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The climate in the UK from November 1994 to October 1995

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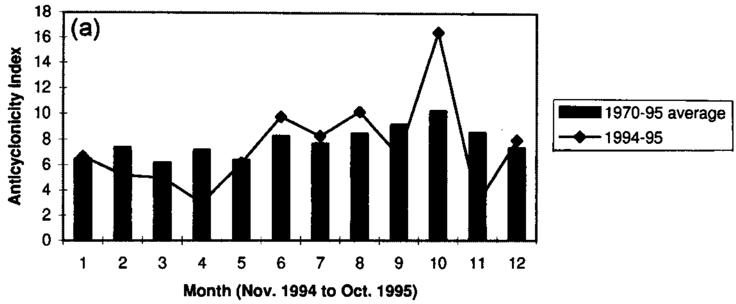
The summer of 1995 was exceptional over much of the United Kingdom (UK) (and indeed much of western Europe) for its high temperatures and also for its low rainfall and high sunshine totals. This hot summer occurred within a very warm 12-month period extending from November 1994 to October 1995. These 12 months were the warmest such period recorded in the long Central England Temperature (CET) series compiled by the late Gordon Manley and which commences in the year 1659. The mean temperature of this period was 1.6 degC warmer than the 1961–90 average. The sequence of monthly temperature



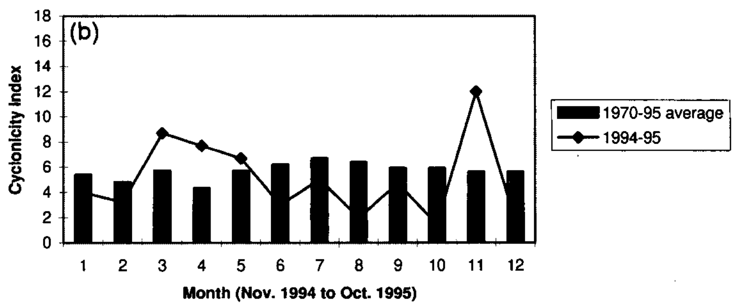


Fig. 1 Monthly anticyclonicity (a) and cyclonicity (b) indices over the UK during the period November 1994 to October 1995 and the average for the period 1970–95. Indices derived from the Lamb weather type catalogue (Lamb 1972, updated).

and precipitation anomalies during this period is closely reflected in the changing patterns of cyclonicity and anticyclonicity (Fig. 1) derived from the Lamb weather type catalogue for the British Isles. The wet months of January and February 1995 were strongly cyclonic, as was the extremely wet September, whereas April to August (excluding July) were anticyclonic months. The warmth of July 1995 resulted more from a strong southerly airflow over the UK than from a dominant summer anticyclone.

The unusual climatic conditions prevailing during most of 1995 were the catalyst for a study of the impact of a climate anomaly on the economy of the UK, commissioned by the UK Department of the Environment, co-ordinated by the University of East Anglia and recently published (Palutikof and Subak 1997). This article originated as part of that study and provides a short summary of the climate over the UK between November 1994 and October 1995 using three primary variables – temperature, precipitation and sunshine. It may be seen as an equivalent summary to those published in *Weather* following some unusually warm seasons between 1988 and 1990 (Jones and Hulme 1990; Hulme and Jones 1991). For the assessment of the impact of the climate anomaly on the UK economy, the study used the period from 1970 to 1995. This period allows for some historic assessment of the relationship between climate variability and economic activity during a period for which economic indicators are generally available. This 26-year period also includes the hot dry summer of 1976, which provides some comparison to the summer of 1995. In this article, anomalies in all of the climate variables discussed are calculated with respect to the average of 1961–90, the current World Meteorological Organization (WMO) climate 'normal' period.

Temperature

The CET series (Manley 1974) is now routinely updated by the Hadley Centre for Climate Prediction and Research at Bracknell (*e.g.* Parker *et al.* 1992; Briony Horton, personal communication) and provides the longest homogeneous record of surface air temperature not only in the UK, but also in the world. The series of monthly mean temperatures commences in 1659 and the series of daily mean temperatures in 1772. These series provide the best long-term context for assessing the significance of recent temperature anomalies in the UK. Although compiled from instrumental measurements extending from the southern Midlands to north-west England, the CET series is representative of a wider domain and is therefore the single most useful dataset for assessing UK climate. Temperature anomalies from most regions of the British Isles correlate very highly with the CET series, the correlation for annual temperatures only falling to below 0.8 in the northern isles of Scotland (Jones and Hulme 1997).

Table 1 Central England Temperature (CET) during the period November 1994 to October 1995, expressed as an actual temperature, as an anomaly from the 1961–90 average, and as a rank in the full 336-year CET series (1=warmest, 336=coldest)

	Temperature (°C)	Anomaly (degC)	Rank
Nov.	10.1	+3.6	1
Dec.	6.4	+1.8	28
Jan.	4.8	+1.0	70
Feb.	6.5	+2.7	17
Mar.	5.6	−0.1	140
Apr.	9.1	+1.1	53
May	11.6	+0.4	107
June	14.3	+0.2	163
July	18.6	+2.5	5
Aug.	19.2	+3.4	1
Sept.	13.7	+0.1	118
Oct.	12.9	+2.3	2
Dec.–Feb.	5.9	+1.8	10
Mar.–May	8.8	+0.5	71
June–Aug.	17.4	+2.0	3
Nov.–Oct.	11.1	+1.6	1

Annual, seasonal and monthly temperatures

Figure 2 shows the 336-year series of November–October mean temperatures from 1659/60 to 1994/95, expressed as anomalies. The period November 1994 to October 1995 was the warmest 12 months recorded in central England and exceeded the previous record anomaly of 1.3degC in 1779. The monthly/seasonal anomalies during the 1994/95 year are shown in Table 1, together with the ranking of each month/season in the full CET series. With the narrow exception of March, every month was warmer than the 1961–90 average; five of the months – November, February, July, August and October – were more than 2degC warmer. November and August set new monthly temperature records for the CET series with anomalies of more than 3degC.

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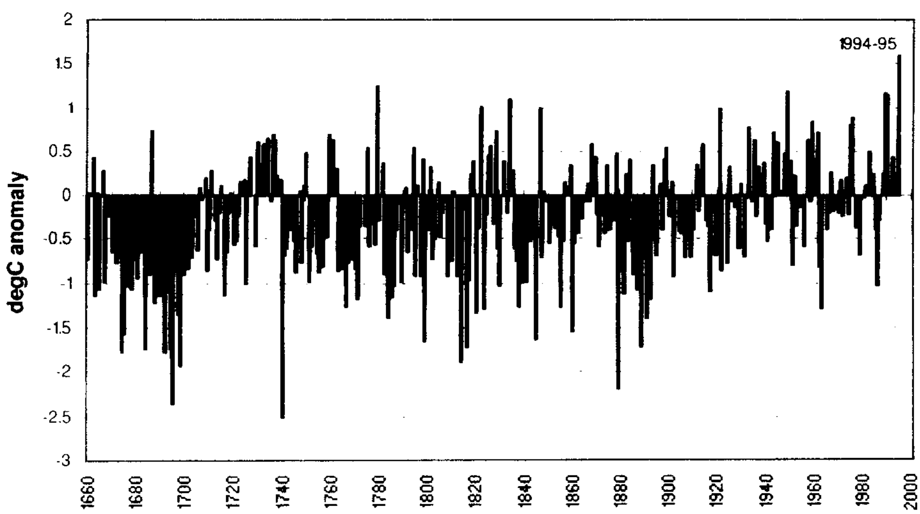

Fig. 2 Mean temperature anomaly, with respect to the 1961–90 average, over central England for each November–October period from 1659/60 to 1994/95. Data extracted from the CET series.

CT © Julian Williams

Cirrus advancing down the Adriatic coast of Italy at Camparino

CT © S. G. Hubert

Cumulus over Kentmere Fell in the Lake District, February 1994

CT © David Brown

Fig. 1 Portion of complete primary and secondary bows, with supernumerary arcs, Port Erin, Isle of Man, 23 September 1987 at 1710 BST (see article on p. 258)

CT © J. P. Mitchell

Fig. 5 A 22° halo in moderately thick cirrostratus, Mammoth Lakes, California, 25 May 1990 at 1100 Pacific Time (see article on p. 258)

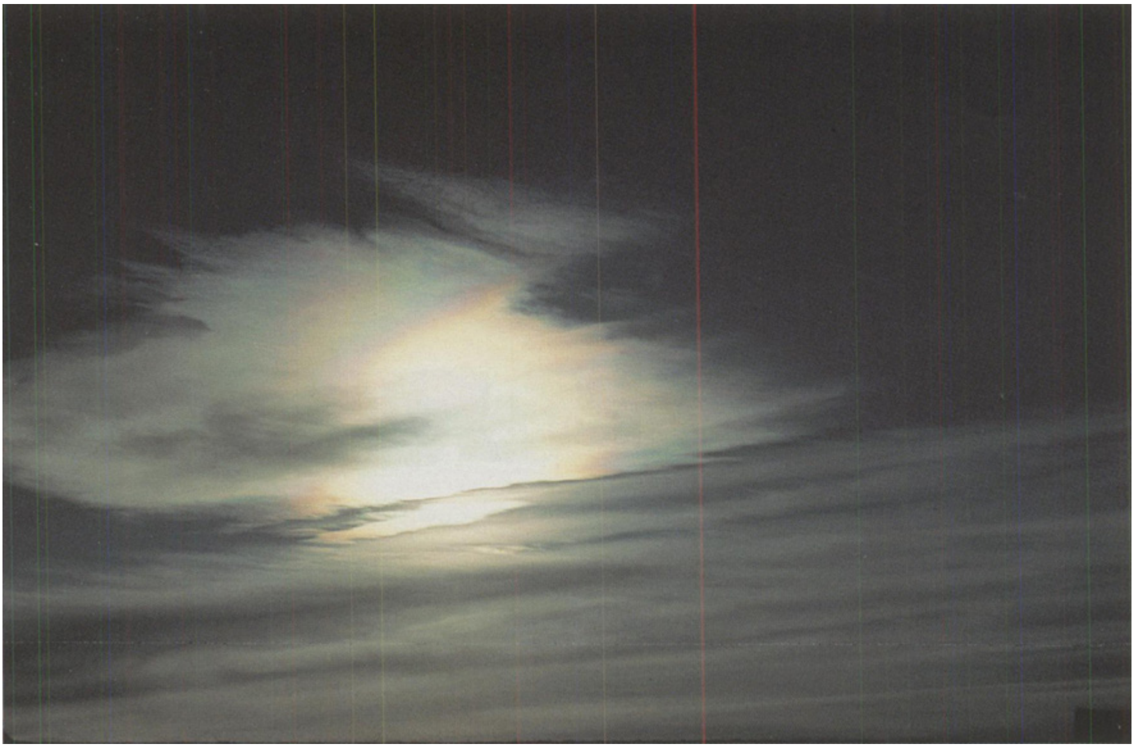

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Fig. 6 Corona in thin altostratus, June 1989 (see article on p. 258)

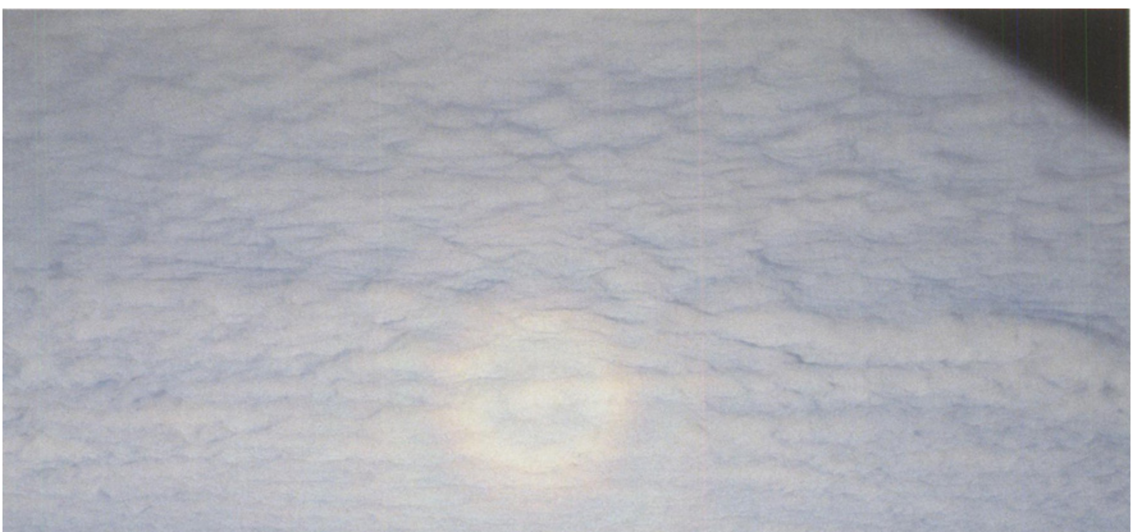

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Fig. 7 Glory observed on a sheet of stratocumulus over Lincolnshire, 7 December 1989 at 1340 GMT (see article on p. 258)

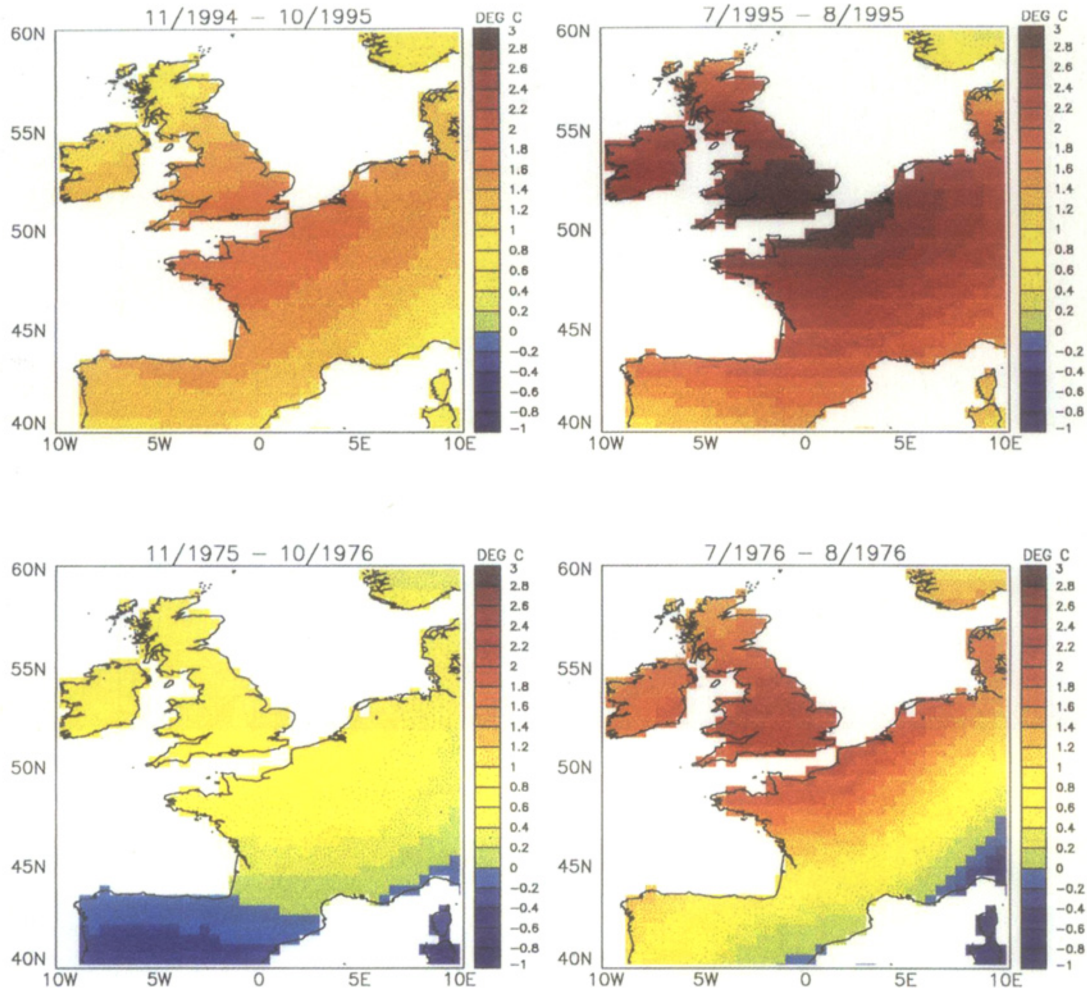

Fig 4 Mean temperature anomalies from the 1961–90 average for the November–October period (left) and 'high summer' (right) for 1994/95 (top) and 1976 (bottom). Data interpolated on to a 0.5° grid from the original 5° dataset of Jones (1994, updated). (See opposite page.)

Short-lived billows in a statically stable layer near Mattingley, Hampshire, 1615 GMT, 7 December 1993

The notable warmth of the 1995 summer did not commence until the last week of June; the first half of June was unusually cold, especially in the east. The conventional three-month summer period – June, July and August – was therefore only the third warmest in the CET series, being exceeded by 1826 and 1976. The two months July and August – sometimes referred to as 'high summer' – combined, however, to give the hottest two-month period in the entire CET series. The July/August anomaly of 3 degC in 1995 exceeded the previous record of 2.5 degC set in 1983 (Fig. 3).

Spatial pattern of warmth

Although the CET series is a good indicator of temperature over the UK, there were nevertheless regional gradients of warmth during 1995. These are shown in Fig. 4 (see facing page) as anomalies from the 1961–90 average for the November to October year and for high summer. The anomaly patterns in 1976 are also shown for comparison. These anomaly data are interpolated from the global temperature dataset of Jones (1994, updated). The warmth in 1995 was centred over southern England and northern France. High-summer anomalies in 1995 fell from 3 degC over southern England to about 2 degC in northern Scotland, and for the November–October year from 1.8 degC to just under 1 degC. Both periods in 1995 were substantially warmer than their equivalents in 1976, but the latitudinal gradients were also stronger. Thus over northern Scotland 1976 and 1995 had more similar anomalies than existed in southern England.

Daily temperatures

A more detailed picture of the sequence of temperature during our period of interest can be gained by examining the daily CET series from 1 November 1994 to 31 October 1995. This is shown in Fig. 5, together with an equivalent plot for 1975/76. The extreme summer warmth in 1995 was continuous from the last week of June to the end of August, while in 1976 mid-June to mid-July was extremely warm as was a shorter spell in mid-August. In 1975/76, with the exception of the period from mid-December to mid-January, the preceding spring and winter were not as mild as in 1994/95.

These daily CETs allow additional series to be derived, such as degree-day counts above or below certain temperature thresholds or the frequency of certain temperature extremes. Several of these derived series were calculated for the Department of the Environment (DoE)

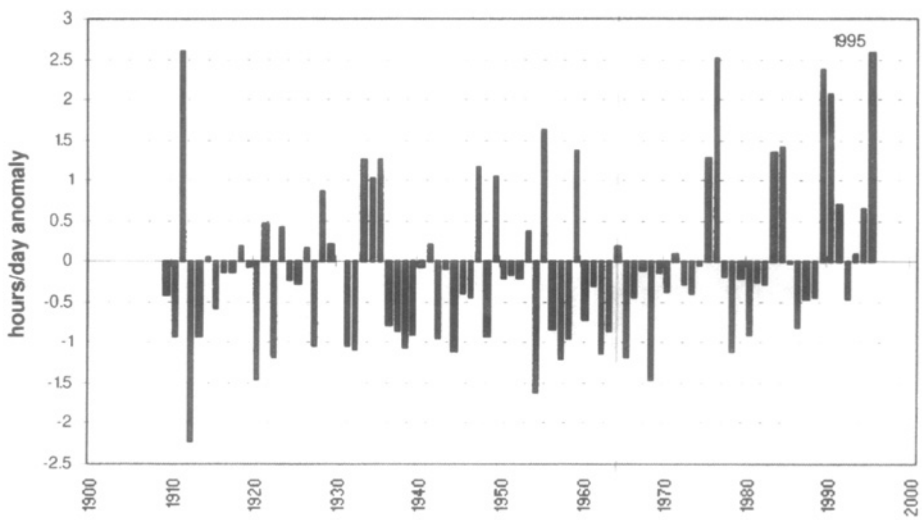

Fig. 3 Mean temperature anomaly, with respect to the 1961–90 average, over central England for each July–August period from 1660 to 1995. Data extracted from the CET series.

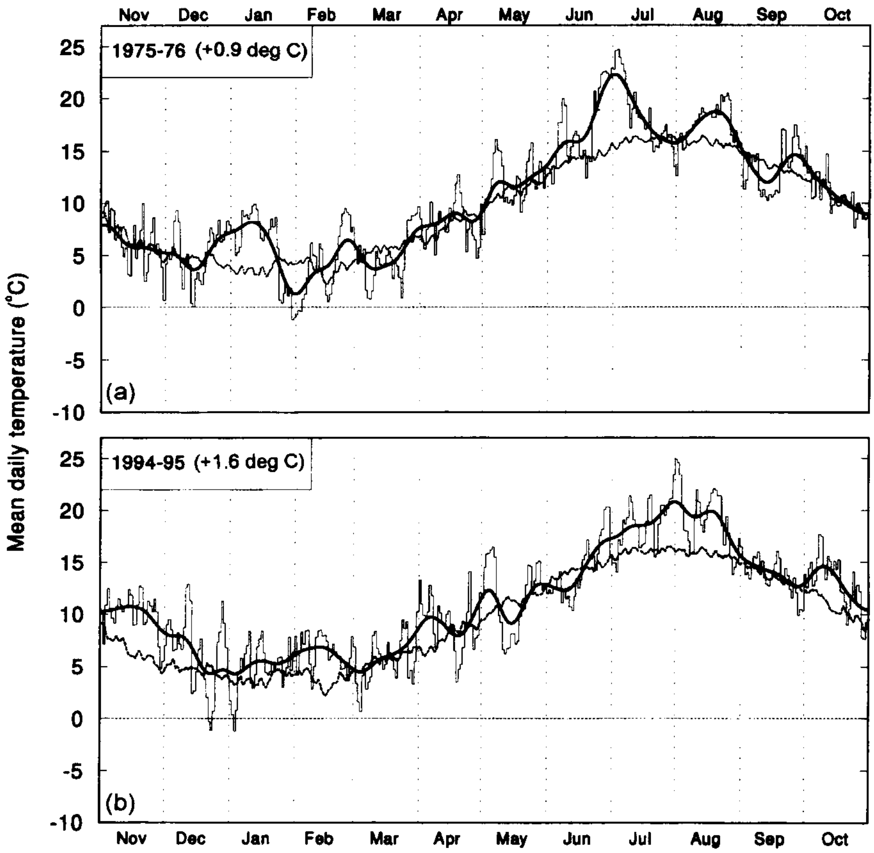

Fig. 5 Daily mean temperature for central England from 1 November to 31 October for (a) 1975/76 and (b) 1994/95. Thick solid line indicates the 30-day average and dotted line the 1961–90 daily average.

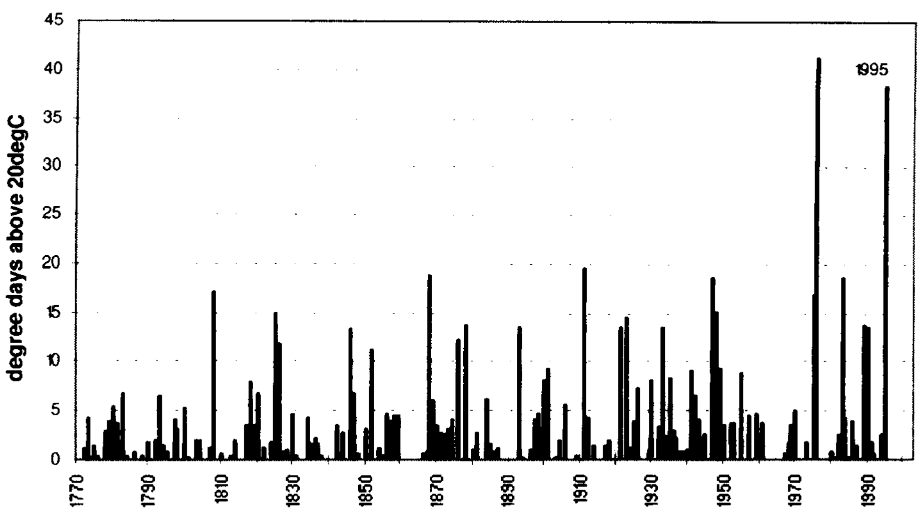

Fig. 6 Annual degree days above a mean temperature of 20 °C for the period 1772 to 1995, derived from the daily CET *series*

study, and one is shown in Fig. 6. This plot shows the series from 1772 to 1995 of annual degree days above a mean temperature threshold of 20°C. The maximum value of 42 was reached in 1976, but the 1995 value of 38 was the second highest by quite some way. Degree-day indicators of this type may be more significant for certain economic activities or environmental processes than monthly or seasonal mean temperatures alone.

Precipitation

The series of England and Wales Precipitation (EWP), compiled by the Climatic Research Unit (Wigley *et al.* 1984; Gregory *et al.* 1991; Jones and Conway 1997), was used as the national indicator of precipitation. This series extends back to 1766 and thus provides the longest historical context for assessing the 1994/95 anomaly. The EWP is derived from 35 rain-gauges across England and Wales and is thus fully representative of this region. The EWP series for the November to October period is shown in Fig. 7 and for the July and August period in Fig. 8. Precipitation over the 12-month period November 1994 to October 1995 was close to the 1961–90 average. This hides a remarkable seasonal contrast, however, with a very wet winter, a dry spring and a very dry summer (see Table 2). The July and August high-summer period was the driest in the 230-year EWP series with only 47 mm being recorded, compared with a 1961–90 average total of 139 mm. This deficit of 92 mm was larger than in 1976 and 1955, the two previous driest high summers. This contrast between winter and summer precipitation anomalies is one that has become more marked in recent years; winters in England and Wales have been getting wetter and summers drier. While there has been little long-term change in annual precipitation over England and Wales and North-

Table 2 England and Wales precipitation during the period November 1994 to October 1995, expressed as totals, and as anomalies from the 1961–90 average

	Precipitation (mm)	Anomaly (mm)	Anomaly (per cent)
Nov.	88	–4	–4
Dec.	138	+43	+45
Jan.	163	+72	+79
Feb.	115	+50	+77
Mar.	71	–3	–4
Apr.	28	–33	–54
May	48	–17	–26
June	20	–45	–69
July	38	–24	–39
Aug.	9	–68	–88
Sept.	123	+45	+58
Oct.	52	–35	–40
Dec.–Feb.	416	+165	+66
Mar.–May	147	–53	–26
June–Aug.	67	–137	–67
Nov.–Oct.	893	–25	–3

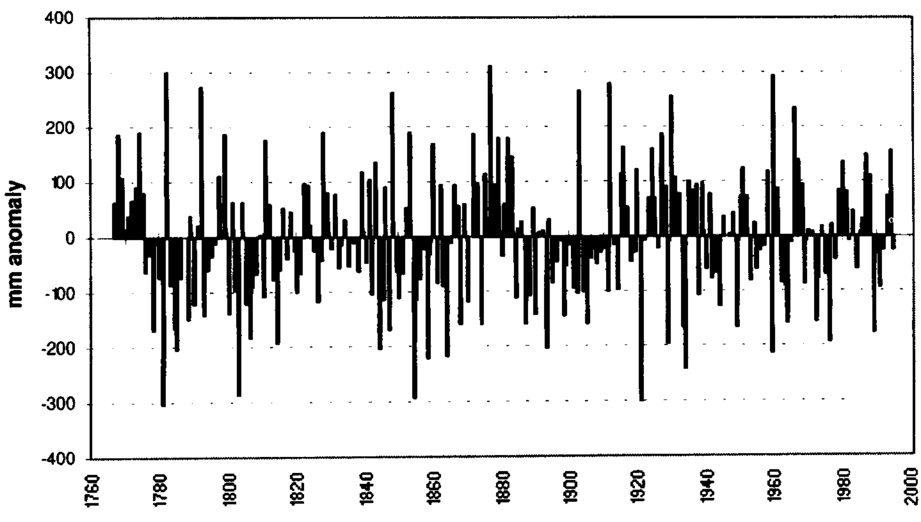

Fig. 7 Precipitation anomaly, with respect to the 1961–90 average, over England and Wales for each November–October period from 1766/67 to 1994/95. Data extracted from the EWP series.

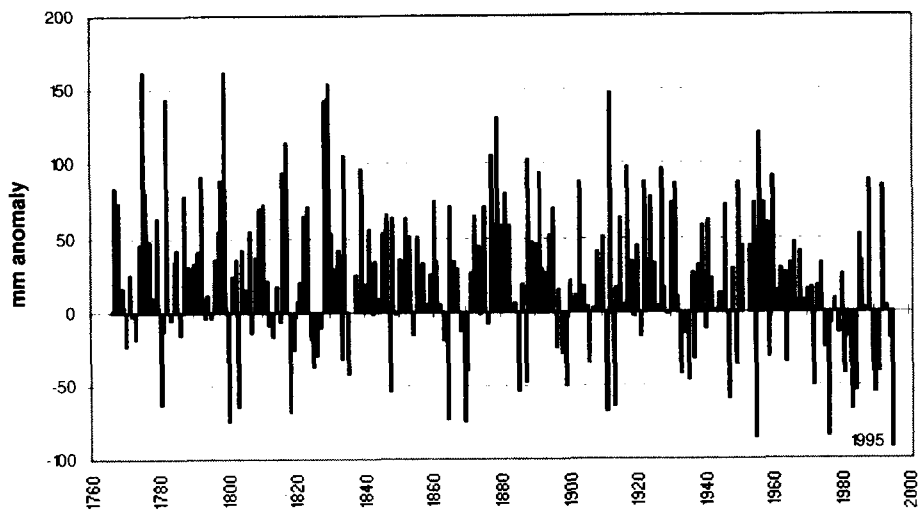

Fig. 8 Precipitation anomaly, with respect to the 1961–90 average, over England and Wales for each July and August period from 1766 to 1995. Data extracted from the EWP *series.*

ern Ireland, this is not true of Scotland where precipitation has increased by about 10 per cent over the last 15 years (Jones *et al.* 1997).

Regional precipitation

Precipitation anomalies over a region as large as the UK are less coherent than temperature anomalies. Nine regional precipitation series were also therefore examined. These regions derive from the work of Wigley *et al.* (1984) and Gregory *et al.* (1991). The regional pattern of anomalies during the 1994/95 period is shown in Table 3. Two features emerge from these data. For the year November 1994 to October 1995, while precipitation was close to average over most of England and Wales (as shown above), and also over Northern Ireland, over Scotland the year was wet with anomalies of up to 300 mm (or 15 to 20 per cent). For the high-summer period of July and August, all regions of the UK experienced similar precipitation deficits – between 65 and 95 mm – although in percentage terms these deficits were largest in central and north-western England. The main difference between the 1976 and 1995 droughts was that in 1975/76 the whole period from November to August was dry over the affected area, whereas in 1994/95 it was generally only the spring and summer seasons that were dry.

Table 3 Annual (November 1994–October 1995) and July–August 1995 precipitation for the nine regions of the UK, expressed as totals and as anomalies from the 1961–90 average

Region	November 1994–October 1995 Precipitation (mm)	Anomaly (mm)	Anomaly (per cent)	July–August 1995 Precipitation (mm)	Anomaly (mm)	Anomaly (per cent)
SE England	711	–10	–1	40	–66	–62
SW England and S Wales	1057	0	0	44	–90	–67
Central and E England	551	–92	–14	32	–82	–72
NE England	1050	+34	+3	68	–94	–58
NW England and N Wales	721	–53	–7	37	–93	–72
S Scotland	1694	+320	+23	122	–80	–40
N Scotland	1904	+290	+18	161	–65	–29
E Scotland	853	+100	+13	48	–85	–64
N Ireland	1043	–30	–3	100	–64	–39

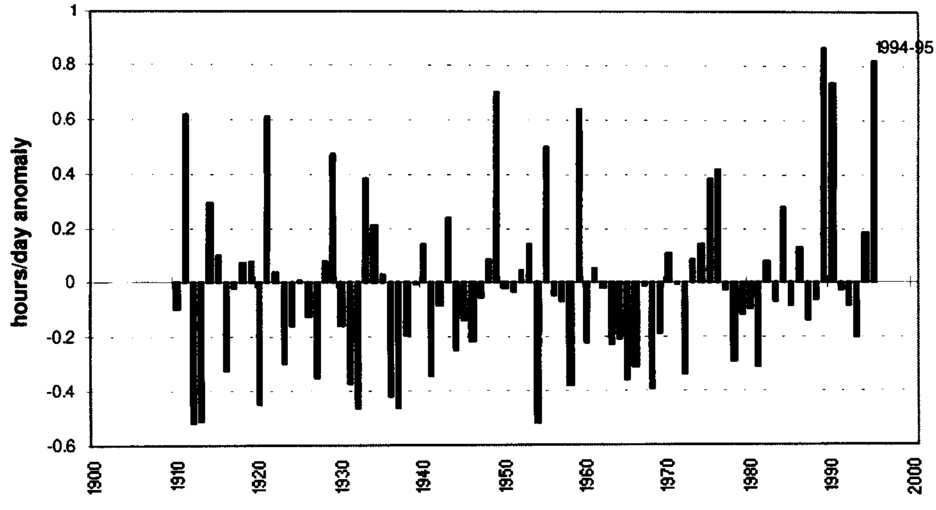

Fig. 9 Sunshine-rate anomaly, with respect to the 1961–90 average, over England and Wales for each November–October period from 1909/10 to 1994/95. Data extracted from the EWS series.

Further analysis of precipitation in the UK during 1994 and 1995 is provided by Marsh and Turton (1996).

Sunshine

The longest homogeneous regional series of sunshine hours for the UK only extends back to 1909 (compared with 1659 for temperature and 1766 for precipitation). This series (EWS), representing England and Wales, has been compiled by the Hadley Centre and is updated by them each month (Mike Harrison, personal communication). The series is compiled from between 10 and 20 synoptic stations across England and Wales.

Figure 9 shows the series of November–October sunshine-rate anomalies from 1909/10 to 1994/95. The 1994/95 year was the second sunniest year in the series with an anomaly of 0.8 h day^{-1} (an extra 299 hours of sunshine averaged over the year) – not quite as sunny as 1988/89. The high-summer period of July and August 1995 was also the second sunniest in the series, not quite reaching the previous record sunshine of 1911 (Fig. 10). The month-by-month and seasonal rates over the 1994/95 period, together with anomalies from the 1961–90 average, are shown in Table 4. With the exception of November 1994 and January 1995, all months recorded above average sunshine, March, April, July and August by 1 h day^{-1} or more. August was exceptionally sunny with about 3.7 h day^{-1} more sunshine than the 1961–90 average – the sunniest August in the series by a long way (the next highest was August 1947 with an anomaly of 3 h day^{-1}).

Table 4 England and Wales sunshine rates for the period November 1994 to October 1995, expressed as hours per day and as anomalies from the 1961–90 average

	Sunshine (h day^{-1})	Anomaly (h day^{-1})	(per cent)
Nov.	1.5	–0.7	–32
Dec.	1.8	+0.3	+20
Jan.	1.6	–0.0	0
Feb.	2.6	+0.3	+13
Mar.	5.2	+1.7	+49
Apr.	5.9	+1.0	+20
May	6.8	+0.7	+11
June	6.8	+0.5	+8
July	7.4	+1.5	+25
Aug.	9.4	+3.7	+65
Sept.	4.6	+0.1	+2
Oct.	4.0	+0.8	+25
Dec.–Feb.	2.0	+0.2	+11
Mar.–May	6.0	+1.1	+22
June–Aug.	7.9	+1.9	+32
Nov.–Oct.	4.8	+0.8	+20

Comparison with previous years

Warm summers were experienced in both 1989

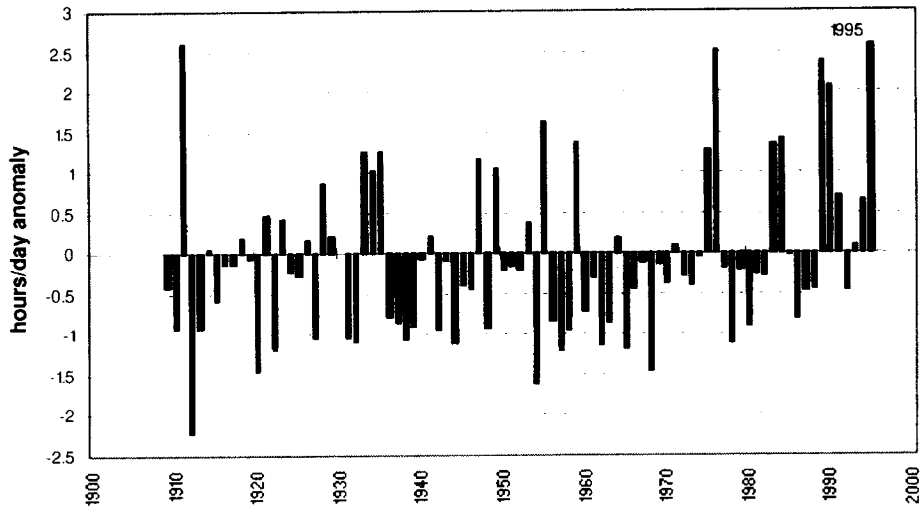

Fig. 10 Sunshine-rate anomaly, with respect to the 1961–90 average, over England and Wales for each July and August period from 1909 to 1995. Data extracted from the EWS series.

and 1990 and are described by Jones and Hulme (1993). Their impact, together with the mild winters of 1988/89 and 1989/90, on terrestrial and freshwater environments is described by Cannell and Pitcairn (1993). The summer of 1983 was also very warm. The closest comparison to the climate anomaly for 1995, however, is perhaps 1976. The climatology and hydrology of the 1975/76 hot and dry year are described by Doornkamp *et al.* (1980).

Using the long series of CET, EWP and EWS we can place these two anomalous years, 1976 and 1995, in a longer historical context by examining bivariate scatter plots for the annual (November to October) and seasonal (July and August) climate anomalies (Figs. 11, 12 and 13). In all three cases – temperature versus precipitation, temperature versus sunshine, sunshine versus precipitation – 1995 is seen to be a more extreme year than 1976. Only in the temperature versus sunshine plot (Fig. 12(a)), however, is 1995 the most extreme of all years; the average precipitation of that year means that there have been other more extreme years in the past for temperature versus precipitation and sunshine versus precipitation. For the

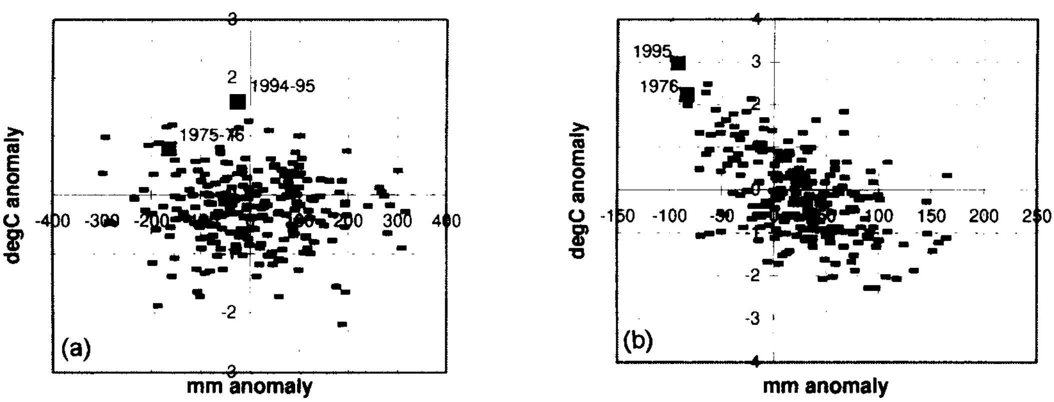

Fig. 11 Distribution of mean temperature versus precipitation anomalies over the period 1766 to 1995 for (a) November–October and (b) July–August. Data from the CET and EWP series. Anomalies are with respect to the 1961–90 average. Squares mark the 1976 and 1995 events.

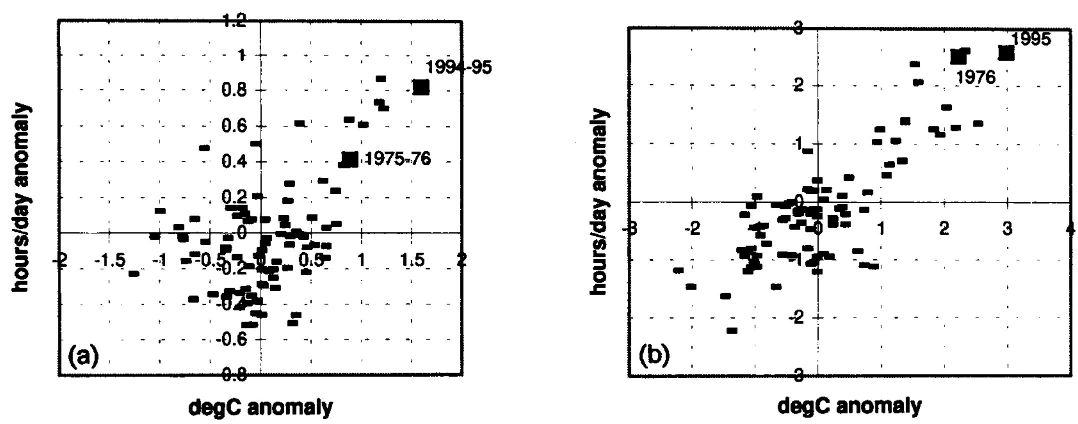

Fig. 12 Distribution of mean temperature versus sunshine-rate anomalies over the period 1909 to 1995 for (a) November–October and (b) July–August. Data from the CET and EWS series. Anomalies are with respect to the 1961–90 average. Squares mark the 1976 and 1995 events.

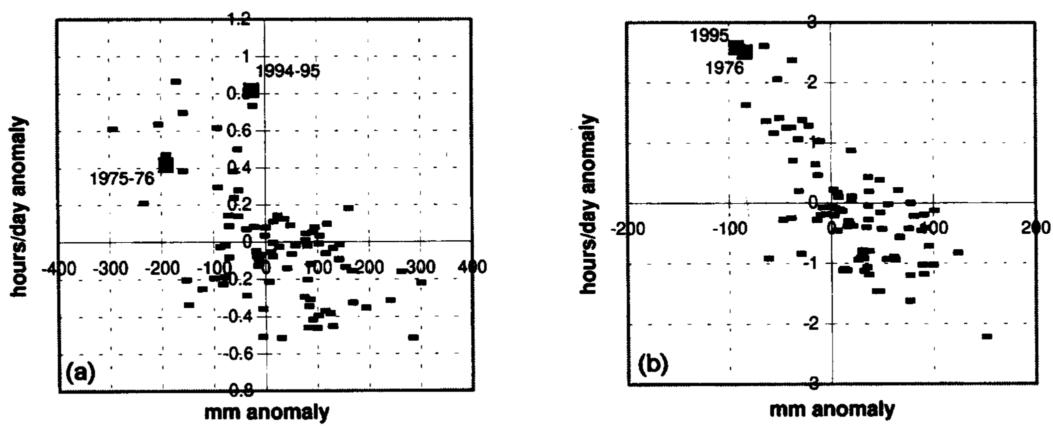

Fig. 13 Distribution of precipitation versus sunshine-rate anomalies over the period 1909 to 1995 for (a) November–October and (b) July–August. Data from the EWP and EWS series. Anomalies are with respect to the 1961–90 average. Squares mark the 1976 and 1995 events.

high-summer period, however, 1995 is the most extreme year in the entire historical series in all three comparisons.

Comparison with future years

One frequently asked question concerns how representative a year like 1994/95, or the high summer of 1995, may be of future climate in the UK, warmed as a result of global climate change. Although considering future climate change is not the primary aim of this article, it is useful to put the anomalous year of 1994/95 into the context of a scenario of future UK climate change. To do this, the scenario described in the 1996 Climate Change Impacts Review Group (CCIRG) report on the potential impacts of climate change in the UK (CCIRG 1996) is used.

The individual 1961 to 1990 values of the CET and EWP are perturbed by the mean temperature and precipitation change contained in the CCIRG scenario for central England for the period from 2021 to 2050 (*i.e.* a period centred on 2035, some 40 years hence). This generates a new distribution of anomalies representing the climate of this future 30-year period and is shown in Fig. 14

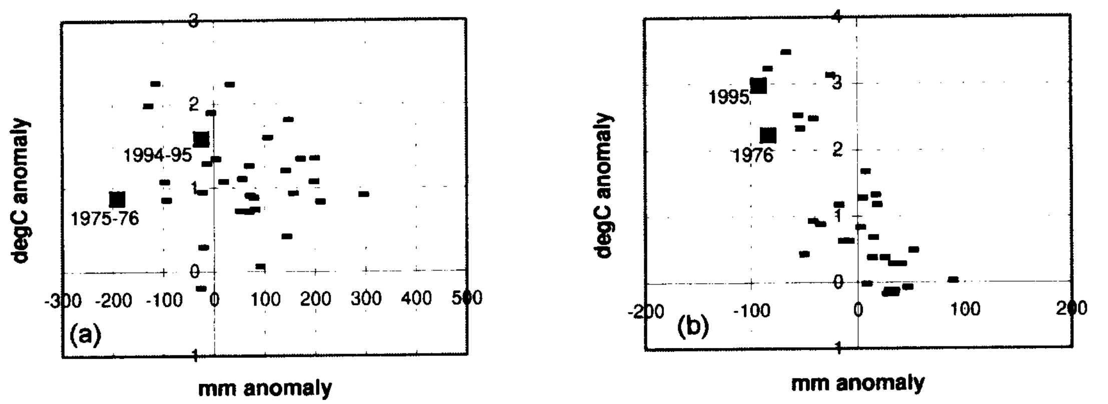

Fig. 14 Distribution of 30 years of climate anomalies (temperature (CET) and precipitation (EWP)) over central England for the scenario period 2021–50 (assuming the CCIRG scenario and constant variability). Squares show the relative positions of the 1976 and 1995 anomalies. (a) November–October and (b) July–August; all anomalies are expressed with respect to the 1961–90 average.

for the November to October year and for the July and August period. This scatter of climate anomalies is still expressed relative to the 1961–90 average and one can see that, compared with Fig. 11, the distribution has shifted to the warmer half of the plot (the CCIRG scenario warming by 2035 is just over 1 degC relative to the 1961–90 average). There has been relatively little change in the precipitation dimension of the plot since the CCIRG scenario presents little summer precipitation change over central England (a 2 per cent decline) and only a modest change annually (about a 6 per cent increase). Neither of these future precipitation changes are significant in terms of natural precipitation variability over the UK.

The 1995 and 1976 anomalies (the squares on Fig. 14) are now superimposed on this scatter of 2021–50 climate anomalies. We see that although both of these years remain towards the extreme part of the temperature distribution, they would no longer be *the* extreme years. For example, during 2021–50 we may expect three high summers warmer than 1995 and six years warmer than the November 1994 to October 1995 period. So, rather than the 1995 event being an unprecedented anomaly in over 300 years of temperature measurements (as it currently is), during the period 2021–50 such a high-summer extreme would occur on average once every ten years and such a yearly extreme once every five years. In precipitation terms both 1995 and 1976 would remain quite exceptional and, owing to elevated temperatures and hence high evaporation rates, actual moisture deficits during such extreme episodes would probably be more severe.

This type of assessment of future climate anomalies assumes that the variability of UK climate does not change (*i.e.* that the variability of 1961 to 1990 will be typical of the variability of climate between 2021 and 2050) and also, of course, relies heavily upon the plausibility of the changes simulated by the climate model used in the CCIRG scenario (in this case the 1991/92 UKTR experiment from the Hadley Centre (Murphy and Mitchell 1995)). Both of these two assumptions are difficult to verify. For example, a more recent climate-model experiment from the Hadley Centre (HADCM2, Mitchell *et al.* 1995), in which the effects of sulphate aerosols were simulated, would yield a somewhat different assessment; temperature over the UK would not warm by quite so much, but summer precipitation would decline more substantially. Although the precise numbers in this sort of assessment are therefore uncertain, this approach does provide one way of placing the unusually warm year of 1994/95 and the summer of 1995 into a longer-term perspective of possible future climate change in the UK.

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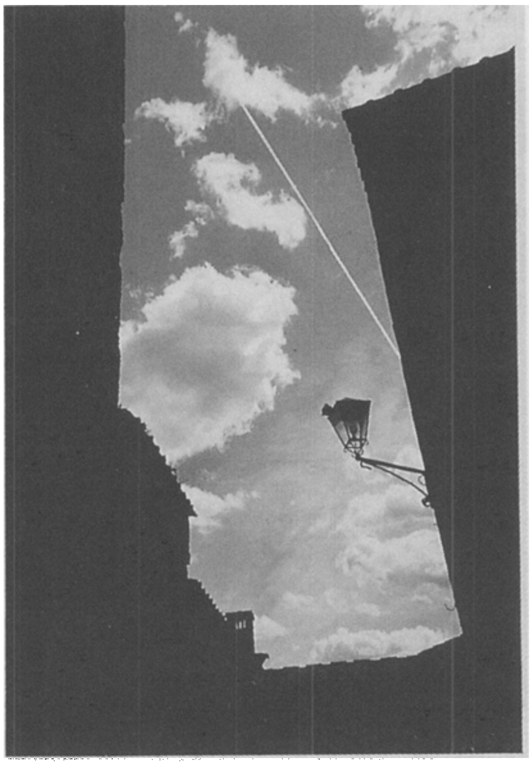
Tuscan skies



Shallow cumulus, cirrus and a contrail in very clear, early afternoon air, near Firenze (Florence), Tuscany, March 1994