pressure at different weather stations can be used to draw up a weather map, Atmospheric pressure is always quoted as what it would be at mean sea level. Pressure increases/decreases by roughly 1 hPa per 10 m decrease / increase in height respectively, although the actual value of the correction to mean sea level will vary with both air temperature and barometric pressure. To accurately set a barometer, you'll need to calibrate it to a local Met Office weather station on a calm day (see below for sources of weather data)— this will already have been corrected to sea level. Subsequently, you can use your barometer either to record changes in atmospheric pressure (if you leave the barometer in the same place) or changes in altitude (if you carry it up a mountain at a time when the atmospheric pressure isn't changing much).

Because pressure does not tend to have small scale variations, it is the easiest data to obtain from a secondary source close to your area of study. The pressure a few tens of km away will be very similar to the pressure at your area of study on a calm day, because there will only be small differences in pressure across a wide area.

### Light



Fieldwork investigations are sometimes connected with other aspects of the environment such as plant growth, forest density, etc, for which light levels are also required. These can be measured with a simple hand-held light meter such as the one illustrated. USB dataloggers are also available to record light levels.

## Wind Speed and Direction



With anemometers, you generally get what you pay for. Cup anemometers (left) are best, because they work whatever direction the wind is coming from. However, they can be expensive and are very delicate. Propeller anemometers (centre) can be much cheaper. However, the propeller has to be pointed into the wind to get a good reading; the wind direction can be hard to judge when the wind is weak or gusty.

Bubbles are a simple, cheap (and fun) alternative – mark out 5 paces in the direction the bubbles are travelling (roughly 5m) and record the length of time it takes the bubbles to travel that far. The most accurate estimate of wind speed will be obtained if the time is measured several times, and if the same person is used to mark out 5 paces every time the method is used. In conjunction with a compass (traditional or smart phone) the wind direction can also be recorded, by following a series of bubbles and then measuring the bearing back to your starting point – as wind direction is the direction the wind has blown **from**.

Smartphone anemometers can also be either cup-type or propeller-type. Using the smartphone compass, propeller type anemometers can also give wind direction. Some smartphone anemometers struggle to record low wind speeds.

Wind speed will vary with height from the ground. Measurements should therefore always be made at the same height – for example as high as you can reach. Buildings, vegetation etc. will have an impact on wind speed and direction.

### Air quality

The availability of relatively cheap sensors to record pollutants such as NO<sub>2</sub> and ozone means that both the instruments and the data they collect are now more readily available. However, a lack of testing means that the accuracy can be very low – and any differences in air quality they collect should be treated very cautiously.



### Complete Weather Stations



A complete wireless electronic weather station can be used to measure pressure, temperature, wind speed/direction, humidity and rainfall. The measuring instruments, typically mounted on a pole attached to an outbuilding, transmit data to an inside display unit. The data can be downloaded continuously (or in batches) to a PC. It can also be put online with thousands of others through websites such as the Met Office's Weather Observations Website (WOW). Such weather stations are best used in one location, showing changes over time.



Cheaper automatic weather stations measure many of the same variables as their more expensive counterparts but do not, generally, record information or allow you to upload it to a computer. They usually also suffer from inadequate thermometer shielding, so will tend to overestimate temperatures when the sun is shining onto the station.

The location of automatic weather stations is often a compromise between exposure, access and security. A wall mounted station won't make measurements which are as accurate as a station which is located in an open space.



Hand-held automatic weather stations record the same range of variables as their larger counterparts (except rainfall), with the benefit of being more portable, allowing them to be used in a variety of locations. For accurate wind speed and direction, they should be used in conjunction with a tripod and wind vane. Some models allow data to be downloaded to a computer. Before use, the pressure should be calibrated (see above).



A newer development is the availability of an (almost) complete weather station that plugs into a smartphone. These can measure and log temperature, humidity, windspeed and pressure, although (perhaps not surprisingly) rainfall. The accuracy of such devices is relatively untested.

### **Secondary Data**

Different types of weather data are available on many sites, including:

#### *Current Weather Observations*

The Met Office <https://www.metoffice.gov.uk/public/weather/climate-network/#?tab=climateNetwork> weather observations and <https://www.metoffice.gov.uk/public/weather> forecast.

The <http://wow.metoffice.gov.uk> Weather Observations Website (WOW). This network is mainly of amateur observations, which can be unreliable but are widespread. Met Office observations are also shown with the label "Official observations".

<http://www.met.reading.ac.uk/~brugge/UK1.html> Reading University's weather data page.

#### *Rainfall Radar*

<https://www.metoffice.gov.uk/public/weather/will-it-rain-today> Met Office rainfall forecast.

<https://www.netweather.tv/live-weather/radar> Netweather.

<http://www.raintoday.co.uk> Rain today.

#### *Lightning Observations*

<https://www.lightningmaps.org/> Lightningmaps.org.

[http://en.blitzortung.org/live\\_lightning\\_maps.php](http://en.blitzortung.org/live_lightning_maps.php) Blitzortung.

#### *Model Data*

<https://earth.nullschool.net> earth.nullschool.net.

<https://www.windy.com/> www.windy.com.

#### *Archived Weather Charts*

[http://www1.wetter3.de/Archiv/archiv\\_ukmet.html](http://www1.wetter3.de/Archiv/archiv_ukmet.html) wetter3.de

<http://www.wetterzentrale.de/reanalysis.php?map=1&model=bra&var=45>

wetterzentrale.de

#### *Satellite Images*

<https://en.sat24.com/en> sat24.com

<http://www.sat.dundee.ac.uk> Dundee Satellite Receiving Station

The Royal Meteorological Society loans weather instruments to students free of charge

<http://www.metlink.org/observations-and-data/instruments/> . Further information about weather instruments and data sources can be found on the MetLink website.