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WEATHER FORECASTING

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PREFACE

The Handbook of Weather Forecasting was written mainly for distribution within the Meteorological Office to provide forecasters with a comprehensive and up-to-date reference book on techniques of forecasting and closely related aspects of meteorology. The work, which appeared originally as twenty separate chapters, is now re-issued in three volumes in loose-leaf form to facilitate revision.

Certain amendments of an essential nature have been incorporated in this edition but, in some chapters, temperature values still appear in degrees Fahrenheit. These will be changed to degrees Celsius when the chapters concerned are completely revised.

CHAPTER 9

ANTICYCLONES AND RIDGES AFFECTING THE BRITISH ISLES

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CHAPTER 9

ANTICYCLONES AND RIDGES AFFECTING THE BRITISH ISLES

9.1 INTRODUCTION

The absence of a general theory of anticyclones, broadly comparable in concept, completeness and practical convenience with the frontal theory of cyclones, is almost certainly a contributory cause to the continued absence of relatively simple techniques for inferring the sequence of weather associated with anticyclones. Current upper air techniques are useful in a general way for inferring the probable formation of anticyclones and for estimating movements of existing anticyclones. As a consequence of the subsidence which occurs through much of the troposphere in anticyclones, the weather expected to accompany an anticyclone is very largely determined by conditions in the lowest few thousand feet of the atmosphere. It is only when these conditions can be estimated in some detail that the weather conditions can be forecast accurately. To a large extent the weather of the anticyclone is essentially confined to lower levels. This is in direct contrast to the weather associated with cyclones where the associated general ascent through the lower and middle troposphere leads to the formation and maintenance of weather (that is clouds and/or precipitation) through extensive depths of the troposphere.

Anticyclones are conveniently classed as warm or cold according to the general temperature in the troposphere over them when compared with surrounding areas. This classification will be followed below.

9.2 COLD ANTICYCLONES

9.2.1. Mobile type

A cold mobile anticyclone is normally embedded in a strongly baroclinic flow which exhibits only relatively flat wave patterns in the middle troposphere. The surface anticyclone is often sandwiched between two cyclones existing in the same general baroclinic current. It often moves at a similar speed and in a broadly similar direction to those of the cyclones. Descriptions of typical thermal patterns associated with such a pattern of cyclones and anticyclones were given in Chapter 5, Sections 5.14.1 and 5.15.1. Reference to these will indicate that the circulation of such cold mobile anticyclones has a barely perceptible effect on the 500-millibar flow and often but little effect as low as 700 millibars. At a place traversed both by an anticyclone and a preceding and a following front, a typical sequence of weather would be as follows. A clearance would follow the cold-front passage as cold air spread in behind the depression. For a time the cold air would deepen and might attain a sufficient depth for the development of instability cloud and precipitation. As the anticyclone moved in there would be substantial rises of pressure and also marked stabilization of the air in the lower middle troposphere so that, within the central and forward parts of the anticyclone, there would be little low cloud - probably just a little shallow cumulus. Visibilities would be generally excellent. As the anticyclone continued to move across, tendencies would probably quickly become negative and there would often be quite a rapid spread of high cloud soon after

the surface centre of high pressure had moved away. In some cases the upper cloud might appear before the axis of highest pressure had reached the area but this would depend in a complex way on the characteristic of the incoming warm air mass and the associated disturbance moving in behind the anticyclone. The essence of successful forecasting of weather of mobile anticyclones is usually in the timing of movement. A mobile cold anticyclone provides a short fine interlude between successive cyclones. Foreknowledge of this type of weather is often of much importance particularly for operations whose success depends on the completion of some outdoor tasks. As the cold anticyclone produces a relatively short dry episode between what may be relatively prolonged wet epochs, its accurate forecasting is not just an academic matter. Much outdoor activity may be accomplished in the brief intervening dry, often sunny, spell. Even near the centre of cold anticyclones, visibilities at night are seldom poor, partly due to the fact that the recent fresh cold air is often unstable in the lower few thousand feet and also due to movement of the system. This movement usually results in but a brief period of slack winds and clear skies. Consequently fog formation is relatively rare and there is scarcely time for an accumulation of much atmospheric pollution.

The cold high remains on the cold side of the cold front so that areas lying in the warm air on the other side of the cold front are not directly affected by the cold anticyclone. There may well of course be secondary effects, for example, those due to the anticyclone causing the cold front to progress farther or less far but these are problems for the general prebaratic/prontour charts.

9.2.2. Slow-moving type

Whereas with the mobile type of cold anticyclone the thickness pattern is only slightly distorted, the slow-moving type has either a very distorted ridge-trough pattern or a confluent trough pattern of thickness lines. These thickness patterns were described in Chapter 5, Sections 5.15.2 and 5.12.3. In either case the anticyclone tends to be centred on the cold side of the strongest thickness gradient. When the thickness patterns display the distorted ridge-trough or confluent trough pattern there is generally an associated outbreak of polar air. Such outbreaks may occur in the rear of fairly deep depressions and they then often arrive as a broad deep stream, sometimes several hundred miles in width, and often extend in depth throughout the whole of the troposphere. With such major changes in tropospheric flow there is naturally an associated change of synoptic type. With the cold polar outbreak a surface anticyclone often appears or intensifies. Initially the anticyclone is closely associated with the baroclinic zone but, if the anticyclone continues to exist for several days, the degree of baroclinity over its central areas tends to become weaker.

These cold anticyclones tend to move fairly quickly in the early stages of the polar outbreak and, in this period, their movement near the British Isles is often along a heading between about east-south-east and south but occasionally the movement may be somewhat to west of south. When the polar outbreak is well established and is losing its initial impetus after penetrating well to the south, any associated cold anticyclone usually becomes much more slow-moving.

During the early periods of their existence the central regions of these cold anticyclones are often almost cloudless with a brilliantly clear atmosphere. The forward eastern regions are much closer to the preceding thermal trough and in these areas there is sometimes a fairly sharp transition between the showery weather associated with the deepening cold air in the rear of the trough and the dry stable conditions associated with the anticyclone proper. Topography sometimes has an important bearing on this demarcation between showery and dry conditions. For example a deep northerly airstream flowing across the North Sea, which is relatively warm and so able to maintain deep convection, leads to very frequent showers near the east coast of the British Isles. Further inland the showers tend to be much less frequent and sometimes the weather is quite dry.

Towards the southern and western flanks of the anticyclone the weather is usually very quiet. There may, however, be extensive sheets of upper cloud near the western periphery of the anticyclone, particularly if a disturbance is embedded in the strong baroclinic zone which usually exists to westward of the cold anticyclone.

In the central regions of mature cold slow-moving anticyclones the amounts of low cloud may lie anywhere between nil and a complete cover. Low-cloud bases are not usually particularly low and bases about 2,500 to 4,000 feet are probably typical of stratocumulus cloud sheets. Low-cloud conditions depend critically on the distribution of temperature and humidity in the lowest four or five thousand feet and sometimes the recent fetch of the low-level winds is important. Low-cloud conditions in these anticyclones do not always show a substantial diurnal variation but in some marginal cases cooling at night or heating and convection from the ground during the day may have an important effect. The problem of forecasting the formation or dissipation of non-frontal layer clouds is more fully discussed in Chapter 16, Section 16.6.3. There are also some seasonal variations in low-cloud conditions. Although there is some tendency for the central regions to be either almost clear of low cloud or almost completely overcast, a half cover of cloud is quite common in spring and summer in the late morning and afternoon. In late summer and early autumn an overcast is rare.

In the mature cold slow-moving anticyclone the air has not recently arrived from the polar regions and visibilities near land masses will often have decreased to a few miles because of the accumulation of atmospheric pollution in the lower stable layer. In very stagnant conditions with an inversion reaching down to ground level in winter there may be very heavy concentrations of atmospheric pollution near built-up areas reducing visibilities to below fog limits. If such conditions persist for many hours dense "smogs" may occur near industrial towns and large conurbations. True water fogs can also be expected at times, more particularly in autumn and winter, in cold slow-moving anticyclones, although not so extensively as in the warm type.

When the central regions of cold anticyclones are cloudless, strong outgoing nocturnal radiation will usually lead to low night minima, both in the screen and on the grass, particularly when fog does not form. These are the weather situations for late spring frosts and early autumn frosts. In the depths of winter night minima may be exceptionally low.

9.3 WARM ANTICYCLONES

The major features of the long-wave pattern associated with well marked and extensive warm anticyclones are such that the warm anticyclone is usually a slow-moving and often long-lived feature of the synoptic chart - at least for several days, sometimes even weeks. In many cases a warm anticyclone constitutes a part of a blocking pattern. The adjective "warm" applies to the middle tropospheric air masses which are warm and indicated on upper air charts by a well marked ridge or set of closed 1000-500-millibar thickness lines and contours. The air in the lower few thousand feet may be either warm or cold. In summer warm anticyclones often cause warm dry sunny weather in the British Isles. Visibilities are then generally moderate to good but, around dawn, there may be a few fog or mist patches which are usually soon dispersed by insolation. By contrast a warm anticyclone in winter may be associated with some of the coldest surface weather in the British Isles. If the cell is centred over the British Isles and the ground is cold there may be clear but very cold frosty nights and sunny days. With higher dew-points there may be persistently foggy periods which in some areas may not clear by day - even for several days. With persistently very slack surface winds and intense stability in the lower layers there may be great accumulations of atmospheric pollution which render the atmosphere particularly noxious and lead to periods of smog. In mid winter when there is a belt of high pressure extending from northern Europe westwards to the British Isles with the axis of the ridge or anticyclone situated towards the north of the British Isles and when the Mediterranean and southern Europe are covered by an extensive low-pressure area, persistent easterly winds may affect the British Isles. When much of the ground in north-western Europe is frozen, as in the latter part of a severe winter, these easterlies bring some of our coldest weather. This cold weather may be mainly dry with only small amounts of low cloud. On the other hand the weather may be mainly overcast with periods of precipitation. In late winter or early spring this precipitation may fall as continuous snow or as very frequent snow showers, particularly in eastern districts. Some further general remarks on these easterly situations are contained in Chapter 12, Section 12.6.6 and some detailed comments in Chapter 16, Section 16.7.6.

Sometimes, the north-westerly quadrant of a warm anticyclone may be invaded by a thermal trough as described in Chapter 5, Section 5.15.4. The warm high retreats, often south-westwards and with marked diminution of central pressure, as the trough advances and moves through the area formerly occupied by the warm anticyclone, bringing a period of unsettled weather. In some cases there is renewed rise of pressure in the rear of the thermal trough, a new anticyclone is built up and high pressure is re-established in a location close to that previously occupied by the old warm high which, although initially it moves away as the trough advances, later often turns, migrates towards and is finally absorbed by the newly developing anticyclone. The net result is the re-establishment of a warm high. This sequence of events results in the transport of a fresh air supply at lower levels in the warm high and, where there had previously been poor visibility due to the accumulation of pollution, this results in an improvement of general visibilities which, in time, may again deteriorate as pollution once more accumulates.

The problem of forecasting cloud cover in the central region of warm anticyclones is sometimes difficult. There seems to be a

delicate state of balance between the various processes leading to the formation or dissipation of extensive layer cloud at low levels in anticyclones. The subject is rather more fully discussed in Chapter 16 Section 16.6.3. Inexperienced forecasters should note that there are usually either very small amounts of low cloud or almost a complete cover. Thus when the forecaster has doubts as to whether there will or will not be low cloud a compromise forecast of about half cover will be seldom correct - a decision should be taken to forecast small or large amounts.

9.4 RIDGES

In many cases regions of rising pressures produce only ridges of high pressure and separate closed anticyclonic cells do not occur. Ridges are more frequent than anticyclones. The weather associated with ridges shows a marked similarity to that in the type of anticyclone which would form if the development of high pressure continued sufficiently. Accordingly some of the comments in the preceding sections may be regarded as applicable also to ridges. The orientation of the major axis of a ridge often has an important effect on associated weather and some comments on this aspect are given below.

In the forward regions of cold-air ridges which have an approximately north-south axis there is often considerable southward penetration of cold unstable air with associated showers. Nearer the axis of the ridge the air usually shows marked stabilization and the depth of convection decreases. If the ridge is mobile and there is a developing disturbance moving in behind the ridge, there is often an appreciable invasion of the ridge by the associated upper clouds. In some cases this penetration will reach as far as the surface ridge line and occasionally beyond. If, with the development of the ridge with a north-south axis, there is also a marked wave pattern in the thickness lines in phase with the ridge, then such ridges are generally slow-moving and the penetration of the weather associated with any developing disturbance is generally in a more north-easterly direction towards the rear quadrant of the apex of the ridge. In the front south-easterly quadrant there is very marked penetration of cold unstable air to southerly latitudes and at times the penetration of cold air may be to some point west of south. If the location of the axis of the ridge is such that the northerly or north-easterly flow has a marked sea track (for example, down the Norwegian coast or North Sea) before it reaches the British Isles, the shower activity may be frequent and prolonged and the accumulated amounts of precipitation may be considerable in eastern districts.

The extension north-eastwards of a warm ridge from the Azores anticyclone towards the British Isles is sometimes heralded by rising pressures (or insufficient falls of pressure) ahead of a warm front or rising pressures in the warm sector. The ridge may persist until it is swept away by an invasion of polar air. Such ridges bring a few days of settled weather. In western and south-western districts and areas near the south coast there may be extensive low cloud which sometimes persists by day and by night and, at times, light drizzle or rain may fall near windward coasts and on hills not far inland. When dew-points are appreciably in excess of the adjacent sea temperatures, as in early summer, the cloud base may be very low (say 200-500 feet) covering even quite low hills near coasts, and rather extensive fog patches will

occur in many coastal districts and there will be hill fog (see Chapter 17). Well inland and to lee of the larger masses of high ground (for example, Welsh mountains, Pennines) cloud bases are noticeably higher. Insolation will sometimes cause breaks in the sheets of low cloud advected that far giving days which are very warm for the time of the year. The low cloud often reforms at night. In suitable conditions the cloud may burn off almost back to windward coasts by day but the cloud must be thin and the advective component light (say < 15 knots at 2,000 feet) before this could be expected with any certainty in early summer.

On some occasions when the axis of the ridge extending north-eastwards from the Azores anticyclone lies somewhat to south of the British Isles (for example, over north-west France) minor troughs or disturbances on fronts located along the north-western flank of the ridge may move generally east-north-east or north-eastwards, causing a thickening of the cloud systems and an increase in the amount of precipitation over areas near the track of the disturbances.

On some occasions a ridge extends southwards across the British Isles from an extensive anticyclone located in northern latitudes. The anticyclone is sometimes centred to north of the Arctic circle and it often maintains a general easterly low-level flow from Scandinavia, across the Iceland region and even to Greenland at times. A ridge extending southwards from this anticyclone towards Scotland and the border country will maintain cold (or cool) and often predominantly cloudy weather in eastern districts of Scotland and north England. In contrast, western districts of those areas and northern Ireland can have some brilliantly sunny and exhilarating weather but, in winter, the nights may be very cold if the wind falls light and the skies remain clear. In such a situation disturbances moving across the Atlantic from the west towards the British Isles tend to follow tracks rather farther south than usual and southern parts of England may experience unsettled weather from the northern parts of such disturbances.

A variant of this type of ridge is one extending to the British Isles approximately south-westwards from an anticyclone centred near the region of Scandinavia, Finland or north-western Russia. Such ridges tend to dominate the weather over much of the country and any unsettled weather is then usually confined to the extreme south-western districts of England or north-west Ireland and the western fringes of Scotland.

Of the many other types of ridge situations which affect the weather over the British Isles the only other one selected for comment in this chapter is the "col"-like area between pairs of anticyclones and cyclones. These cols tend to be predominantly either cyclonic or anticyclonic according to the shear between the low-level flow on opposite sides of the col. For example, over the United Kingdom in an anticyclonic type of col between anticyclones centred near the Azores and the Gulf of Bothnia, the air to the north-west arrives predominantly from a south-west direction from the Atlantic whilst that to the south-east is predominantly from a north-east direction from north-western Europe. This situation may cause quite dissimilar weather in, say, southern England and southern Scotland. When a slow-moving upper thermal ridge exists over such a col, that col, although possibly appearing as quite a weak feature on surface charts, may be quite

persistent and successfully resist invasion and displacement by air masses involved in the circulation of quite vigorous disturbances associated with the stronger middle tropospheric flow patterns which sometimes exist well to north-west and south-east of the axis of the high-pressure belt. The weather associated with such a col is typically anticyclonic. Thick fogs may form, particularly in the damp air mass, and sometimes they are persistent.