Geo Factsheet

Number 50

Urban Microclimates

Defining climate and weather

The term climate refers to the state of the atmosphere over a period of not less than thirty years. It includes variables such as temperature, rainfall, winds, humidity, cloud cover and pressure. It refers not just to the averages of these variables but to the extremes as well. By contrast, weather refers to the state of the atmosphere at any particular moment in time. However, we usually look at the weather over a period of between a few days and a week. Climate and weather are affected by factors such as atmospheric composition, latitude, altitude, distance from the sea, prevailing winds, aspect, cloud cover and increasingly, human activities.

What is a microclimate?

A microclimate is the distinctive climate of a small area. For example, coastal areas have land and sea breezes and are generally mild in winter and cool in summer. Mountain climates have valley (ascending) winds and mountain (descending) winds. Forest climates are less windy, more humid, and have a more even seasonal and diurnal (daily) temperature range than open grassland. Urban climates differ from rural climates in many ways - notably in terms of heat, rainfall and wind (Table 1).

Table 1. Average changes in climate caused by urbanisation

Factor		Comparison with rural environments
Radiation:	Ultraviolet, winter	30% less
	Ultraviolet, summer	5% less
	Sunshine duration	5-15% less
Temperature:	Annual mean	1°C more
	Sunshine days	2-6°C more
	Greatest difference at night	11°C more
	Winter maximum	1.5°C more
	Frost free season	2-3 weeks more
Wind speed:	Annual mean	10-20% less
	Gusts	10-20% less
	Calms	5-20% more
Relative humidity:	Winter	2% less
	Summer	8-10% less
Precipitation:	Total	5-30% more
	Number of rain days	10% more
	Snow days	14% less
Cloudiness:	Cover	5-10% more
	Fog, winter	100% more
	Fog, summer	30% more
	Condensation nuclei	10 times more
	Gases	5-25 times more

Exam hint *- Candidates should concentrate on the reasons for the differences between rural and urban areas and not the percentage increase or decrease of particular factors.*

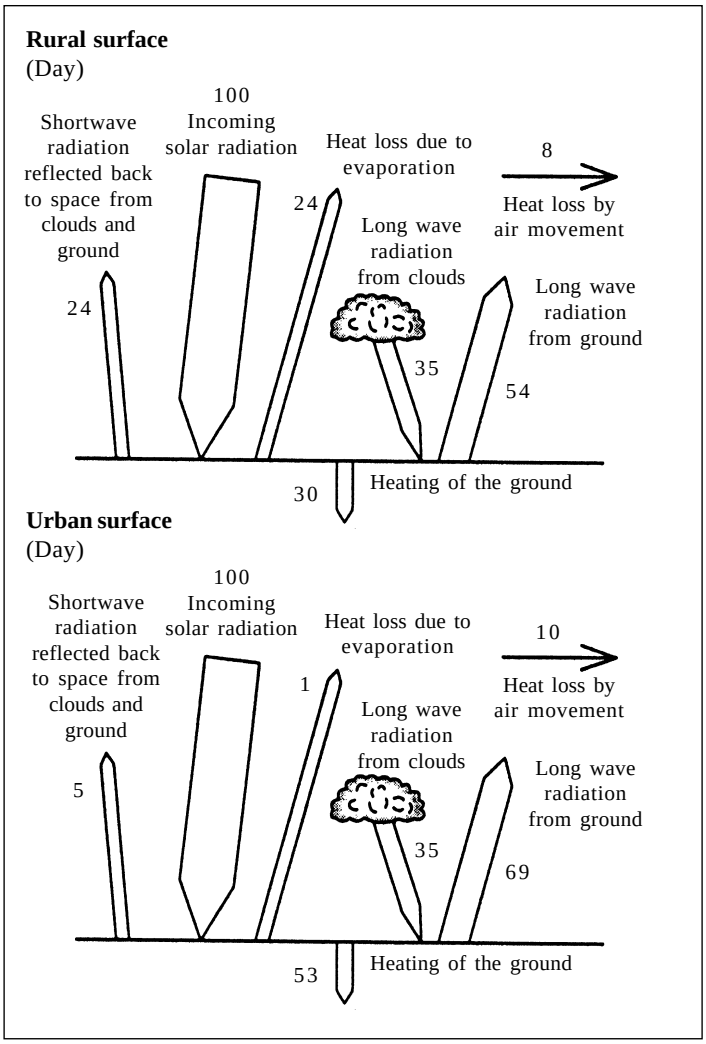
Urban heat islands

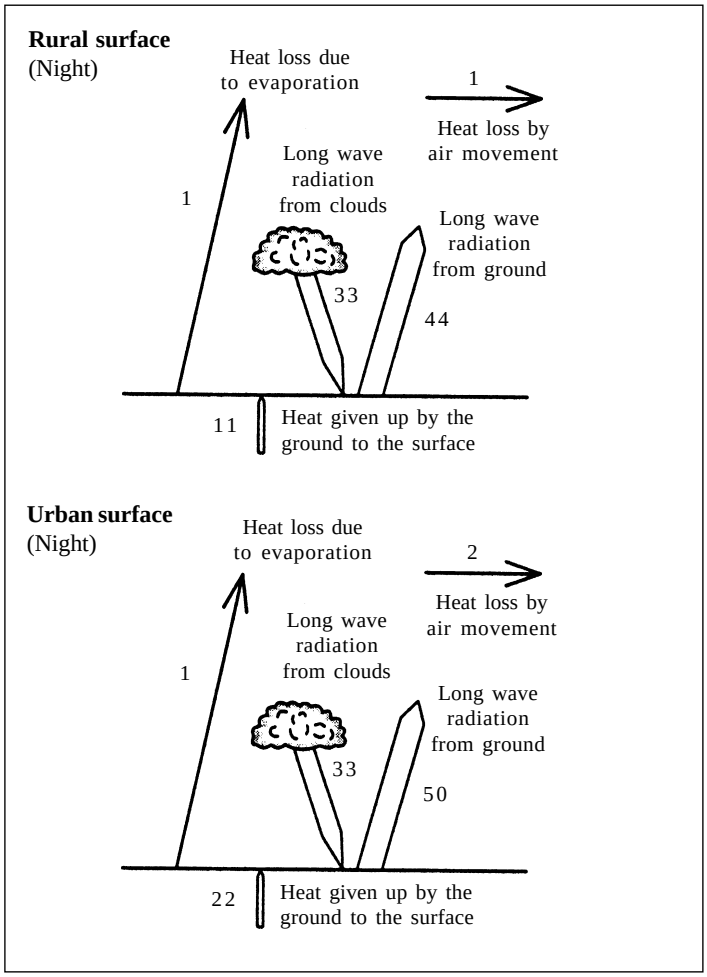
The energy that drives all weather systems and climates comes from the sun. However urban areas tend to be warmer than surrounding rural areas because:

1. Industries, homes and vehicles burn fuel which release heat.
2. Air polution from cars and industry traps radiation in urban areas.
3. Building materials such as concrete, glass, bricks and tarmac absorb large quantities of heat and release them slowly by night.
4. There is a relatively small amount of water in urban areas, so little energy is used for evapotranspiration, hence more is available to heat the atmosphere.

Fig 1 illustrates the energy transfer in rural and urban locations during the day and night. Note the high level of radiation that is reflected during the day in rural locations compared to urban ones.

Fig 1. Energy transfer in rural and urban locations during the day and night (arbitrary units)

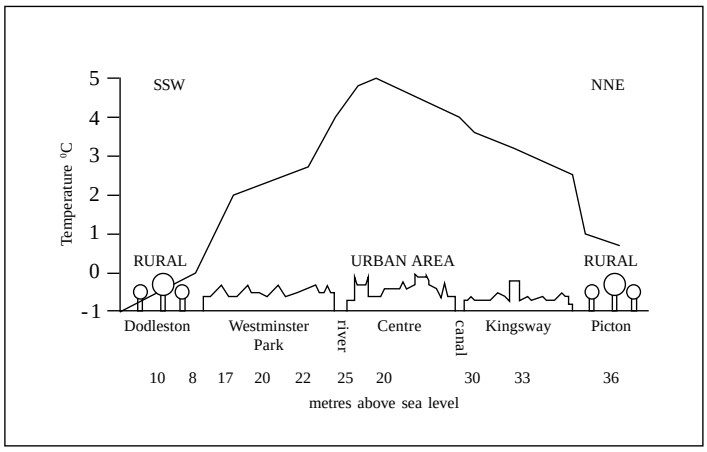




The contrasts between urban and rural are greatest under calm, high pressure conditions. The term **urban heat island** is given to describe the typical pattern of temperature in an urban area and its surrounding countryside. The typical heat profile of an urban heat island shows the maximum at the city centre, where building densities are highest, a plateau across the suburbs, and a temperature cliff between the suburban and rural areas (Fig 2).

Small scale variations within the urban heat island occur with the distribution of industries, open space, rivers, canals etc. Significant minor peaks of temperature may be located close to areas of manufacturing industry and energy production. By contrast, the rest of the suburban area shows a lower temperature, although still higher than the surrounding countryside.

Fig 2. Urban heat island in Chester



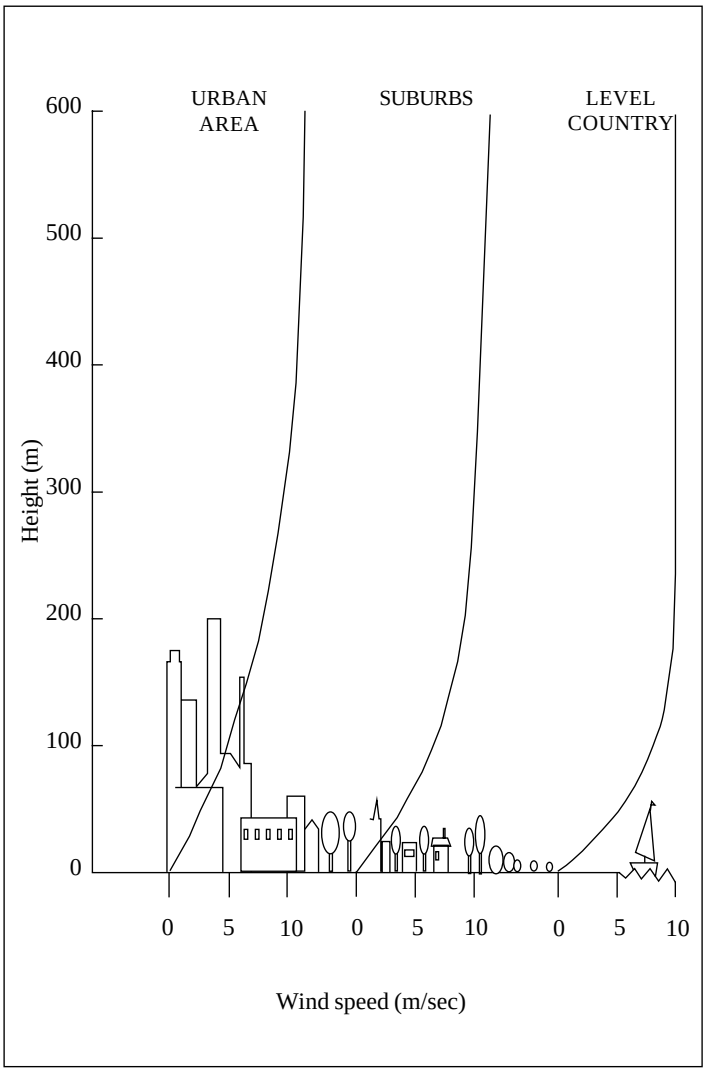
Changes in the nature of heat islands

The nature of heat islands may be changing. Recent research on London's heat island suggests that high levels of air pollution are actually decreasing the temperature by day, by blocking the radiation from the sun. However, by night, the same pollution is trapping heat within the urban area. Thus, the difference between urban and rural temperatures during the day may be decreasing.

Urban winds

Fig 3 shows the effect of tall buildings on wind speed. Note that the graph representing the urban wind speed is very steep compared to the graph for suburbia or level country. This indicates that wind speed is slower at lower altitudes in urban areas because winds are slowed and deflected over tall, buildings.

Fig 3. The effects of terrain roughness on wind speed



Winds are affected by the shape of buildings in urban areas as well as by their size. Turbulence is caused by the very uneven nature of the urban skyline. Strong pressure gradients develop between the windward and leeward side of buildings and can lead to severe eddying of winds.

Under calm, high pressure conditions, country breezes blow from the colder rural areas to the warmer urban areas. This is because, as warm air rises it creates a centre of low pressure below it. Air blows from high pressure to low pressure, thus winds converge on central areas and may bring pollution from outer areas into the city centre.

Urban Pollution

Urban and industrial areas generate huge volumes of pollution. Many of the particles are hygroscopic (water attracting) hence water vapour condenses around them. As a result, hours of sunshine are reduced in urban areas and fogs and smogs are more common. Pollution control measures, and the decline in coal as a source of energy has resulted in less SO_2 pollution and thus the amount of fog in UK urban areas.

Urban precipitation

Climatologists have demonstrated the effect of air pollution in urban areas on precipitation since the early part of the twentieth century. Rochdale, for example, had significantly less rainfall on Sundays when the mills and factories were not producing smoke (condensation nuclei). Rainfall is generally more frequent in urban areas due to raised levels of condensation nuclei in and downwind of the urban area. These changes often cause:

- More rainfall, especially in summer
- Heavier and more frequent convective rain storms and thunder

However, in urban areas there is a relative lack of moisture, this is due to:

- Lack of vegetation
- High drainage density (sewers and drains), which remove water

Thunderstorms are aslo more common. This is partly due to warmer temperatures over urban areas and stronger convectional uplift. Snow is less common due to the increase in temperature. Relative humidity may be reduced because of the higher temperatures and the lack of moisture in urban areas (Table 1, Page 1).

Advantages and disadvantages of urban microclimates

The characteristics of urban areas, such as little vegetation cover, high buildings, the generation of pollution and the radiation of heat, combine to form a very different climate to that of the surrounding rural areas. Some of the effects are beneficial and others are undesirable (Table 2).

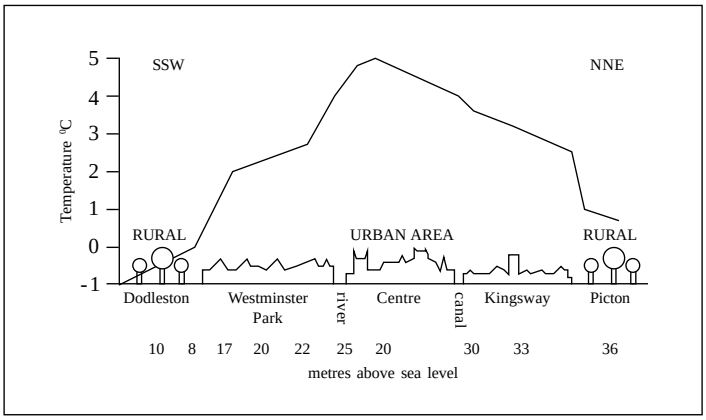
Table 2. Advantages and disadvantages of urban climates.

Advantages	Disadvantages
lower heating bills	increased air conditioning bills
reduced wind speeds	increased wind turbulence
less frost	increased number of thunderstorms
less snow	pollution
quicker melting of snow	greater cloud cover, therefore less sunshine
overall reduced atmospheric humidity	high temperatures may be linked to aggressive behavoiur
	particulate smogs
	photochemical smogs

Exam hint *- Many candidates emphasise the disadvantages of urban microclimates but struggle when asked to state their advantages.*

Practice Questions

The diagram below shows a heat island in chester



1. (a) Describe the temperature relationships shown. (2 marks)

   (b) Explain the temperature relationships shown. (2 marks)

   (c) Suggest *two* advantages of the urban heat island effect. (2 marks)

   (d) Suggest how atmospheric pollutants can lead to;

   (i) Increased rainfall. (1 mark)

   (ii) Decreased temperatures. (1 mark)

Answers

Marking points are shown by semicolons

1. (a) Highest temperatures in city centre/central business district;
   temperatures decrease in suburbs;
   large temperature decrease between suburbs and rural areas;

   (b) Combustion processes in city centre creates heat;
   credit examples e.g. vehicles/industry/homes/buildings;
   little energy used in evaporative processes;
   accept converse in rural areas;

   (c) Lower heating bills;
   less frost/snow;
   less inconvenience/accidents;

   (d) (i) More particulates/hygroscopic/condensation nuclei;

   (ii) Particles/soot/clouds etc. block insolation;

Acknowledgements;
This Geo Factsheet was researched and written by Garrett Nagle

Curriculum Press, Unit 305B, The Big Peg,
120 Vyse Street, Birmingham, B18 6NF

ISSN 1351-5136