Geofile

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John Pallister

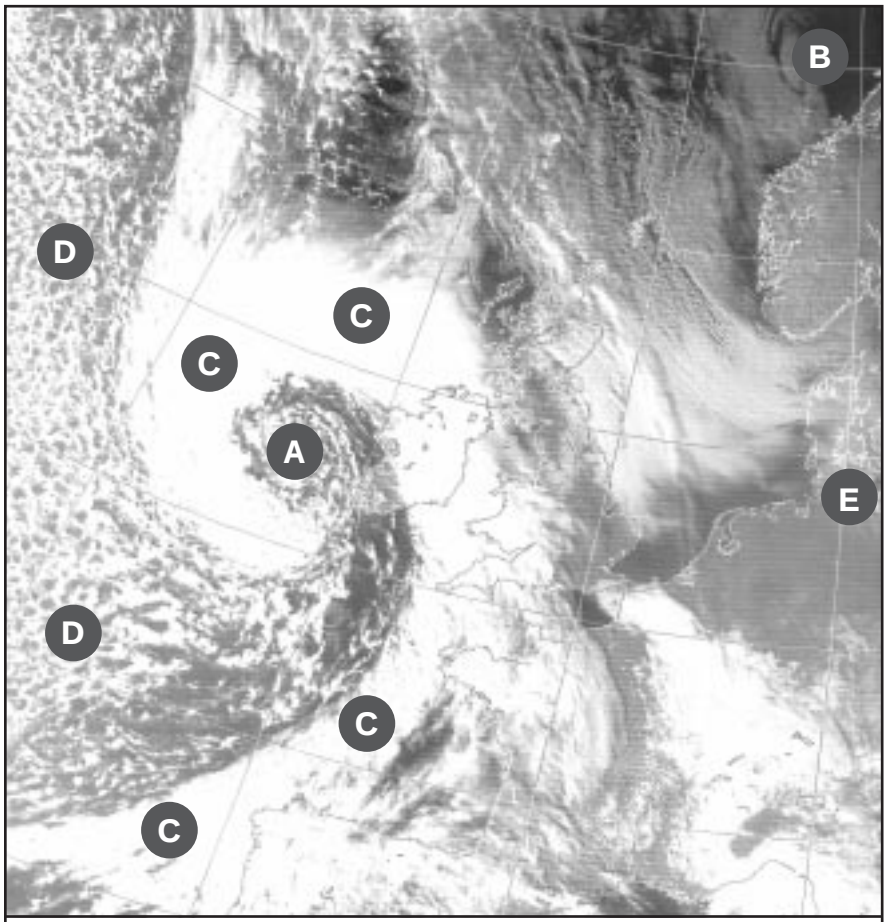
Meteorological interpretation and satellite images

Meteorology is the most challenging topic in any geography syllabus. Once understood, however, probably less revision is needed than for any other geographical topic, and writing a good examination answer on weather and climate can be a satisfying experience. However, the many and varied weather conditions which affect the British Isles, as well the day-to-day changes in weather, are not always easy to comprehend or explain. The variety in weather has two main causes, both related to the position of the British Isles.

1. The British Isles' position in temperate latitudes means that for most of the year the weather is dominated by low pressure. The frontal depressions which form over the Atlantic Ocean follow different tracks, move at different speeds and bring different patterns of weather. To add to the variety, from time to time the British weather is dominated by high pressure, which itself brings different weather between summer and winter, between night and day and between one locality and another.
2. The position of the British Isles on the western edge of the continental land mass means that they are exposed to both maritime and continental effects. Sea and land surfaces influence temperature and precipitation in different ways. Whilst maritime influences, both tropical and polar, dominate, occasionally an air mass of continental origin takes over, which has a major effect upon winter weather.

The weather map, or synoptic chart, is the traditional way of showing the spatial pattern of weather over and around the British Isles. The weather information from which these maps are plotted is recorded at the network of weather stations throughout the country. What is always scarce is recorded information about weather conditions over the sea surfaces to the west and north of the British Isles, the source areas for so much of the British weather. Satellite images of cloud patterns, such as Figure 1, have eased the problem. With their aid, greater accuracy in weather forecasting is now possible. There are few weather forecasts on television which don't make use of satellite images. Often a sequence of satellite images are run together so that the direction and speed of movement of the weather systems can be observed. Information from both surface weather stations and satellites forms the basis from which to forecast the weather for the next few hours or days.

Figure 1: Satellite image of a frontal depression reaching the west of the British Isles



A The swirl of cloud in the centre of the low pressure. This is where the air, having been drawn into the centre by the anticlockwise circulation, is being sucked upwards most vigorously.

B Areas shown as black which are without cloud cover. The existence of large areas of cloudless skies suggests areas of high pressure.

C The continuous sheet of white clouds. This is the thick sheet of stratus cloud, formed where the warm tropical air is being forced up above the cold polar air. Because this is happening along the wavy line of the polar front, a long but relatively narrow band of cloud is formed. It is gloomy at ground level beneath a sheet of stratus cloud, because its density prevents so much of the sun's light from passing through. When you look down on a sheet of stratus cloud from an aeroplane or satellite, it looks white and bright, although equally continuous in its cover.

D Broken white cloud, in dots or in patches. These indicate cumulus clouds. Figure 2 shows cumulus clouds and a showery downpour, for which they are frequently responsible. Individual clouds grow vertically where currents of air are rising strongly to high levels in the atmosphere. Their white fluffy tops are picked out from the satellite view. In between are areas of clear sky which form the dark patches.

E Patches of cloud, darker in colour. These clouds are not as thick nor as tall as the others. These are either at or near ground level, or at low levels in the atmosphere. If any precipitation at all is coming from them, it is more likely to be fog or drizzle than rain

Interpreting a satellite image

Just as either an understanding of the conventional symbols used or reference to a key is essential for interpreting weather maps, the ability to recognise different types of cloud and cloud patterns is essential for

Figure 2: Cumulus clouds behind; a summer thunderstorm in front

understanding the black and white satellite images which are used in examination questions. Features you need to recognise in Figure 1 are illustrated by the letters A—E. If you fix in your brain how to recognise these five features, you should be able recognise them again on any other satellite image. Recognition is essential before meaningful explanation can be attempted.

Anticyclonic conditions over the British Isles

Study the satellite image shown in Figure 3. Look for many of the same features which were identified on Figure 1. Skies are clear over most of the British Isles and adjacent areas of Europe. A continuous sheet of stratus cloud, associated with the low pressure, can be seen across the North Atlantic Ocean. Patches of cumulus cloud are most clearly observed over parts of central and eastern Europe.

So large is the area without cloud over and near the British Isles that the weather must be dominated by the presence of an anticyclone. High pressure at the surface is created by air sinking. As the air descends, it reaches layers where the atmosphere is denser; the sinking molecules of air are warmed up adiabatically — they are compressed as they are forced down through the thicker air. This May day must have been pleasantly warm and sunny almost everywhere over the British Isles as a result of the high angle of the sun and long hours of daylight, except along coasts where low cloud persisted. In Figure 3 we see an example of a blocking anticyclone over the British Isles. If the high pressure stays in a similar position for several days, the UK can expect one of its relatively rare hot, dry spells of weather. The frontal depressions are forced further north over Iceland, the north Atlantic and northern Scandinavia, taking their cloudy, wet and windy weather with them.

Even when there is an anticyclone resident over or near the British Isles, the large area of clear sky shown in Figure 3 is not common. Figure 4 shows another occasion when an anticyclone was blocking the free passage of frontal depressions over the British Isles, but this time much more cloud is present. The cloud patterns suggest two centres of low pressure. There is one swirl of cloud in the north-western corner of Figure 4 off the southern tip of Greenland and a second further south over the Atlantic between Ireland and Spain. The position of the cloud-free zone suggests that the centre of high pressure lies over the Atlantic just to the west of Scotland. The sheet of cloud along the line of front is much wider and more continuous for the depression in the north (indeed it is a really prominent feature), because this is a newly formed depression, as opposed to the older depression north-west of Spain which is gradually being 'filled in'; this means that pressure is rising so that it will shortly disappear. Numerous patches of cumulus cloud are associated with the southern depression; however, there are some wide gaps between the speckles of cloud, which suggests that showers may not be as widespread as in the areas marked D in Figure 1. A similar cloud pattern can be seen over the western and southern parts of England and Ireland, which makes it likely that some places could be caught by an afternoon shower. Further north in England, and down the eastern side of Scotland, note the presence of some large patches of the darker and probably low clouds. There is a sharp contrast between cloudy skies in the east and clear skies in the west across Northern Ireland and north-west Scotland.

Figure 5 summarises the pressure pattern and wind movements at the time shown in Figure 4. The clockwise circulation around the anticyclone produces an easterly wind, which is bad news for those living along the east coast. The wind has been cooled by crossing over the North Sea, still a cold body of water at the end of April. The winds have also picked up moisture which helps to form the low stratus cloud down the eastern side of the country. This cloud blocks out the sun and keeps the temperatures several degrees below those in north-west Scotland. The appearance of the cloud in Figure 4 suggests that locally it was quite thick, sufficient to give some fog and drizzle, which would have meant a miserable spring day for those affected by it. This illustrates just one of the

Figure 3: Satellite image taken in the middle of a day in early May

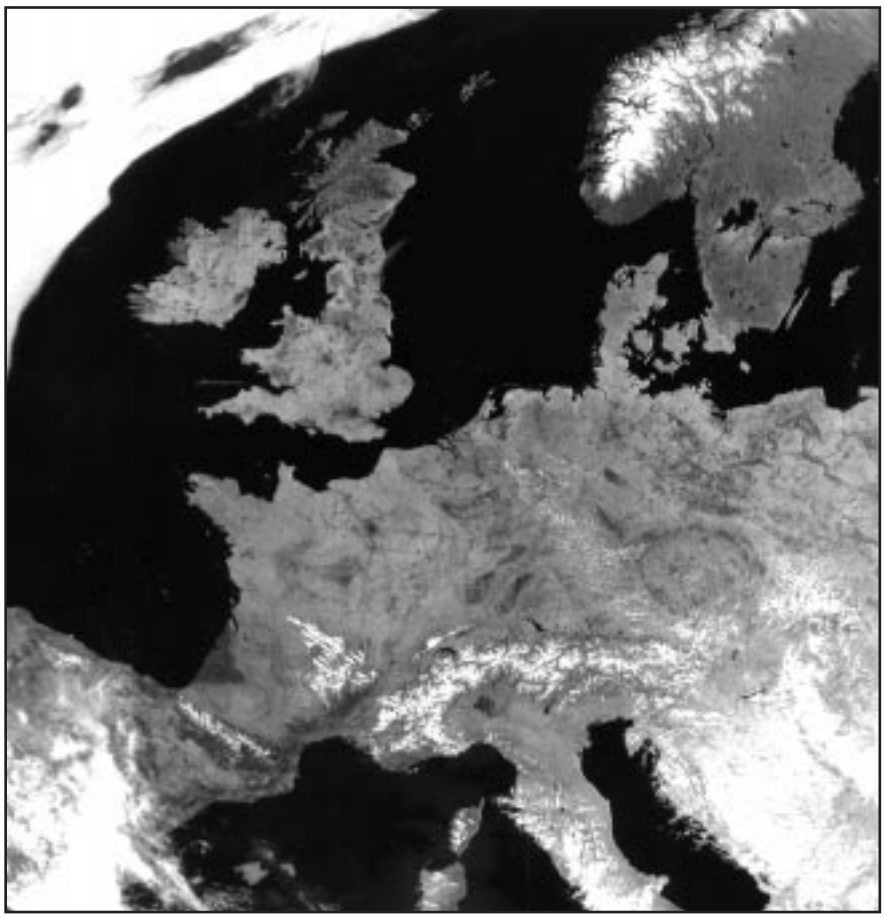


Figure 4: Satellite image taken in mid-afternoon in late April

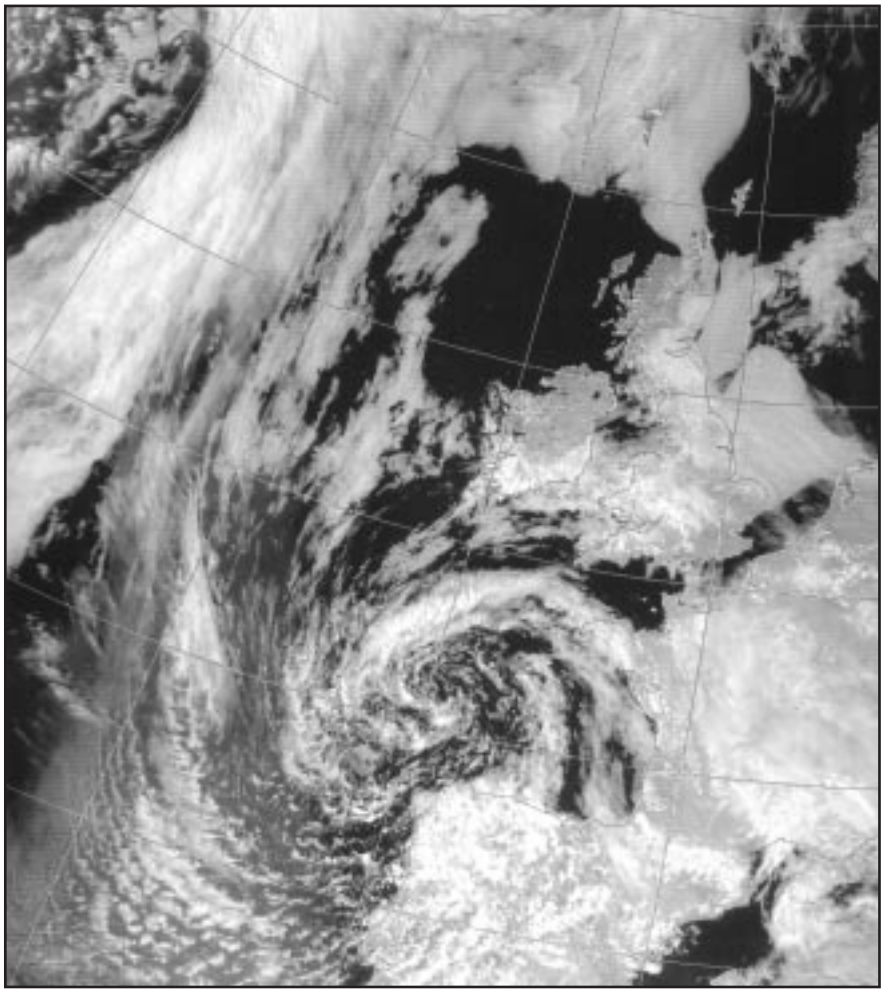
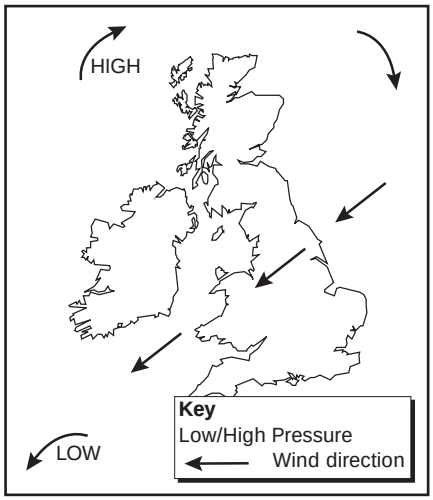


Figure 5: Pressure distribution for Figure 4 (British Isles only)



local weather variations that exist within the UK when an anticyclone controls its weather.

Air mass weather over the British Isles

Somewhat more difficult to interpret directly from satellite images are those occasions when air mass weather dominates. Figure 7 is an image for mid-January. It shows the British Isles suffering the full blast of a polar continental air mass. The cloud pattern and likely weather conditions in the British Isles can only be explained by reference to what is happening to the air as it blown from east to west across continental Europe and the North Sea. However, before attempting to explain the weather, Figure 7 must be interpreted according to the guidelines already suggested.

There are swirls of cloud suggesting centres of low pressure over Greenland and the Bay of Biscay. Cloud-free zones are present this time over sea surfaces north of the British Isles. Continuous lines of cloud lead away from the centres of low pressure.

Patches of shower clouds are present over the North Sea, although individual patches are not shown to be as bright or as large as on the other satellite images already used. Darker clouds are a feature of the areas out in the Atlantic Ocean to the west of Ireland.

Description forms the basis for explanation. High pressure is producing the cloudless skies north of the UK (for the reasons previously stated). Areas of low pressure which lie over the ocean are being stopped from making free progress eastwards by the presence of this anticyclone. Wind direction is controlled by the distribution of pressure; air is being drawn in over a considerable distance from the interior of Europe because of clockwise circulation around the high pressure to the north and anticlockwise circulation around the low pressure to the south (Figure 5). These easterly winds are carrying polar continental air across the British Isles and out into the Atlantic Ocean.

The weather delivered to an area by any air mass is determined by a combination of the characteristics produced by the ground surface in its source region and of the modifications caused by movement over ground surfaces with different characteristics. By the middle of January, ground surfaces in the middle of the Continent are very cold. Polar continental air in its source region is therefore very cold; it is also dry because it forms over a land surface. There is a pronounced

Figure 6: How a polar continental air mass changes from being stable to unstable (a) Over the continental interior (stable) (b) Moving westwards (c) Over the North Sea and eastern England (unstable)

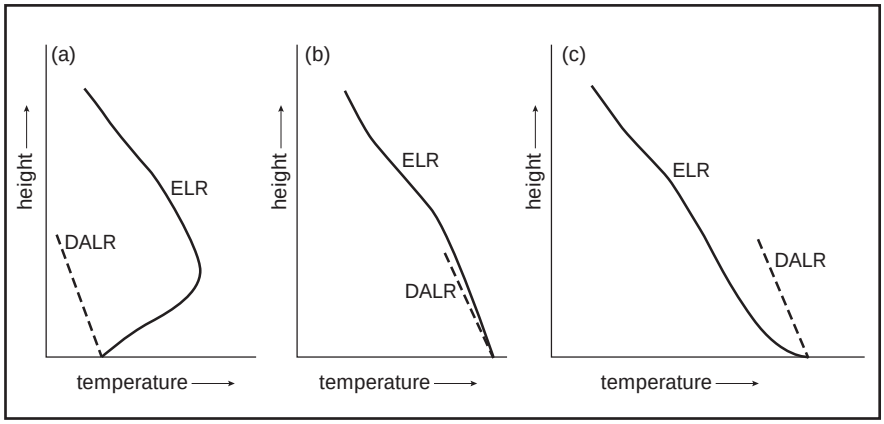
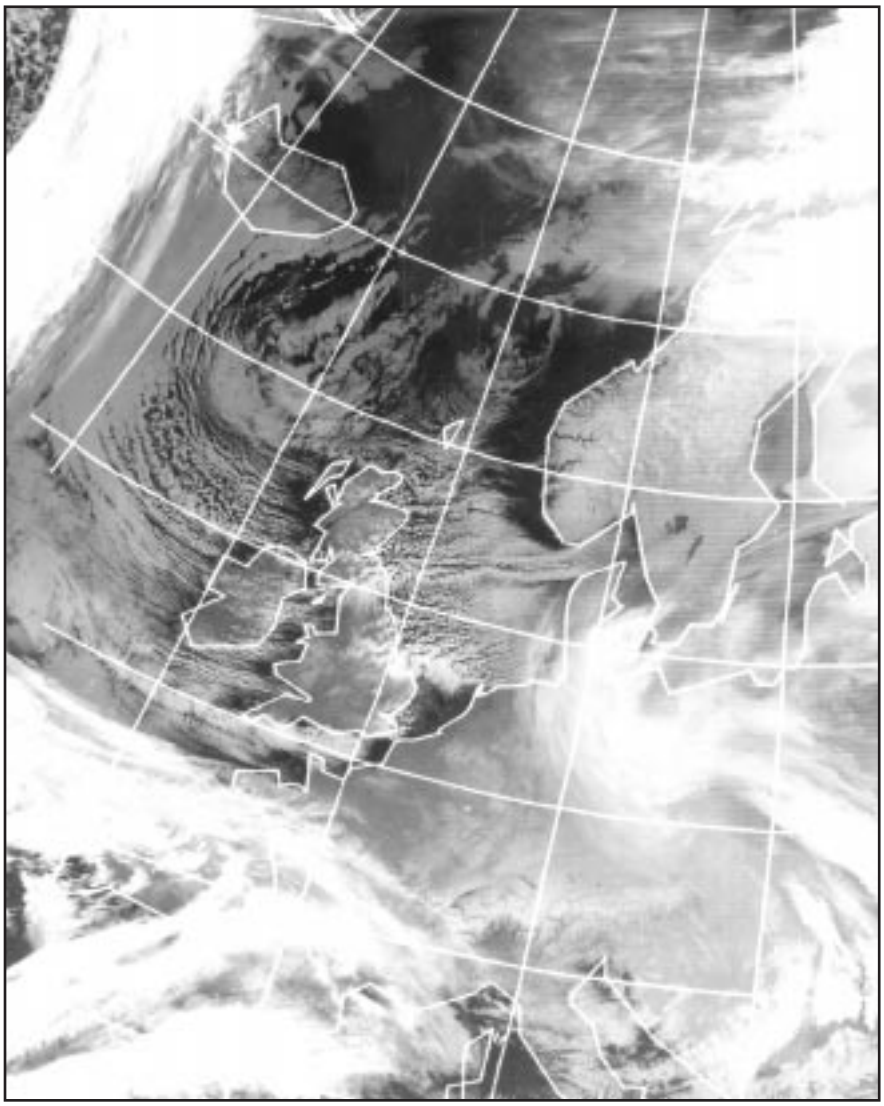


Figure 7: Satellite image taken in mid-afternoon in the middle of January



surface inversion of temperature in its source region (Figure 6(a)), as the curve in the ELR (environmental lapse rate) shows. As the air is drawn westwards over land surfaces which are less cold, the inversion becomes less pronounced as surface warming occurs (Figure 6(b)). Crossing the North Sea produces a major modification. Sea surface temperatures, even those of the North Sea, are much warmer than those of land surfaces at the same latitude in January. The base of the air mass is rapidly warmed, moisture can be absorbed, the surface inversion is destroyed and warming at the base takes place. What was very stable air over the continent of Europe has becomes unstable air over the North Sea and along the east coast of Britain (Figure 6(c)). Surface warming encourages air to rise; even if the rising air cools at the DALR (dry adiabatic lapse rate), its temperature will remain higher than the air around it (indicated by the ELR). Figure 7 shows some shower clouds present along the east coast of England, but these are reduced as the air moves west by the relative coldness of the land surface in January. Both over the North Sea and the Atlantic Ocean more clouds are present than over the land because of the warmer sea surface temperatures encouraging air to rise and its moisture to condense into clouds.

Summary comments

Like most other sources of geographical and meteorological information, such as OS maps and synoptic charts, satellite images contain more detail than you can ever hope to use in examination answers. You are not going to be able to understand and to give reasons for all the cloud patterns shown in a satellite image. However, in order to prevent confusion and increase the chances of pinpointing the significant information, adopting a guided approach to interpretation, like the one suggested, is essential. Irrespective of the task set or the question asked, survey the whole of the satellite image first. Ascertain the main cloud patterns shown. Find the likely locations of the pressure centres suggested by the clouds. Identification of low and high pressure is the key to explaining the weather. Not only do differences in pressure show where air is rising or sinking, but pressure controls wind direction, which in turn controls the movements of air masses, which in turn control the weather of the British Isles during much of the year.

The satellite images in Figures 1, 3, 4 and 7 are reproduced with the permission of the Satellite Receiving Station, University of Dundee.

Focus Questions

1. Describe and give reasons for the differences in appearance on satellite images between:
(a) areas of low and high pressure;
(b) stratus and cumulus clouds.

2. (a) From Figure 7, draw a sketch map to show the positions of areas of high and low pressure and indicate the likely wind directions between them.
(b) Explain with the help of labelled temperature-height graphs why a polar continental air mass changes from being stable in its source region to unstable over eastern Britain.

3. (a) What is meant by a 'blocking anticyclone'?
(b) How is its presence indicated on satellite images?
(c) Describe and explain why it produces mainly dry but varied weather conditions from place to place across the British Isles.

4. With reference to the satellite images shown, state and explain the meteorological conditions which can lead to different weather being experienced between the western and eastern sides of the British Isles.