Europe's drought (1)

Under the weather

R. M. Morris and R. A. S. Ratcliffe of the Meteorological Office, Bracknell, discuss recent anomalies of the weather and the general atmospheric circulation

THE drastic reduction in rainfall over much of the British Isles from early 1975 represented a rather sudden acceleration of a trend which began at the end of the 1960s. The average annual England and Wales rainfall for 1971–75 was 826 mm, the lowest mean five-year value since the 1850s. There have, however, been six five-year periods since 1825 with annual averages less than 840 mm, so the recent five-year rainfall may be expected to occur once in about 25 years.

Rainfall in the period May 1975 to August 1976 was exceptionally low—in fact the driest such period in England and Wales since 1727, when records officially began. The rainfall total for this period is provisionally assessed at 760 mm compared with the next lowest value of 809 mm in the eighteenth century. Records are regarded as unreliable before about 1825 and if one excludes years before that date the next driest 16-month period starting in May was in 1933–34 with a total of 900 mm. It is difficult to calculate return periods of such an unusual event, but the standard formula suggests at best a once-in-500-year occurrence.

In England the period 23 June to 8 July, 1976, was also exceptionally warm. Mean daily maxima were some 10 °C above the normal values for the time of year and reached 32 °C in some places. Such an event is also unprecedented over the past 250 years. These high temperatures were partly due to the very dry ground, which meant that a smaller proportion of incoming solar radiation than usual was used for evaporating moisture; more was thus available for heating the ground and hence the atmosphere.

Broader perspective

Despite the severity of dryness in England it is important to view the anomalies in a broader spatial and temporal perspective. The distribution of rainfall over most of Europe for the period October 1975 to July 1976, expressed as a percentage of the long-term average (see map), shows that the area of less than 75% broadly extends southwest from Sweden, across the low countries and France to northern Spain, embracing much of England, Wales, eastern Scotland and also southern Germany. Less than 50% is confined to southern England

and northern France with minimum values near the coast of central southern England. On the other hand above average rainfall has occurred over Norway and extreme northern Scotland probably extending across Iceland, whilst similar or greater excesses are evident over western Russia, the Balkans and southern Italy.

The distribution and evolution of rainfall anomalies on the scale shown is closely linked to the evolution of the major circulation systems in the tropospheric flow around the northern hemisphere. In particular the jetstreams (that is, zones of strong quasi-horizontal wind flow in the middle and upper troposphere) are usually closely associated with the zones of strong thermal contrast which separate regions of markedly different temperature and humidity characteristics. Jetstreams are intrinsically associated with weather because they represent a major cause of the upward and downward motion of the air in the middle layers which produces both extensive cloud systems and cloud-free regions in the circulation. The presence of a jetstream above a certain region usually implies changeable weather, with periods of rain alternating with periods of fine weather. Regions on the cold side of the jetstream (usually the northern side) tend to have a good deal of rain and showers; regions on the warm side tend to have a predominance of dry weather.

Within the past two years the location of the mean jetstream in the Atlantic–European sector of the circulation has shifted almost 1000 miles northwestwards in a coherent and continual manner. The second map illustrates the movement of July–August mean mid-tropospheric jetstream flow from 1974 through 1975 to 1976. Relatively small changes have occurred in the St Lawrence–Newfoundland area and also across the Mediterranean, and a major change has occurred between the northwest European seaboard and Iceland. To put matters in perspective, the mean summer position of the jetstream over the period 1951–70 was close to latitude 50°N across the Atlantic and extended rather weakly to the English Channel. With the jetstream in this position English summers tend to be rather cool and unsettled.

Jetstream shifted

During the winter of 1974–75 the main jetstream across Britain shifted to a position just northwest of the Hebrides. Apart from a temporary falter during the spring it maintained this position throughout most of 1975, moving a little further northwest during November and December. Despite some extremely vigorous cyclonic activity in the northwest Atlantic early in 1976, which actually encroached upon western parts of the British Isles during May, the mean jetstream clung tenaciously to a position between Iceland and Scotland.

Following the recent summer the jetstream cannot extend further north in view of the proximity of the Arctic ice fields, which will inevitably extend southwards in the winter. The distribution of temperature gradient in the ocean–atmosphere system seems certain

to develop a new jetstream from the eastern USA across the Atlantic towards western Europe, thereby fundamentally changing the situation. Indeed this has already occurred and has been responsible for the recent heavy rain over much of the area worst affected by the drought.

The movement of the mean jetstream flow well to the north of the British Isles was the major cause of the marked reduction in rainfall, and the excesses of rain further north were clearly associated with an increase of jetstream activity not normally present in those latitudes. At the same time the influence of a jetstream upon rainfall anomalies is of limited geographical extent and such is the nature of the circulation that the predominance of cyclonic or anticyclonic regions in a particular region usually leads to the development of anomalous regimes in an adjacent region. The excess rainfall over the eastern and southern fringes of Europe is probably associated with this kind of circulation compensation.

The overall trend during the 1970s has been one of increased cyclonic activity in the Arctic basin, especially across the extreme north Atlantic and

Norwegian Sea, and increased anticyclonic conditions over western Europe. Such a circulation implies more frequent and stronger westerly winds than usual north of about 55° N in our sector. The increased westerly winds and cyclonic activity in the north have been associated with a marked recession northwards of the Arctic ice.

Up to 1969 Arctic ice to the north of Britain was extending southwards and reached its extreme southern position in March 1969 (see map). By March 1976 the area of open water in the Greenland-Spitzbergen area had increased by about 1.4 million square kilometres compared with March 1969. □

Europe's drought (2)

Water everywhere?

Haydon Richards of the Central Water Planning Unit assesses Europe's water resources

WATER is one of the natural resources with which Europe is better endowed than many other large areas of the world. This generalisation does, however, mask variations in geographical distribution of resources as compared with demands. The summer of 1976 has emphasised an extreme of variation. The driest 16-month period on record, from May 1975 to August 1976, has severely tested resources designed to provide a continuous water supply, but on the whole demands have been met and criteria used for design have proved to be sound. If living conditions are to be maintained or improved then demands have to be met for the four main sectors of public water supply, industry, agriculture and thermal power station cooling. The unusual conditions of 1976 have at least emphasised those areas where additional storage of water in some form needs to be made available in order to satisfy these demands and not impose severe restrictions on water use.

Estimating demand

Reasonably accurate estimates of

demand need to be made in order to plan development of suitable resources. Traditionally, trends over a number of years have determined the level of demand to be met at a particular time in the future, but more recent estimates have attempted to break down the components of the total demand. A good deal still remains to be done in this field. Publicity this summer has led to marked lowering of demand for public water supplies and for industry, amounting to at least 20% of normal demand in some areas. However, the knowledge that water is again abundant after a time may well reduce the attitude of care and thus increase demands to "normal" levels.

Apart from the demands to be met from the four major sectors the needs of ecology and amenity have to be borne in mind. Sufficient water must be left in rivers and lakes for aquatic life to continue, effluents to be suitably diluted, navigation to be possible and for fishermen and picnickers to enjoy their leisure. There must therefore be some idea of the quantity to be left in a natural watercourse to prevent un-

acceptable damage to the environment. This quantity can be determined only by agreement between all users of a particular river catchment and the criteria used may differ from one to the other, general amenity perhaps being over-riding in an upland or rural setting and effluent dilution in an industrial area.

Future projections in demand for water until the end of the century suggest high growth rates in excess of 200% in the Netherlands and at least 150% in Luxembourg, whereas in France demands may increase by little more than a quarter. Recent estimates indicate that Germany and the United Kingdom will need to increase use by 60 or 70%. Those countries with a high proportion of agricultural water demands locally, such as France and Italy, may have developed methods of meeting those demands locally, whereas the increased industrial demands in other countries have to be met by providing major new resources at some distance from the centres of demand.

Increasingly, demands for cooling water are being met from saline waters. Italy and Denmark benefit from long coastlines and use only a small proportion of freshwater for cooling in thermal power stations, although thermal pollution then becomes a problem. Some 30% of cooling tower water is evaporated, and this forms a consumptive use of water because it is lost as a resource. In the same way