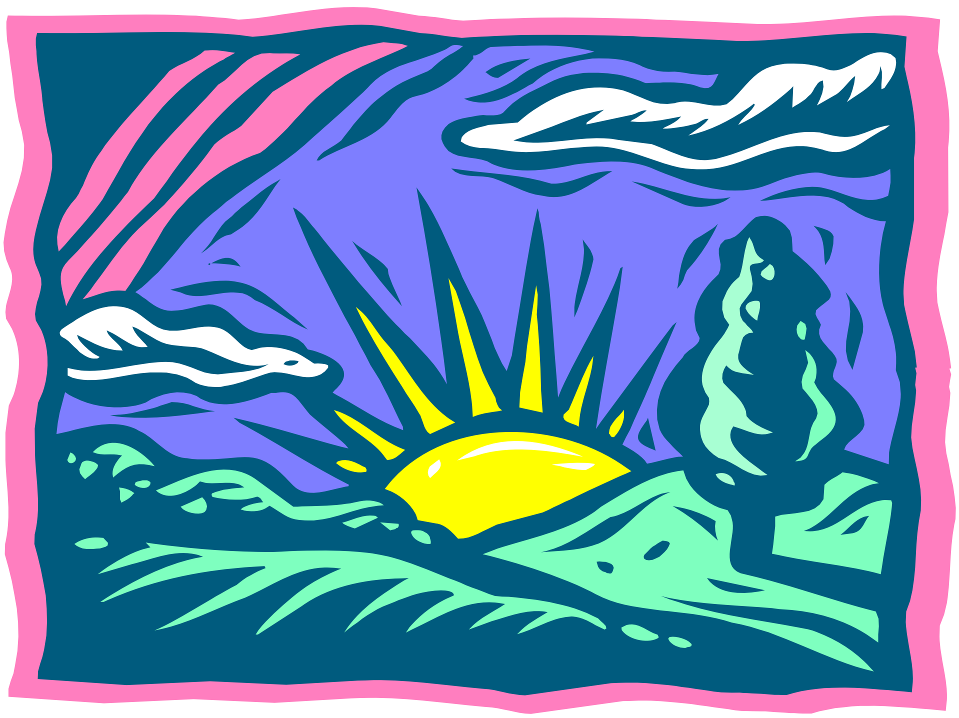
INVESTIGATING CLIMATES ON A LOCAL SCALE:
URBAN CLIMATE IN MENDE



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INVESTIGATING CLIMATES ON A LOCAL SCALE: URBAN CLIMATES

TEACHERS' NOTES

It is possible to carry out an investigation of the effects of urban areas upon local climates. The small size of Mende allows data to be collected over much of the town, in a way more difficult in a larger urban area.

The role that relief plays in affecting the urban microclimate of Mende is also examined within this unit.

This unit could be combined with other urban or climate work.

Students will need to work in small groups to collect data. Regular meetings should be arranged to ensure that all students are present and safe.

REFERENCE TEXTS

Burton, S & Jeanes, A. (1997) "*Central Southern France*". Hodder and Stoughton.

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Waugh, D. (1995) "*Geography - An Integrated Approach*". Nelson.

Specification Links

AQA A2 Unit 3 (GEOG3) Contemporary Geographical Issues

Weather and Climate and Associated Hazards

- Climate on a local scale: Urban climates

WJEC A2 G3 Section B Individual Research Enquiry

- G3 B6 Microclimates

International Baccalaureate Diploma Programme

- 3.6.3 Local Climate Change – Modification of urban micro-climates.

INTRODUCTION

GENERAL INFORMATION

Local climates or microclimates relate to a small area and possess clear contrasts with other nearby areas. The space studied could be very small (a garden) or large (a city). Localised changes in the environment can lead to pronounced changes in temperatures, wind speed, humidity and precipitation. These in turn may lead to changes in air quality due to the build up of atmospheric pollutants**.**

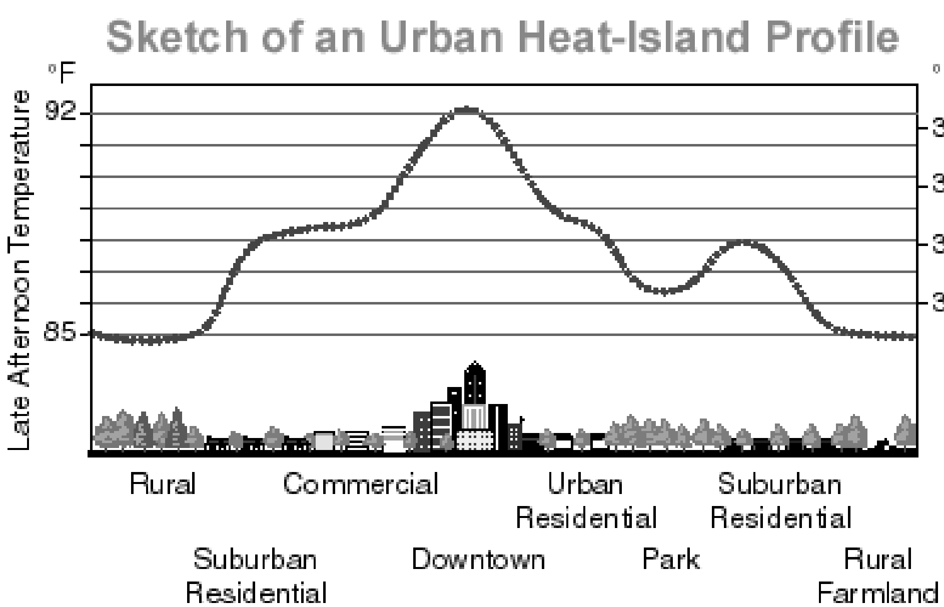
Urban Microclimates

One of the most distinctive and varied of all local climates is that of urban areas. Changes made to the natural environment provide a clear example of a positive feedback. Human activities disturb the system to such an extent that some processes are exaggerated, such as increases in temperature. This in turn may lead to other effects such as reduced humidity. Urban microclimates are therefore recognised to have important social, economic and ecological effects.

Temperatures

Large cities and conurbations experience climatic conditions different from the surrounding countryside. In many European and North American cities, average minimum winter temperatures are 1 – 2^{o}C higher than the surrounding rural areas. The term URBAN HEAT ISLAND (Figure 1) is used to acknowledge temperature increases within urban areas.

FIGURE 1



This is a result of a number of characteristics of the urban environment:

- Buildings have a higher capacity to retain and conduct heat than soil and vegetation. Also darker surfaces (such as roads and car parks) will heat up more quickly. This heat is then stored and released during cooler periods or at night. The result is a smaller diurnal and seasonal temperature range.

- The release of energy through the heating (and poor insulation) of buildings, by industries and transport systems is a major potential source of heating. Only 10% of a conventional light bulbs energy is used to produce light, most of the rest is released as heat. Energy from heating in some large European cities has reached 25 W/m^2 which exceeds local inputs of energy from the sun.

- Lower wind speeds allow the heat to build up in areas. Even where wind speeds may be increased through local factors, a heat island effect can still be observed.

- Smog and pollution may trap outgoing radiation and help maintain higher urban temperatures.

- Localised differences in temperature within the urban area may be due to the effect of shading and exposure caused by buildings. This is often most effective where high buildings are present and/or the angle of sun rays is low.

Winds and Air Movements

The urban heat island effect seems to be capable of producing its own winds. Higher temperatures can lead to lower air pressure and the drawing in of air from the surrounding area. It is possible that this effect may prevent the build up of heat islands in smaller towns.

Urban areas also create their own relief and landscape features. Wind speeds are therefore much more variable since they are affected by buildings and street layout. Strong gusts may occur in streets roughly parallel to the wind direction whilst those at right angles remain comparatively calm. Increasingly architects and town planners must consider these effects when designing buildings and urban layouts.

Precipitation

A number of factors within urban areas may also influence precipitation. The higher temperatures, reduction in air pressure and drawing in of surrounding air can lead to upward movements of air. This in turn can encourage convectional rainfall. With very large buildings it may also be possible to produce an orographic or relief effect. In addition the huge quantities of dust and particles produced within cities (3 – 7 times greater than rural areas) act as hygroscopic particles (tiny particles around which water may condense). Studies have shown that cities have a higher incidence of cumulus cloud, greater precipitation totals and higher numbers of thunderstorms. Research by NASA showed that rainfall downwind of a number of urban areas was on average 28% greater and in some cases over 50% greater. Maximum rainfall rates were also shown to be greater downwind of these cities by up to 116%.

However, in spite of the greater rainfall, the lack of surface water, higher temperatures and impermeable surfaces result in lower humidity levels within urban areas.

Air Pollution

Stable atmospheric conditions, particularly when combined with the effects of relief and temperature inversions can result in hazardous air quality. With little air movement, pollutants cannot be dispersed horizontally and the inversion prevents vertical dispersion. High concentrations of particles can encourage the formation of

smog (a combination of smoke or pollution and fog that occurs when condensation takes place on particles). Photochemical smog is a reaction between vehicle exhaust (oxides of nitrogen and unburnt hydrocarbons) with sunlight and ozone. Smog is a severe meteorological hazard as it concentrates pollutants in air. Such conditions have caused many deaths in urban and industrial areas as well as exacerbating asthma and other breathing problems.
Pollution may also be seen in the blackening of buildings and damage to certain materials, such as limestone.

Ecological Effects
Although not as well recognised as other urban local climate effects, there are a number of examples of how urban ecosystems are being changed:

- Mating in moths may be affected by artificial lights.
- Concentration of insects around street lighting is concentrating feeding sources for birds and bats.
- Lichens have been shown to be very sensitive to air pollution and may not be present in many urban centres.
- The growing season for urban plants has been extended by the heat island and reduction in frost.

INVESTIGATION :	The effect of urban areas on microclimate – an investigation into local climate within the town of Mende.

AIMS

1. To identify how urban areas can influence local climate.

2. To use a range of techniques and equipment for the manual collection of climate data.

OBJECTIVES

1. To set up a series of stations to measure the diurnal changes in climatic factors which result from human urban infrastructure.

2. To understand the relationships between climatic variables.

HYPOTHESES

1. Proximity to the urban centre will result in:
   - Higher temperatures
   - Lower relative humidity
   - Lower wind speeds

2. Human made surfaces will heat up more quickly than natural surfaces.

3. Buildings will distort both wind speed and direction.

4. Shading by buildings will change the levels of light and temperature.

5. Surface temperatures will be greater than air temperatures.

6. Temperature and humidity will show a negative relationship.

EQUIPMENT

PER GROUP:

- Air Thermometer
- Ground thermometer
- Wind watch (or ranging pole, air thermometer, polystyrene chip and meter ruler)
- Whirling hygrometer
- Ground hygrometer
- Light meter (lux) or environmental comparitor

METHOD AND ORGANISATION OF STUDY

A number of microclimate stations are set up in the area to be studied. Sites selected should vary in distance away from the central square and reflect a number of different land-use types (e.g. dense urban, residential, open etc). Consult with your tutor about the most suitable sites and the number required. The minimum number of sites needed to carry out the Spearman's Rank Correlation Coefficient, is 8, but up to 20 sites can be accessed. The data collected can be compared with that from the Centre's automatic weather station, which can be used as another contrasting station or to show how the macroclimate can affect the microclimate. It is also important that all the groups collect their data in exactly the same way and at the same time, as class data will be collated later. Record the data on recording sheet 3. Readings will be taken at regular intervals during the study. An examination should be made of the characteristics of each site. The following climate factors are measured at each station:

Surface Temperature (^oC) – rest the pocket thermometer on the surface so that the bulb is in direct contact with the ground. The thermometer should be positioned in such a way that it can be read without being disturbed.

Air Temperature (^oC) - measure using the digital wind watch (set to temperature, ^oC). Hold at shoulder height, facing into the wind. If the wind watches are unavailable, use a thermometer held at 1.50m above the ground, turned out of direct sunlight. Allow one minute to allow the thermometer to equilibrate.

Wind Speed (m/s) and Wind Chill (^oC) - measure wind speed and wind chill using the wind watch (set to wind speed, m/s, and then temperature ^oC). Hold at shoulder height, facing into the wind. If the wind watches are unavailable, drop the polystyrene chip from 10cm above the top of the meter ruler held vertically, touching the ground. Measure the distance the chip is blown.

Wind Direction - ascertain the wind direction using a piece of grass thrown into the air (repeat as necessary) and record either as one of the major 16 points of the compass, or by taking a bearing using the compass.

Surface Humidity (%) – position the hygrometer on the surface of the ground. It is best if it is placed at an angle to facilitate reading. Record the humidity to the nearest percentage.

Air Humidity (%) – spin the whirling hygrometer for one minute. Calculate the difference between wet and dry bulb temperatures and use the chart to work out % humidity.

Light (0 – 10 or lux) – hold the environmental comparitor, or lux meter away from the body at shoulder height. The lux meter is simply calibrated to allow for higher light intensities.

RECORDING SHEET 1: CLIMATE IN URBAN AREAS

Site Number:	Time of readings:																			
Surface temperature (^{o}C)																				
Air temperature (^{o}C)																				
Surface Humidity (%)																				
Air humidity (%)																				
Wind speed (m/s)																				
Wind Chill (^{o}C)																				
Wind Direction																				
Light (0 – 10 or lux)																				
Record any changes in the weather during the study.(e.g. cloud cover, rain, wind, sun)																				

MEAN DATA SHEET: CLIMATE IN URBAN AREAS.

	Site Number:																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Surface temperature (^oC)																				
Air temperature (^oC)																				
Surface Humidity (%)																				
Air humidity (%)																				
Wind speed (m/s)																				
Wind Chill (^oC)																				
Wind Direction																				
Light (0 – 10 or lux)																				
Changes in the weather during the study																				

DATA ANALYSIS AND INTERPRETATION

There is a wide range of techniques that students can use to process and analyse their data. The following are just a few suggestions.

1. Calculate and record the mean value for each factor. Plot the mean surface temperature for each station on a map and show variation using isolines. This method can be repeated for each of the climatic factors.

2. Use line graphs to show relationships over time between the factors at a particular station. This can be compared to a contrasting station.

3. Use Correlation Analysis (Spearman's Rank) to test the validity of proposed relationships - for example between humidity and temperature or temperature against distance from buildings.

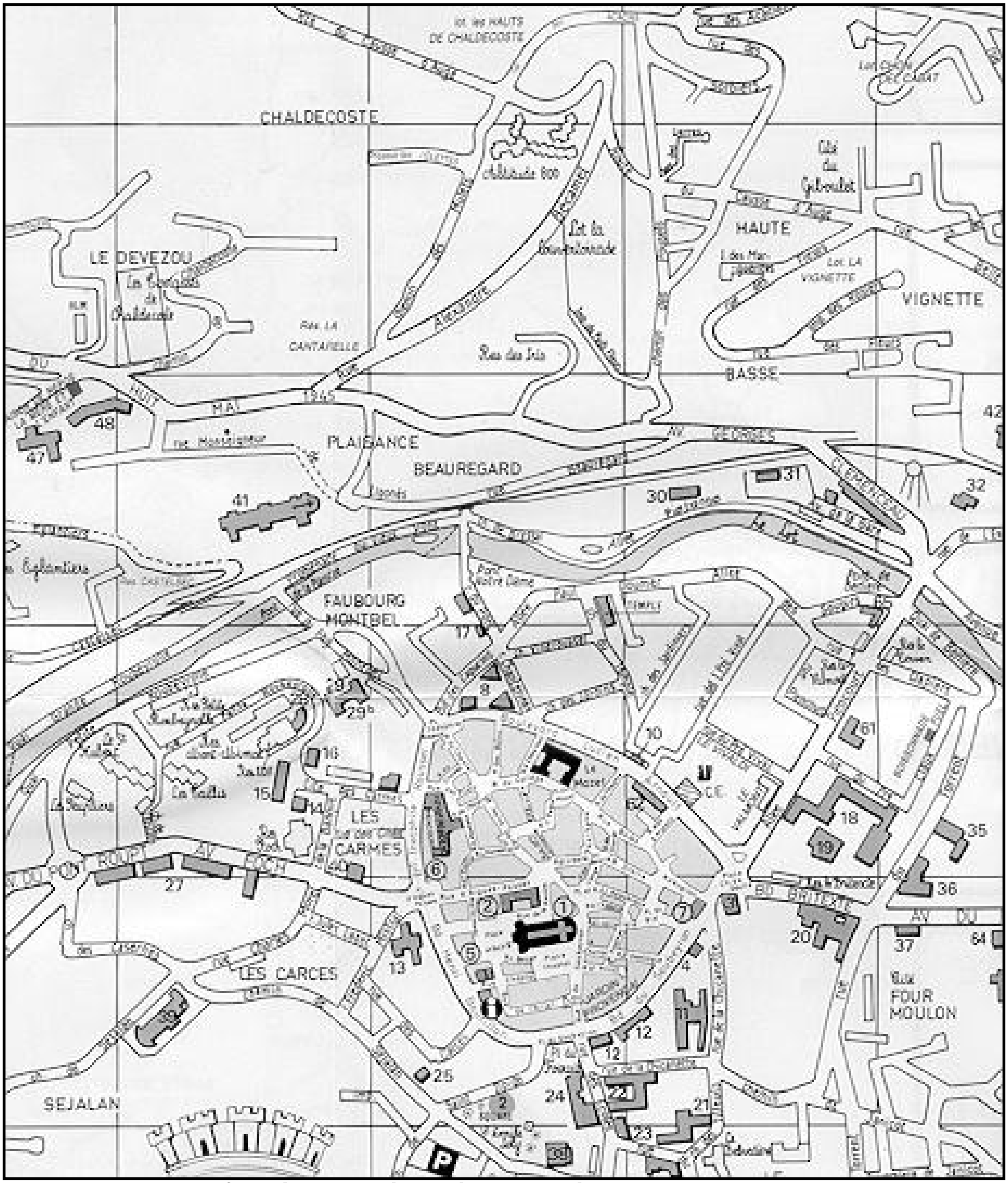
4. Test for significant differences between sites using a 'Mann-Whitney U test'.

DISCUSSION POINTS:

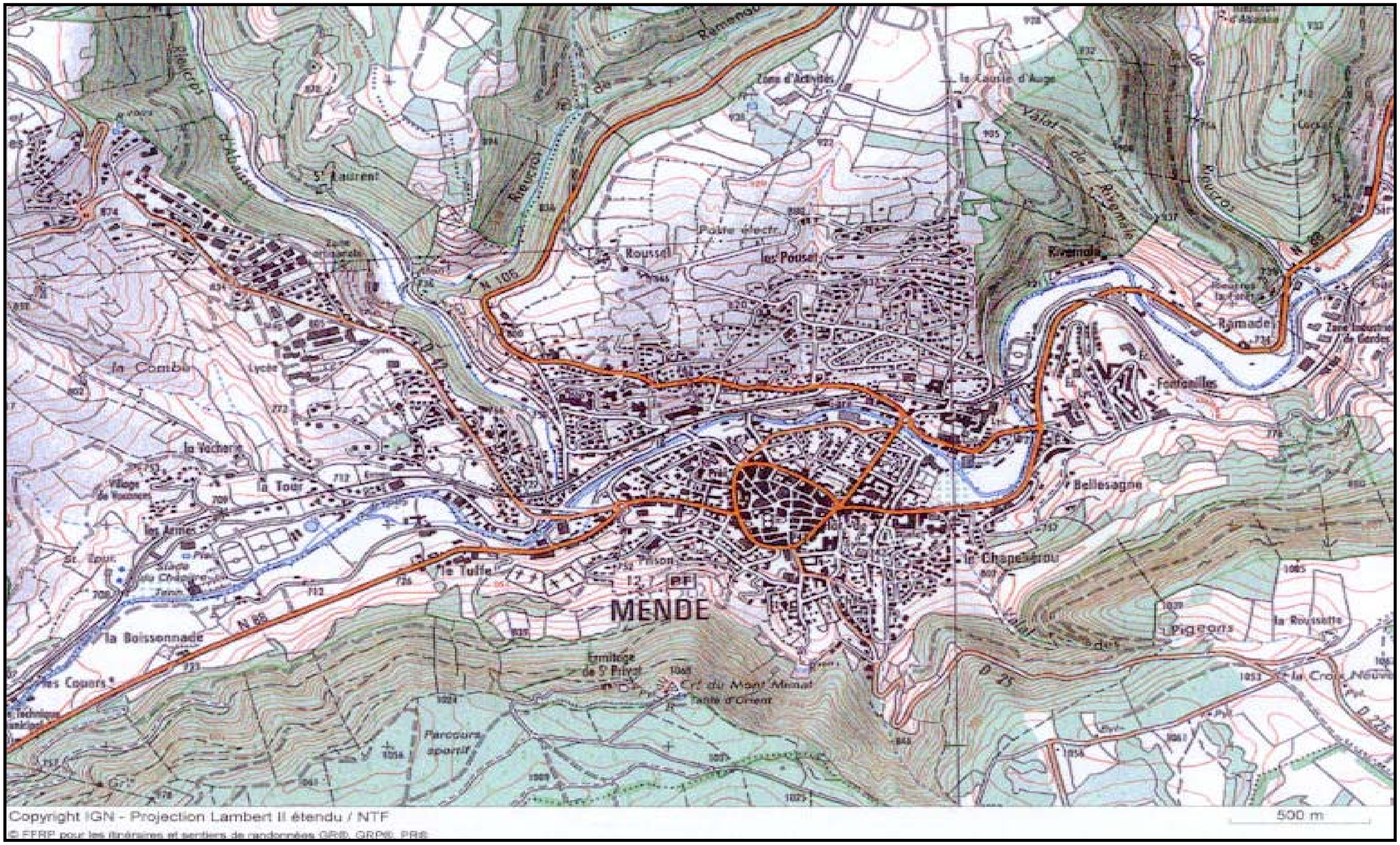
Remember - students should refer to data from the Centre's weather station and the hypotheses when discussing trends and relationships observed in the data set. Some questions that could be considered during your analysis are listed below:

- What variations in urban climate were observed? Did these follow the pattern of urban climate variation described in the introduction? If not, why not?
- Were any microclimate factors directly influenced by another factor, eg. Temperature and humidity?
- Are the *patterns* that you have observed today representative of what you may observe at other times of the year? How might these be different?
- Would the results you have observed be similar if a larger or smaller settlement was used?
- How did the microclimate relate to the overall weather system passing through the region today (download current satellite images from the internet facility in the resources room);
- Would it be possible to attribute variations to a single factor?
- Assess the degree of importance for each of the weather indicators in affecting overall climate?
- Is air pressure a good indicator of weather characteristics?

Base map of the centre of Mende



Base Map of Mende centre and immediate surrounding area


MENDE
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Lycée
la Vacherie
la Tour
les Aires
la Tuile
la Boissonnade
St Laurent
Roussel
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