Geofile Online
SEPTEMBER 2002
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ALAN CLOWES

MICROCLIMATES

All geographical areas contain small-scale variations in the atmospheric conditions. Sides of a hill have different temperatures at different times of day. Opposite sides of a wood have different rainfall patterns, depending on the wind direction, and the vertical variation of temperature in mountains, in woodland and over cropland is well known. These local differences are known as 'micro-climates' and standard meteorological stations try to eliminate them.

The purpose of this **Geofile** is to give a practical guide to measuring these small-scale variations of the 'climate' and to give some ideas of what sort of study is likely to give you the best results. Figure 1 shows some of the geographical features which influence the climate. Wherever you live, there is bound to be some local variations in the climate which are easy to compare.

Setting up the study

Variations in the weather microclimate can be studied:

- over an area at one point in time (**spatial variation**) – the space may extend horizontally and vertically (Figure 4); or
- in one place at different times (**temporal variation**) (Figure 5); or
- by combining the two to look at spatial variation over time.

Most studies carried out by students look at short-term variations, ranging from a few hours to a few months.

Measuring the weather

There are many sophisticated systems for measuring and recording weather data. **Geofile** 407, 'Using ICT to Complete Geographical Enquiries', explained how you could use computers to measure and store atmospheric data. However, most of the equipment is expensive, your school or college may not have access to it, or may be reluctant to allow it to be used unsupervised or in remote locations.

Ideally the equipment should:

- be reasonably cheap and easy to obtain
- be light and portable and
- enable you cover a large area quickly.

Equipment like this may not give results to the standard of accuracy required by the Met Office, but it will be more than sufficient to show the variation over a short time period. The deficiency in accuracy is more than made up for by the number of readings you can take, and the area covered.

Survey methods

In order to cover an area with one set of equipment the usual method is to traverse and make your measurements at pre-selected sample points. These points can be at regular intervals, randomly selected, e.g. as a stratified random sample, or at key points, e.g. changes of slope.

Atmospheric variables

It is possible to measure a wide range of features of the atmosphere with simple equipment:

- rainfall
- temperature of the air, soil or ground surface
- humidity
- wind speed and direction
- light input
- soil moisture
- evaporation.

Measurement

There are some instruments which you can make yourself:

Rain gauges can easily be made from a plastic screw top lemonade bottle, but they have the habit of falling over in the wind. Putting a large pebble in the bottom will solve this and it will not affect your results (Figure 2).

The amount of rainfall is always given in millimetres (mm). This is calculated by measuring the volume of rainfall collected in the rain gauge in millilitres (ml) and dividing it by the area of the rain gauge cross-section.

Figure 2: DIY weather measurements

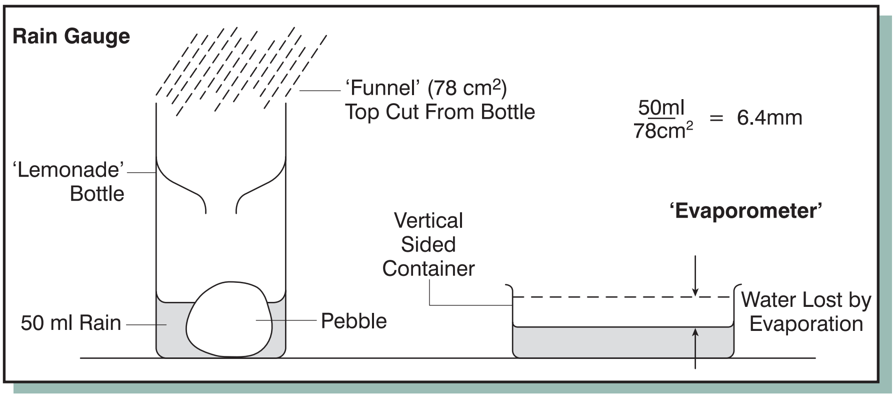
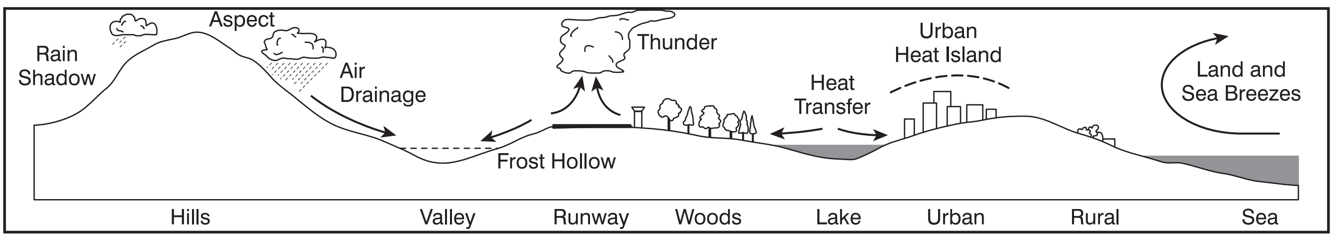


Figure 1: Some influences on microclimate



If you collect 50 ml of rain it would represent 6.4 mm of rainfall, which would be a very heavy day of rain. You are unlikely to collect this much from one storm. Generally you need an intense rainstorm, or to leave them out for a few days to collect an appreciable amount of rain. It is best to target a good thunderstorm or depression coming by watching the weather forecast.

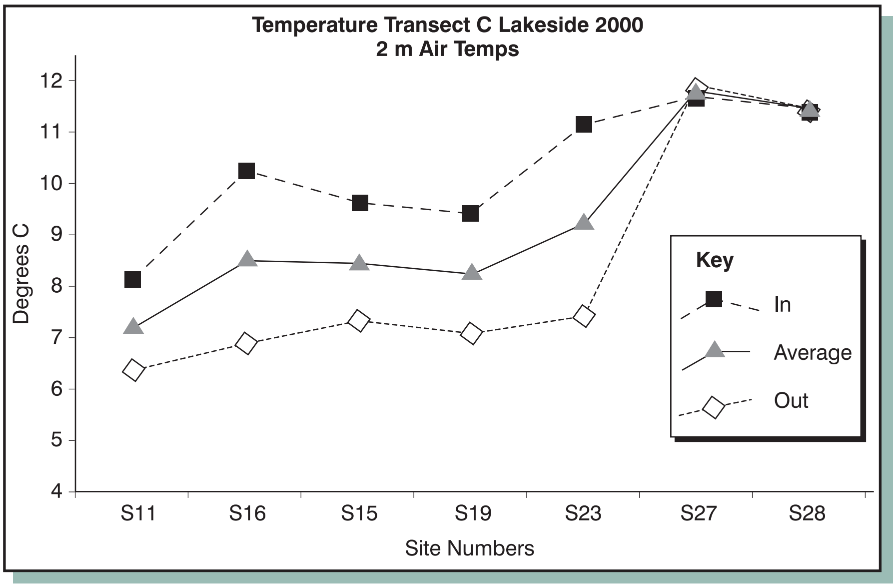
Rainfall is affected by many of the features shown in Figure 1. Around buildings, individual trees, inside and around woodland, the opposite sides of lakes, on windward and lee hill slopes are all potential areas for carrying out rainfall studies.

Temperature can be measured on the ground surface, at various heights in the air, or beneath the surface. The standard way of doing this is by using a mercury thermometer. For measuring air temperatures, these should be shielded from the sun. Cover a toilet roll with aluminium foil and tape the thermometer inside. A simple aquarium thermometer with a probe on a wire can be taped to a stick and will enable you to measure up to 3 or 4 m above the ground, where there is often a great deal of variation. You can even place the thermometer into trees if you are interested in the effect of vegetation. For ground surface temperatures, use the aquarium thermometer either shielded, which gives a more accurate impression of the surface temperature, or just placed on the surface, where it will act like a radiometer, indicating the solar input. Most of these sensors are black so they rapidly absorb incoming short-wave solar radiation.

The problem with temperature measurement is that of rapid change. The way to overcome this is to traverse the points going out, and then return to the start measuring the same points in reverse order. Taking the average 'in' and 'out' readings at each point eliminates the time difference in taking the readings. Figure 3 is a record of a traverse at the edge of Windermere on a clear, bright March morning. You can see the temperature has risen about 1.5°C in an hour between the 'out' measurement of the first point and the 'in' measurement.

Rapid measurement of the temperature makes it possible to show how factors like wind, water bodies, woodland, slopes and aspect influence

Figure 3: Temperature transect, Windermere, March 2000

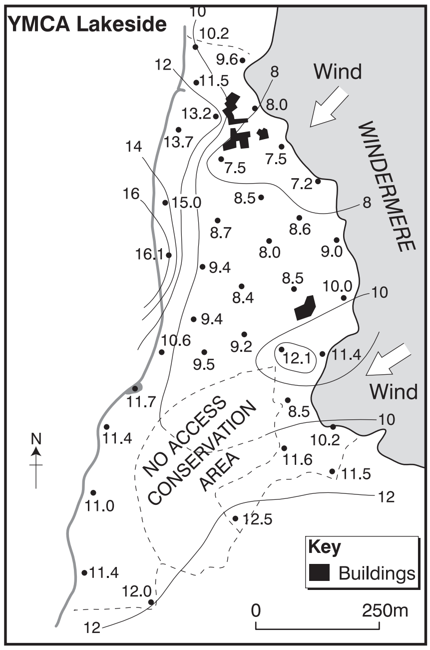


the microclimate. Figure 3 was part of the morning survey shown in Figure 4. The large area between 8 and 10°C in the centre of the map was woodland, which insulated the surface. Two tongues of relatively cool air were spreading into the area on a light NE wind from the bays on Windermere. The higher temperatures on the west side were in more open ground on a hill slope which faced the rising sun. Downwind of each of the buildings are warm spots which could be due to 'heat islands' from the buildings, or to warming up of the road surfaces in the sun.

Figure 5 shows two of nine sites a student visited in succession over almost 24 hours. He took about 40 minutes to visit all the sites on each traverse. The diurnal and vertical fluctuations of temperature were much greater in the dunes. In the wood, the effect of the trees was to moderate the temperature changes. The humidity fell steadily at both sites, but the dunes' humidities were erratic. The high temperature at the surface at 1600hrs in the dunes is probably due to the sun heating up the sensor on the aquarium thermometer.

Surface temperature is determined by albedo, which is a measure of the reflectivity of the surface. A black tarmac road reflects very little and the incoming solar short-wave radiation is transformed into sensible heat energy (i.e. you can feel it), which can be seen making the road steam after rain.

Figure 4: Temperature survey – air temperature at 1m, 10.00 am 22.3.2000



In towns and cities the concrete of buildings acts in the same way but the surface is topographically rougher and multiple reflection between the buildings causes them to heat up further. Thunderstorms are therefore more frequent over built-up areas. On sunny days temperature traverses can show considerable differences, revealing urban 'heat islands'. The temperature of the rural areas to the south of Vancouver, shown in Figure 6, is about 17°C. The edge of the built-up area causes a steep rise in temperature, 'the cliff', to the 'the plateau' at about 23–25°C. In 'the peak', over the CBD, here split into two by the water area of the harbour, temperatures rise to about 27°C. Heat comes from the sun in the day but

Figure 5: Temperature and humidity surveys of dunes, 6.9.1998

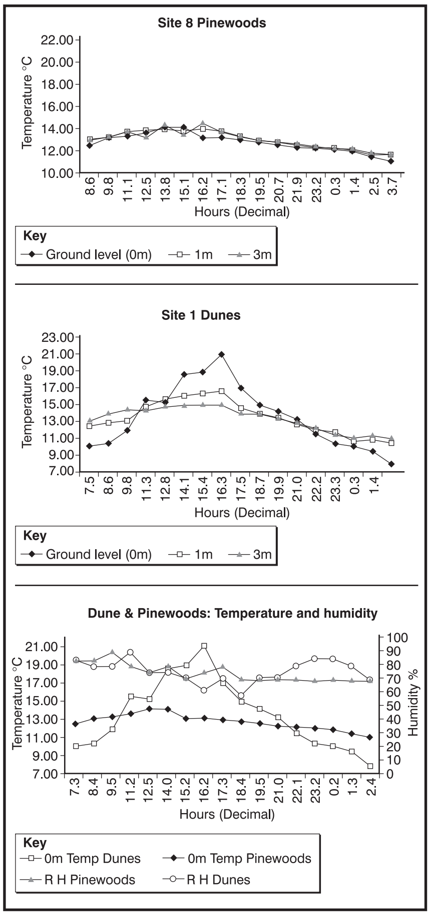
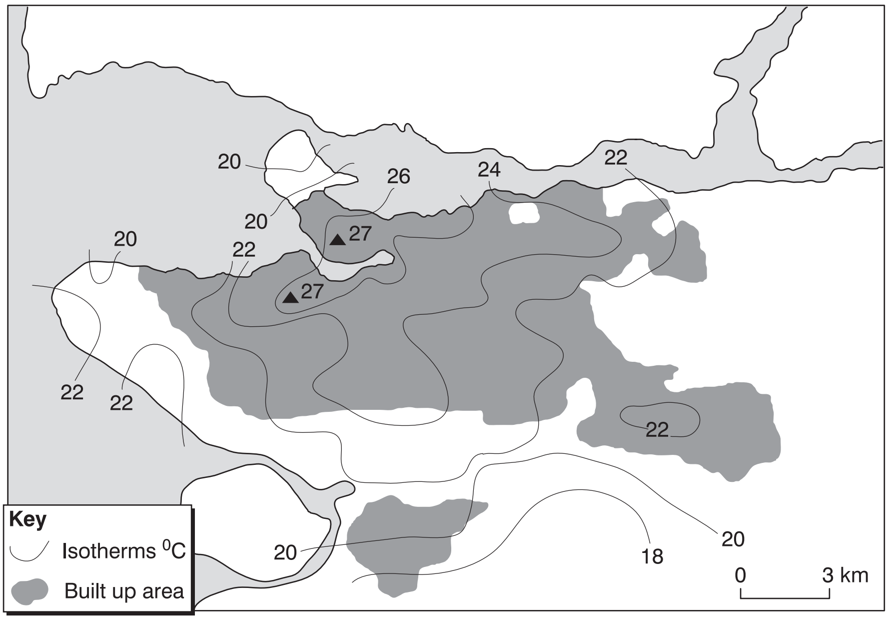


Figure 6: Vancouver temperatures



also from traffic and from the heating and cooling systems in the buildings during the night. A city like Vancouver is too large for an individual to study, but parks, lakes, woodland, industrial zones and areas of different building density all show differences, particularly on still nights when mixing with air from the rural areas is at a minimum.

Humidity is measured by a whirling psychrometer which has a wet and a dry bulb thermometer. The two readings enable the percentage relative humidity (RH) to be read from tables. There are many electronic humidity meters available. They give a quick reading of the RH but are not as flexible as the electronic thermometers and require a little more care to keep them functioning.

Lakes and woodlands cause the humidity to vary considerably, but the results of humidity surveys are less varied if the winds are above force 4 (8m/s). The humidity variation over a day is shown in Figure 5 and the cool air from the lake shown in Figure 4 was significantly more humid.

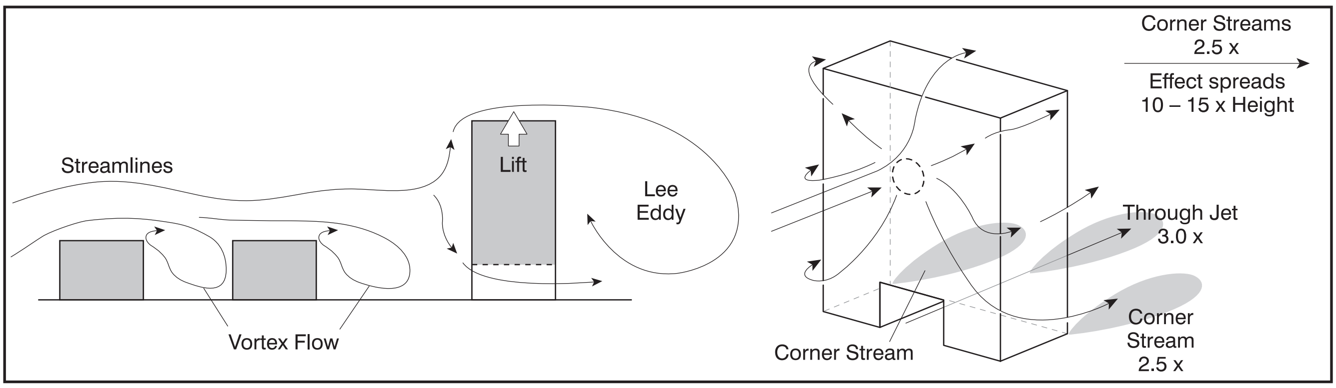
Soil moisture can be measured quickly with a garden soil moisture meter. These work better in clayey or silty soils. Soil moisture meters can be combined with a light meter, in order to compare inputs into woodland.

Evaporation is perhaps the easiest variable to measure. Simply record the fall in the level of water in a container placed at the site (Figure 2). Minimise the error by selecting standard size containers and placing them in the shade

Wind speed measurements, particularly light winds, to have any degree of accuracy require more expensive equipment. Wind meters are small and durable and there are many investigations possible in urban and rural areas. Streets act like funnels and studies have shown that winds can be increased by up to 2½ times in the 'corner stream'. Figure 7 shows where the windiest places are likely to be. Eddies form in the lee of buildings, and wind directions are reversed. 'Jetting winds' up to three times the normal street level wind occur where buildings have underpasses or are raised up on stilts. Some building designs have had to be modified because of their effect on the wind.

In towns with gridiron street plans, the wind blowing down the streets should be significantly faster than in

Figure 7: The effect of buildings on wind flow



Source: Oke (1978) Boundary Layer Climates

Orientation of street	Speeds over 5m/s		Speeds under 5 m/s		Total
SW-NE	16	10	9	10	26
SE-NW	8	10	7	10	15
					40

those that are transverse to the wind. The results of a survey of 40 points in one such town show some evidence of this, although testing by the Chi Square method showed that the pattern could have occurred by chance almost 5 times in 100. The student who made this study was not convinced of the funnelling effect. He concluded that windier days probably accentuate the effect and that the buildings were not high enough to create a real problem.

Exposure to the wind can be gauged using the TOPEX (Topographic Index of Exposure). Foresters use this index to assess the best place to site trees when planting new woods. It can be adapted to measure exposure anywhere and fits our criteria of being light, portable and cheap. A compass and simple clinometer will give more than adequate results. Measure the angle to the horizon at each of the eight main points of the compass (Figure 8). Upward readings are + (plus), and downwards - (minus). Simply totalling the readings in degrees will give you an index of exposure. A negative total is very exposed and represents a hill, positive values a depression.

The readings in Figure 8 are from a site that is protected from the N and NE, where the readings are positive, but exposed to the SW. These readings can be plotted in Microsoft Excel as a 'radar' diagram and positioned on the map to show site exposure.

Exposure can be related to wind speed and used to explain the effect on vegetation, soil moisture, humidity and plant growth.

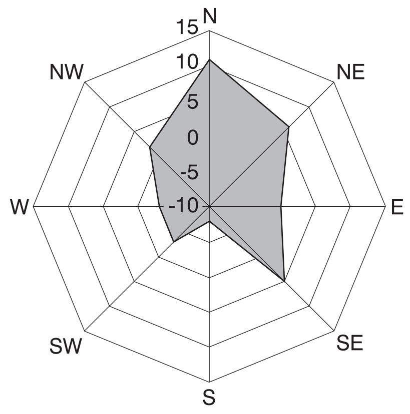
In dunes the effect of the vegetation on the wind is not greatly different between the seasons but in woodland there can be a significant variation with leaf cover. You may not have time to conduct your study over the seasonal variation, but Figure 9 shows the influence of tree cover on the wind. Investigating wind speeds in the trunk space in relation to tree spacing can be successful.

Wind speed	Effect
5m/s	Disturbs hair, clothing flaps
10m/s	Difficulty experienced in walking, dust and litter swirls
20m/s	Potentially dangerous for old and frail

Conclusion

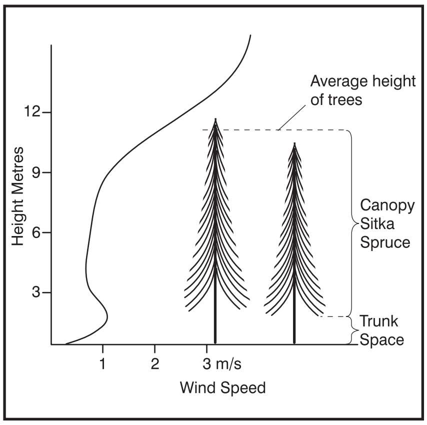
Once you have made your study you may need to compare your readings to standard meteorological ones. There are many web sites to enable you to do this. Reading University Meteorology Department has many links to weather recording sites and has an on-line weather station, www.met.rdg.ac.uk/Data/Brugge.

Figure 8: Exposure readings, plotted as a 'radar' diagram



Direction	Angle
N	+11
NE	+6
E	0
SE	+5
S	-8
SW	-3
W	-3
NW	+2
Index	+20

Figure 9: The effect on wind speed of tree cover



Focus Questions

1. Design a recording sheet for a survey of temperatures and wind speeds in a town with a gridiron road pattern. Explain how you would site your sample points.

2. Explain how you would conduct a survey of the influence of a small rectangular wood in an area of arable land . Explain what differences you might expect to find.

3. Construct a matrix to summarise the climatic differences between urban and rural areas.