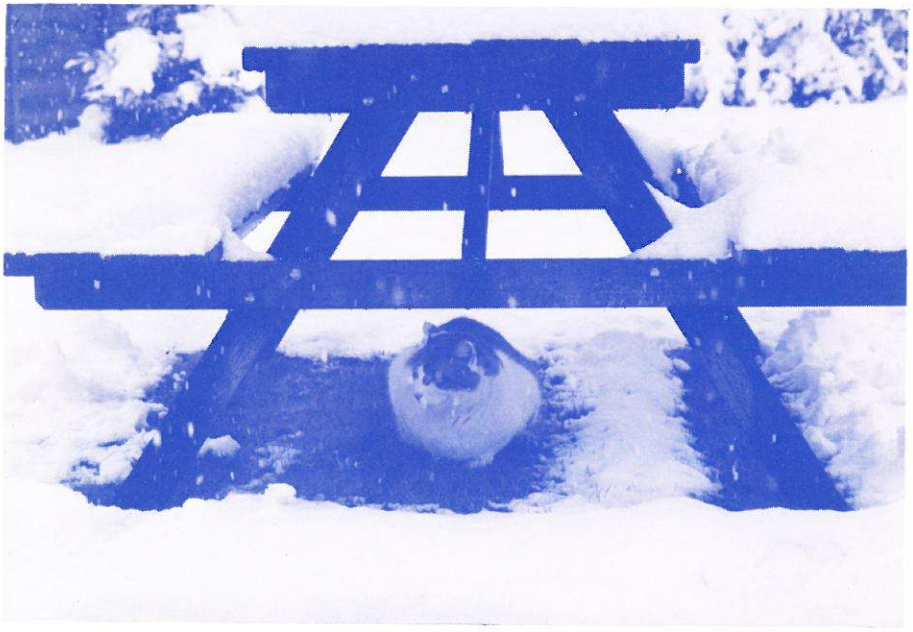
The JOURNAL of METEOROLOGY



JASPER THE CAT SHELTERING FROM HEAVY SNOWFALL AT CATERHAM, SURREY, ENGLAND ON 5 APRIL 1989

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An international journal for everyone interested in climate and weather, and in their influence on man."

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FRONTOGENESIS CAUSES UNEXPECTED HOME COUNTIES SNOWFALL ON 5 APRIL 1989

By W. S. PIKE
19 Inholmes Common, Woodlands St. Mary, Newbury, RG16 7SX.

Abstract: During daylight on 5 April 1989, the western 'Home Counties' were affected by an appreciable period of mostly-moderate snow, lasting 2-5 hours on low ground and 5-9 hours on some higher parts of The Downs and Chilterns producing unexpected morning accumulations (above about 40m) of 5-10cm in parts of Berkshire, Buckinghamshire and Hertfordshire, with a maximum 15cm reported locally on the North Downs (i.e. at Tadworth) in Surrey by 1200 GMT.

The snowfalls formed part of a precipitation belt associated with an occlusion undergoing temporary frontogenesis as it returned south-westwards over England. A developing 'tongue' or "trowal" of warmer air aloft was moving northwards and being 'undercut' by colder low-level air arriving from the east-north-east, resulting in temporarily-increased thermal contrast, enhanced frontal activity, and the pulses of heavier precipitation which were seen to move west-north-westwards on radar displays.

Snowfall was prolonged by continuity of the primary surface depression to move northwards nearby (at longitude 2½-degrees East) into the southern North Sea, causing the occlusion to become quasi-stationary (through London) over S.E. England during the day. Early morning commencement (between 06 & 08 GMT) produced heaviest accumulations, which were also due to the height of the 0°C isotherm being lowered by at least 1,500ft (450m) to near the surface in moderate to heavy snow.

INTRODUCTION

Discussing events of 5 April 1989 with friends, ex-colleagues and correspondents, a distinct impression was gained that they had been genuinely *surprised* to see both intensity and duration of snowfall, especially that morning, hence its description as "unexpected" here because by definition a 'surprise' cannot be an expected event.

To my recollection, a slow warming trend had been correctly anticipated to have commenced later during the previous evening, and this was forecast to continue overnight and during the 5th in S.E. England. Presumably, this story had changed overnight, because early morning BBC Radio 4 forecasts made reference to outbreaks of rain, sleet or snow. The forecaster conveyed a reluctant air of 'We-hadn't-wanted-to-be-still-talking-of-snow-but-it-seems-like-we'll-have-to-now'.

This feeling of 'reluctance' changed to one of 'acceptance' when BBC 1 TV 'lunchtime forecasts' mentioned the "inch or two" which had fallen (to some, an understatement) and predicting 'another 1-2 inches possible in C.S. England' during the afternoon. It seemed that 'change' had become necessary to earlier forecasts overtaken by subsequent events. Why so much snow?

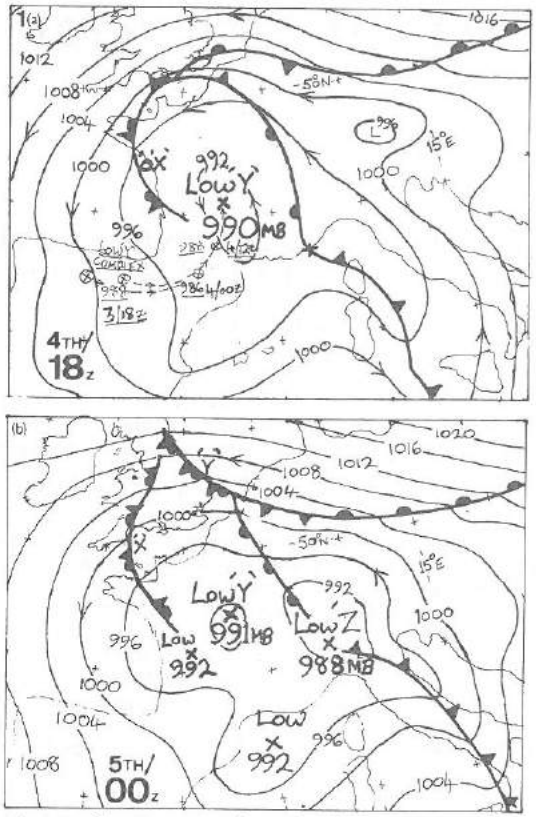

Fig.1: Surface Synoptic Charts for (a) 4 April 1989, 1800 GMT, with continuity of Low 'Y' centre at 6-hrly.-intervals since 3rd/1800 GMT, and (b) 5 April 1989 at 0000 GMT.

THE SYNOPTIC SITUATION

Figure 1 shows Low 'Y' was swinging northwards over Southern France during the evening of 4 April 1989, with its associated fronts pushing into S.E. England and giving a light snowfall ahead of (temporarily) milder conditions. By 00 GMT on the 5th, occlusion 'OX' was weakening, having recently 'split' over The Pennines; however, its eastern part (labelled 'Y') then near the east coast of England, was beginning to return south-westwards as a more-active feature.

Although occlusion 'OY' was not well-marked at the surface, ascents (radiosondes) from Crawley (Figure 2) demonstrate a temporary situation of increasing thermal contrast, in which warmer air was being advected aloft from the south-south-east, over colder air 'under-cutting' from the east-north-east, leading to a period of probable frontogenesis during the morning of the

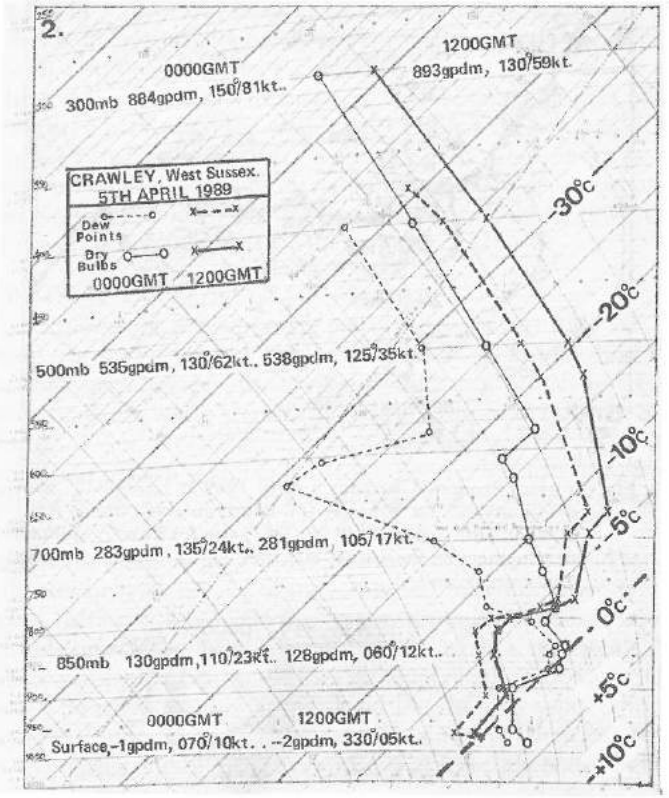

Fig.2: Tephigrams for Crawley, West Sussex (Alt., 144m) for 0000 GMT and 1200 GMT on 5 April 1989, showing the warming aloft and cooling below 800 mbars which took place during the period. N.B. Winds backing and decreasing (on the south side of the occlusion undergoing frontogenesis) during the period of snow, which has reduced the height of the 0°C isotherm to near the surface. Heights of standard pressure levels are in geopotential decametres (gpdm).

5th over S.E. England. Hence a period of more intense activity with heavier precipitation was likely; also the frontal surface 'OY' had risen to around 2,000m over S.E. England by 12 GMT.

There was a further important complication. Figure 3 and sequential UK Radar Network precipitation pictures (Figure 4) show that as 'OY' moved south-westwards, its progress was being retarded, particularly over S.E. England, as Low 'Y' moved steadily northwards over N.E. France at a longitude near 2½-degrees East, during the morning of the 5th.

Low 'Z', which began to fill rapidly after 12 GMT on the 5th, was a short-lived feature compared to low 'Y', which continued moving northwards over

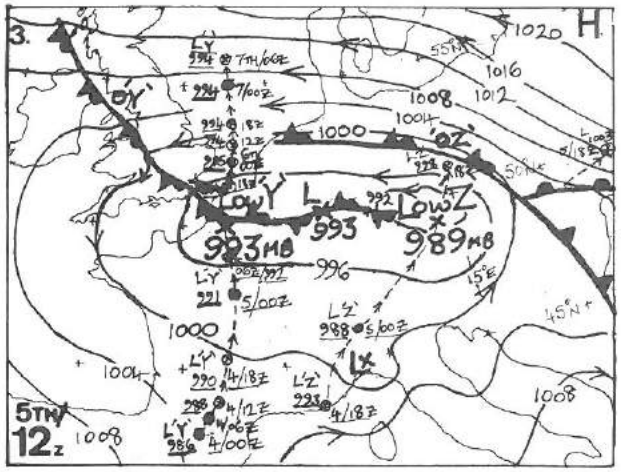

Fig.3: Surface Synoptic Chart for 5 April 1989 at 1200 GMT, with continuity of Low 'Y' centre at 6-hourly-intervals from 4 April at 0000, until 7 April at 0600 GMT; also for Low 'Z' from its development on the 4th at 1800, until losing identity 24-hours later over Poland.

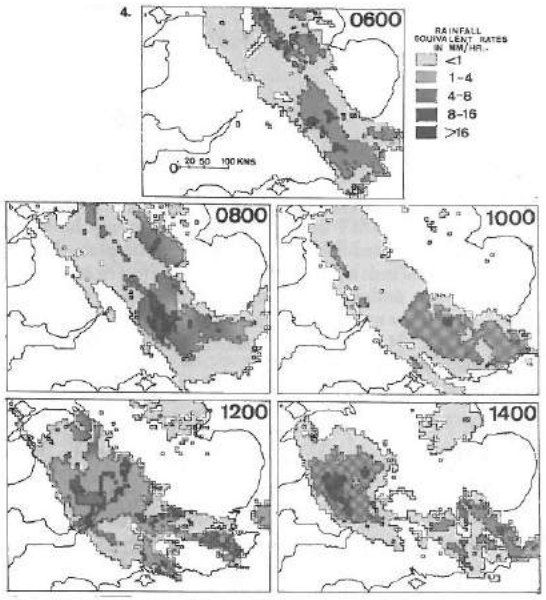

Fig.4: UK Weather Radar Network Precipitation Pictures, based on computer interpretations of average intensities over 5km x 5km squares, at 2-hourly-intervals from 0600 to 1400 GMT on 5 April 1989.

the North Sea at a slow rate during the next two days with little change in central pressure at around 994 to 995mb throughout its progression over the sea (Figure 3) until much later on the 7th.

Over the south-eastern half of England, surface temperatures had steadily risen overnight to between 3 and 6°C by 03 GMT on the 5th, but rain was still continuous at Coltishall in Norfolk (indicating reluctance of the occlusion to move away northwards) and moderate sleet was suddenly reported from Wattisham, Suffolk. By 05 GMT, sleet was widespread in the E. Midlands, and moderate rain was breaking out further south-east.

DEVELOPMENT OF THE SNOW AREA

UK Radar Network precipitation pictures (Figure 4) indicate a band of precipitation moving steadily south-westwards at about 10kt over the Midlands, and it temporarily broadened to 'blot out' much of S.E. England around mid-morning, while remaining 'quasi-stationary' through Surrey and East Berkshire where precipitation was often heaviest. Much fell as snow to the west of a fairly-sharp dividing line running north-south from Bromley to Biggin Hill in Kent. To the east, mostly rain fell (personal correspondence with Mr Martin Nunn).

More-frequent imagery from radar (not shown), when viewed sequentially, clearly indicates heavier 'pulses' of snow moving west-north-westwards along the belt itself. Infra-red 'METEOSAT' imagery sequences show a mass of cold-topped cloud, orientated NW-SE (Figure 5), with a mesoscale 'wave' of cloud-masses with tops below –40°C moving north-westwards from over Hampshire to South Wales between 08 and 14 GMT, by which time Figure 4 shows precipitation more in a series of mesoscale areas (than in a general belt as previously) with a notable area over S.E. Wales. A clear feature of the upper cloud masses on the satellite imagery was their sharp but wavy edge in the south-west compared to a much less-smooth edge in the north-east.

Table 1 attempts a chronological listing of correspondents' reports by onset times of at-least-moderate snowfall at their particular locations, and this listing generally confirms a slow westward spread of the appreciable snowfall. It is dangerous to draw conclusions when observers' diligence varies from person to person in the early morning, but from most reports the process of either (1) initial rain turning to snow or (2) sudden onset of snow appears to have been quite rapid, with only the observer (Jon Webb) in Oxford noting it took as long as one hour (i.e. 0630-0730 GMT) for 'rain/wet snow-transition' to occur. With a rapid onset of snow came the expressions of surprise, that such an event occurred with a matter of minutes . . . or 'tens of minutes', to be more accurate!

Downward penetration of snow (Lumb, 1960 & 1961; Stewart et al, 1987) is aided by increasing intensity of precipitation. Note well the sharp south-western edge to heavier intensities indicated by radar pictures (Figure 4) at 06 and 08 GMT over Berks., S. Oxon & Surrey; hence the sudden onset of snow in these areas as the heavier precipitation edged westwards.

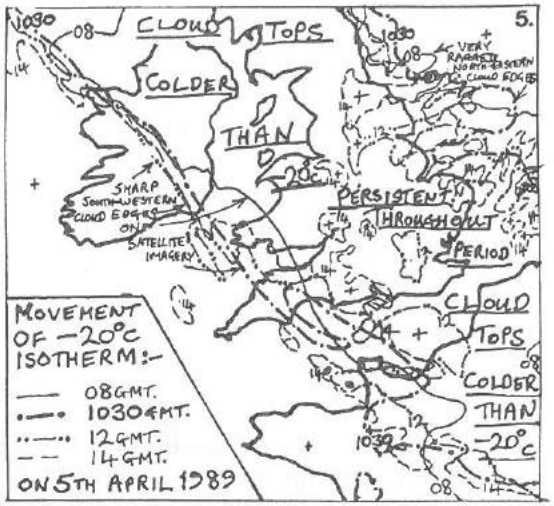

Fig.5: Based on geostationary 'METEOSAT' Infra Red data over period 0800 until 1400 GMT on 5 April 1989, showing movement of the -20°C cloud-top-temperature isotherm, which exhibited a sharp but 'wavy' edge in the SW, compared to a less-well-marked, 'ragged' edge in the NE, with much of the UK beneath a broad band of colder (higher) topped frontal cloud, orientated NW-SE. Much of the upper cloud associated with occlusion 'OX', currently lying from Biscay to S. Eire as a 'dying' feature, was no longer in evidence, as occlusion 'OY' became dominant.

Figure 2 shows the freezing level ('height of the 0°C isotherm') had lowered relatively close to the 144m altitude surface at Crawley, where otherwise it had been (at 00 GMT) and might be expected nearer to 2000ft (ca. 600m) had there been no appreciable snowfall. Falling snow probably lowered the wet-bulb freezing level typically by some 1,500ft (ca. 450m) between 07 and 09 GMT. At Beaufort Park, Bracknell, temperatures (wet bulb) fell from Ps3.0 to Ps0.7°C in the hour during which rain had become snow (07 to 08 GMT), with perhaps the wet-bulb freezing level lowering at a large initial rate, near or in excess of 1,000ft (ca. 300m) hr^{-1}, in heavier precipitation.

One explanation for the intensification of precipitation is given by the movement northwards of an amplifying 'tongue' of warm air aloft (Figure 6) whose axis would have only been 'in phase' overhead 'OY', perhaps for a few influential hours as it passed. This could well have led to temporary frontogenesis of the occlusion as it moved slowly south-westwards, producing 3-6 hours of appreciable snowfall on low ground, and the 6-9 hours that were reported on The Downs and S.W. Chilterns. At Crawley, the 1000-500mbar thickness values were quite high for snow, having risen from 536 to 540gpdm

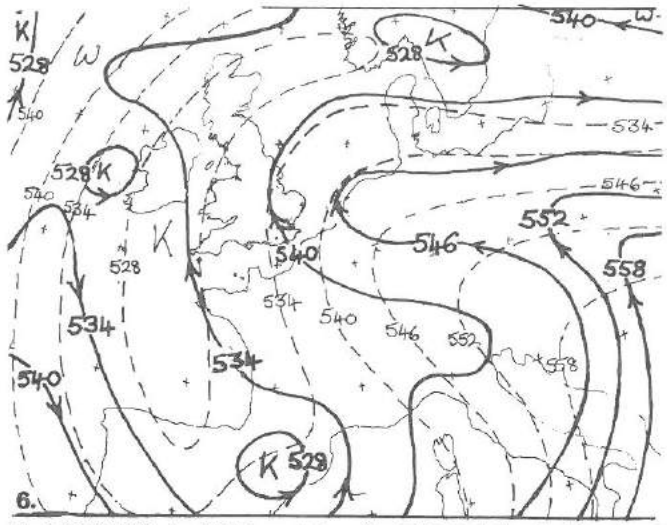

Fig.6: 1000-500mbar 'Thickness' charts for 0000 GMT (pecked lines) and 1200 GMT (full lines) on 5 April 1989. N.B., movement north of a developing 'tongue' or 'trowal' of warm air aloft, the axis of which moves over S.E. England during the period.

CHRONOLOGICAL TABLE 1.

LOCATION	ALT(m)	PERIOD OF SNOWFALL(GMT)	DEPTH AT 12GMT(cms)	REMARKS
1. Heath End, Berkhamstead, Herts.(175)		0600—1500.(9hrs) (14.3mm read at 07h GMT on 6th,over past 24hrs)	9cm.	Often Heavy Snow with Vis reduced to 100yds.
2. Warlingham(170) and New Addington, Surrey(154)		Before 0615—1230(6h.15m+) (26.3mm during the 5th)	6cm.	Moderate Snow until 11GMT, thereafter slight.
3. Reigate, Surrey(61).		ca.0655—1013 (3h.18m.) (11.5mm in 12hrs ending 09Z/5th)	Tr. (22.6mm in 24hrs to 21GMT)	Slight or mod.snow, with 1cm at 09 GMT.
4. Caterham Hill(195) and Caterham School(149),Surrey.		ca.0655—1200 (5hrs+).	10cm.	Mod. or Heavy Snow producing rapid accumulation to 8cm by 0830GMT.
5. London Weather Centre(23m)	Holborn.	ca.07—09 (2hrs)	Nil.	Mod.snow,then 2hrs mod.sleet.
6. Tadworth, Surrey.(176)		0715—1125 (4h.10m.) (24.8mm in 24hrs during 5th)	15cm.	Snow becoming Heavy between 09 & 1045GMT
7. Guildford(Onslow Village,81m)		0730—1200 (4½hrs) (15.7mm in 12hrs to 09Z on 5th)	7cm.	Mod.Snow 0730–11GMT., 5cm in Guildford town
8. Gatwick Airport (62)		ca.0730—1100. (3½hrs). (11.7mm in 12hrs ending 21Z on 5th)	?	Mod. Snow mostly,with 1cm lying at 09Z.
9. Met.Office Technical Training School, Beaufort Park,Nr.Bracknell.(74) Berks.		ca.0730—1330 (6½hrs) (14.4mm in 24hrs ending 09Z/6th)	11cm.	Moderate 0730—1200, with 1cm lying at 09Z. 3cm still at 09Z on the 6th.
10. Oxford, Headington (c.90m)		ca.0730—1300 (6hrs)	6cm.	Moderate 0730—1230 .
11. RAF Benson, S.Oxon.(70)		0743—1240 (4hrs 57min) (12.9mm in 12hrs ending 21Z)	4cm.	Mod.0743—1127, thereafter Slight.
12. Wokingham, Berks(44).		ca.0750—1300+.(5hrs.10min+)	8cm.	Slight, intermittently Moderate.
13. Woodlands St Mary, W.Berks.(183)		0755—1500 & 1600—1700. (8hrs)	4cm.	Often Moderate with visibility reduced to 300m. Sleet 15–16Z.
14. Reading West(c60m)		ca.0800—1300.(ca.5hrs)	1cm.	Mostly Moderate Snow.
15. RAE Farnborough (72)		0808—1240 (4hrs 32min.)	2cm,on concrete; 3-4cm,on grass.	Mod. 0808–1153.
16. Windsor, Berks.(18m)		0830—1400 (5½hrs)	2cm.	Mostly Moderate 0830—1145, but Heavy around 1100 GMT.
17. RAF Odiham, Hants.(123m)		0811—1330(5hrs20min) & ca.1730—2100 (ca.3½hrs) (13.1mm in 24hrs	2cm.	Moderate 0850–0823, otherwise slight, with light sleet 1330-1730.
18. RAF Lyneham, Wilts. (156m)		0930—1530 (6hrs) ending 09Z/6th) (10.8mm in 24hrs	1cm.	Moderate 1030—1430 with 3cm Lying by 1500.
19. RAF Boscombe Down (124m)		1000—1300(3hrs) & 1900—2100(2hrs) (14.4mm in 24hrs to 09Z/6th)	Tr.	Mostly Moderate Snowfall, with 1cm at 13Z. 3cm between 19–21.
20. RAF Brize Norton(88m)	W.Oxon.	1050....1250 (2hrs) (11.5mm in 12hrs ending 21Z/5th)	Tr.	Moderate Snow 1050—1200.

Fig.6a: Chronological listing of snow onset times at certain locations, 5 April 89.

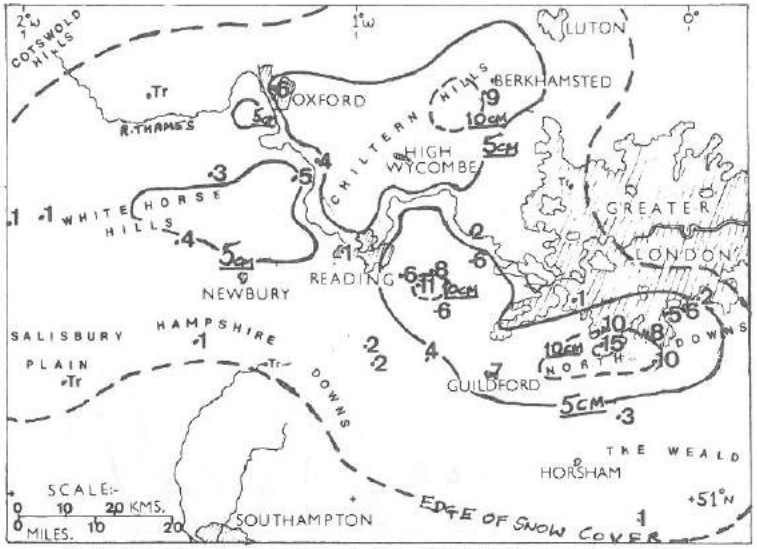

Fig.7: Snow depth chart (cm lying) for 1200 GMT on 5 April 1989.

during the morning of the 5th. It is likely that yet higher values precluded snowfall further east in Kent and Essex, as was observed by Martin Nunn. A snow depth chart for 12 GMT on 5 April 1989 is suggested in Figure 7. Quite a wide area received over 5cm, and only very built-up areas (much of Western Suburban London) or low-lying land near the River Thames and its tributaries escaped with just a light cover or nothing at all.

A train journey is ideal to note how snow cover changes with location, and Dennis Mullen travelled from Guildford to London on the 5th April. He writes:

"Leaving Guildford 0944 (BST), snow was lying on grass and trees up to around Weybridge; after Walton-on-Thames it was mostly on the grass and tarmac on side roads to around 1cm depth to Esher. After Esher, a very thin cover on the ground; patchy, very thin cover by Surbiton Berrylands to New Malden. After New Malden, a trace on grass to Earlsfield. No snow lying after Earlsfield, but falling as sleet/wet snow until arrival at Waterloo, 1026 (BST)".

Snowfalls further west, particularly over the S. Wales Mountains, did occur later on 5th and into the 6th, however fewer observations make a concerted effort needed to investigate these. Certainly, Rhoose (Cardiff) Airport reported appreciable sleet for much of the night, and Cwmbargoed (alt. 372m) in Mid-Glamorgan reported 8cm lying at 09 GMT on the 6th.

EFFECTS OF GROUND TEMPERATURE AND ALTITUDE ON THE SNOWFALL

Several correspondents remarked that, had ground temperatures been a few degrees lower, a snowfall of perhaps twice the actual depth would have occurred. Water equivalents in rainfall totals of 12-25mm (Table 1) confirm that snowdepths of 12-25cm may well have been reported in colder conditions.

That snow settled at all on low ground (e.g. the 11cm at Beaufort Park, just 74m/243ft high) may be attributed to both its intensity and also the grass minimum having fallen just below 0°C (as it did over much of the S.E. half of England apart from Kent and Essex) in this heavier snow, or that falling the previous evening. Certainly, soil temperatures were still quite high, having been warmed up by the previously-mild winter and, more recently, a spell of warm weather early in April, with air temperatures near 16°C on the 1st.

Fig.8: During the afternoon thaw at Woodlands St. Mary, W. Berks. (at 183m alt.) snow is still lying on bare soil and over cracks but not on the concrete itself at 1400 GMT, 5 April 1989.

Phenologists might confirm that many flora were in bloom two weeks or so before usual, from the snowdrops onwards, during spring 1989, a tendency which continued into the summer with the later-flowering varieties here at Woodlands St. Mary. Figure 8 shows a garden border at the author's home, the photograph taken at 1400 GMT, with snow on the soil but not on the concrete, whose temperature was higher. Daffodils and primulas are in bloom, incidentally, and the snow by this time was thawing more rapidly than fresh falls were accumulating; all tarmac and concrete surfaces cleared of snow soon after 1300 GMT at altitude 183m. Reports from RAF Lyneham and Corsham (Keith Mortimore) suggest that parts of N.E. Wiltshire (above 100m) were an exception to the afternoon thaw on the 5th, with accumlations of up to 3cm, as the heavier snow moved westwards. These reports suggest that snowfall there was very altitude-dependent and confined to high ground, as it appears to have been later in S. Wales also.

Further east around Windsor in Berkshire, observations of John Bye and Bernard Burton appear to indicate the heavier morning snowfall (of 5cm or more) occurred on land above 40m (ca. 130ft), such as in the Great Park, whereas only 1-2cm accumulated at most down near the River Thames.

An early-morning commencement of snowfall, following immediately after overnight cooling, appears the ideal time for accumulations in 'unseasonal' months of the year, such as in November (Lumb 1960) or in April/May on high or low ground.

BRIEF SUMMARISING OVERVIEW

The western 'Home Counties' snowfall of 5 April 1989, in producing accumulations of up to 15cm, was the most long-lasting snowfall (up to 9 hrs) of the 1988-89 Winter in S. England. Snow that day came as something of a surprise to most of the author's correspondents, partly because the winter had hitherto been mild on the whole. However, unlike the three previous falls of the 'season' (namely on 20 November 1988, 25 February 1989, and 4 April 1989), which had been well-forecast, the accumulations of 5 April 1989 were 'underplayed' even on the day, leading to a suggested Meteorological Office 'skill factor' of 75%-successful for 1988-89 winter snowfall forecasts (at least for Woodlands St. Mary in W. Berks. at 183m altitude).

CONCLUSIONS

The 5-15cm snowfalls of 5 April 1989 in the western 'Home Counties' may be considered appreciable particularly in terms of their duration, lasting up to 9 hours on modest high ground (between 1000 and 5000ft/150-300m) and 3-6 hours on low-lying land down to approx. 40m/130ft asl. Accumulations were due to:

(1) Frontogenesis of an occlusion which was returning south-westwards just as a developing 'tongue' of warm air aloft (orientated east-west) was moving northwards overhead. This caused temporarily-increased thermal contrast, leading to intensification of the associated frontal snow for a period

of several hours before the features moved 'out of phase' again.

2) Moderate to heavy intensity of the snowfall significantly lowering the height of the 0°C isotherm (i.e. by some 1500-2000ft/450-600m), permitting downward snow penetration.

3) Snow commencing just after dawn, as effects of nocturnal radiation cooling of both the cloud tops and the ground were at a theoretical maximum. N.B. Places with maximum reported snow depths had snow onset between 06 and 08 GMT.

4) The occlusion becoming quasi-stationary just south of London as Low 'Y' moved steadily northwards from N.E. France to the southern North Sea at Longitude 2½-degrees East during the 5th. This had the effect of *prolonging* the precipitation over S.E. England.

This complex synoptic situation, analysed with the benefit of hindsight, would have probably been very difficult to predict, as would have the associated weather in detail.

Snow depth information for 12 GMT on the 5th (at Official Stations) was obtained from the individual sources because, although observed and reported at 'synoptic hours' (following a change of 3cm or more since the previous measurement) this information is not plotted, as it could be by computer (and as it normally is at 09 GMT only) on the Public Record British Isles Chart in the Met. Office Technical Archives. At 09 GMT on 5 April 1989, only one station in Wales was reporting more than 1cm of lying snow, a situation which had rapidly changed by 12 GMT (as Figure 7 suggests).

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road), J. D. C. Webb (Oxford): with late reports from D. Barnett (Vernham Dean) and J. Bird (Epsom Downs). To each my thanks.

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MID-WINTER MILDNESS FOLLOWS THE SPANISH DOWNPOURS

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Late holidaymakers to Spain's southern coasts in November and early December 1989 were disappointed and soaked by deluges of rain as a result of monthly rainfall totals that exceeded normal annual expectations. Worst hit was Gibraltar with 950mm in three weeks; this total included the second wettest 24hr period in the long series of observations on "the Rock". During the 24 hours ending at 0900 GMT 4th December 1989 257.2mm (10.13in) of rain was recorded, causing widespread flooding. This total was only exceeded by the 293.9mm (11.57in) recorded on 30th January 1989. In the period 1-4th December 1989 a total of 341mm of rain was recorded, almost as much as the annual total of 355.8mm recorded in the dry rainfall years ending on 31st July 1981. The monthly average (1947-76) for November is 123.5mm and for December 144.4mm. Both months have a very high degree of rainfall variability with totals ranging from 478mm to 1.6mm in November and 417mm to 0.7mm in December. Prior to 1947 various sites were used for meteorological recordings many of them elevated "up the Rock" and from these records it is known that 1861 with 598mm in December and 1858 with 633mm were both extremely wet. Traffic chaos and a number of landslips and rockfalls resulted from the 1989 rainfalls and Gibraltar airfield had to be closed for the period from 1100hrs on 4th December to 0645 on 5th December.

Further east Malaga was badly flooded when 138mm of rainfall fell in 12 hours on 17th November 1989 and severe gales caused extensive damage to promenades and sea walls all along the Costa del Sol, where a state of emergency was called. The bad weather in the central Mediterranean received widespread publicity when the summit talks off Malta were disrupted by easterly gales and Valletta recorded over 50mm of rain on the first day of the superpower meeting. While, on occasions, spectacular amounts of rain are a feature in the latter months of the year at many Mediterranean locations the persistent blocking high near Britain and cold upper low near Spain this year was conducive to the persistence of bad weather for an extended period (Figure 1).

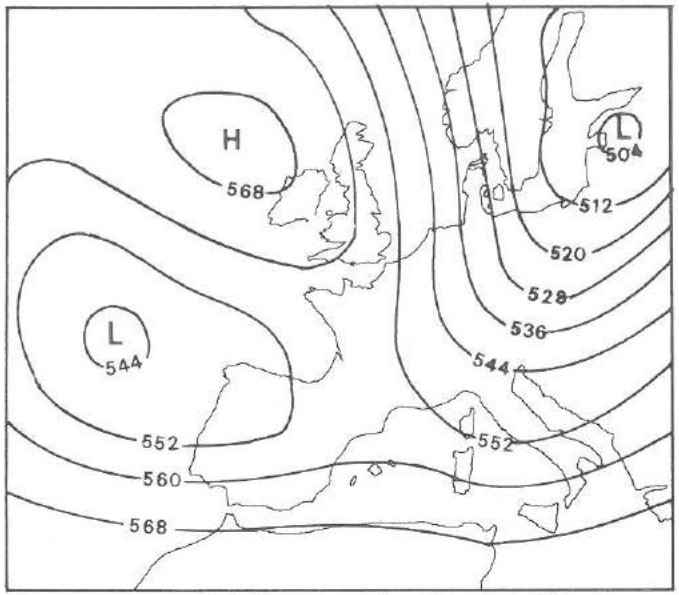

Fig.1a: Typical 500mb pattern late November 1989.

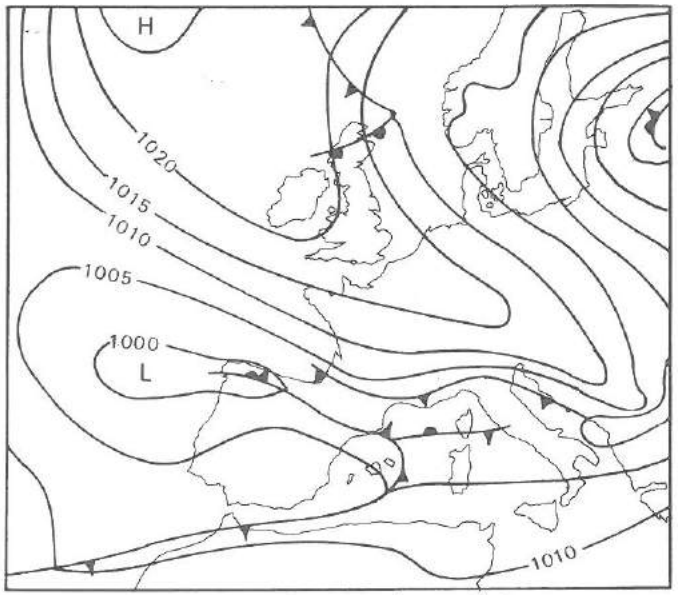

Fig.1b: Typical surface map during the Spanish downpours.

As the blocking high that had hovered near to Britain for almost a month began to decline and slip eastwards in mid-December a depression of record depth moved north-eastwards from around 40°N. 20°W. of Spain to the British Isles. At 1800hrs. on 15th December 1989 central pressure was below 940mb and by 1200hrs. on the 16th the low was near 50°N. 15°W. at 936mb. Preliminary analysis suggests these central pressures were nearly 10mb lower than the previous record in this quadrant of the North Atlantic. On the forward side of the low a spectacular surge of sub-tropical air gave may places in central Europe new December record-high temperatures (Figure 2). Alpine

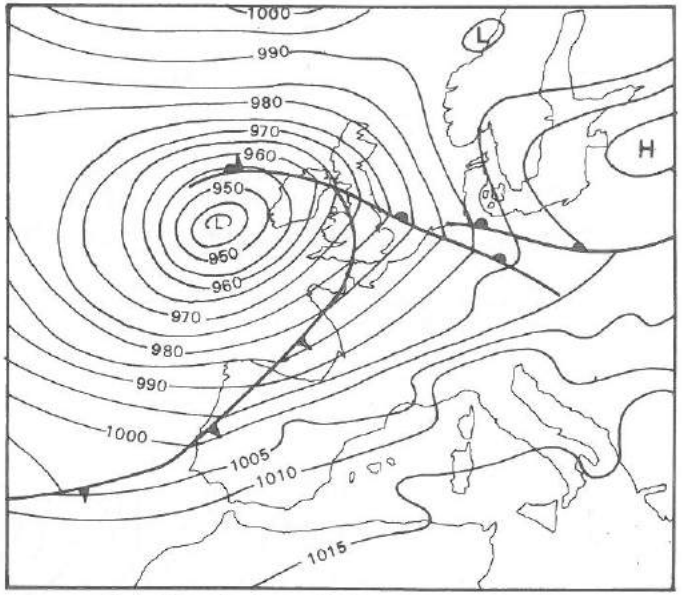

Fig.2: Synoptic chart at 1200 on 16 December 1989.

ski-slopes were completely denuded of snow, while around the Italian coast the beaches were reported busy with swimmers enjoying an unseasonally late dip. Previous record maxima for December and some of this year's mid-day reported temperatures are shown below.

	Previous Record	*December 1989*
Algiers	24°	30° 17/12, 27° 18/12
Budapest	15°	17° 17/12, 16° 19/12
Biarritz	-	21° at 12.00 & 18.00 hrs. on 15/12
Rome	19°	20° 18/12, 19° 19/12
Naples	20°	21° 17/12, & 18/12
Belgrade	20.3°	20° 17/12, 19° 19/12

From Algiers in the west to Budapest in the east temperatures reached or exceeded all-time maxima at stations which in a number of cases have over 100 years of record. At a time when thoughts were turning towards Christmas temperature levels in many places reached levels more typical of late summer.

SUNDERLAND'S DRIEST SEPTEMBER IN 130 YEARS

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Abstract: Sunderland has an unbroken run of 130 years of rainfall observations. In all that time there has been no drier September than that of 1989. This paper reviews the month's conditions.

INTRODUCTION

For many parts of the British Isles 1989 has been a year of memorable weather. Most areas have enjoyed exceptional summer and winter warmth; some areas, for example western Scotland, have had spells of very heavy rainfall while many eastern districts have, conversely, remained extremely dry. The sunshine has everywhere been notable. Yet even in this protracted spell of peculiar weather Sunderland's September rainfall, or lack of it, is a curiosity. The town boasts a rainfall record that dates back to October 1859 when the then young Thomas Backhouse set up his observatory which was to occupy so much of his free time until a few years before his death in 1920 (Wheeler, 1983). The record was then picked up by the local Public Health Department and, latterly, by the Polytechnic which has contained the work of the town's weather station since 1974 (Wheeler, 1983). In all that time there has been no drier September than that of 1989. Indeed, its 8.1mm has only been approached on two occasions, 1971 with 8.9mm and 1907 with 10.4mm. Furthermore, considering all twelve calendar months, of which September is, on average, one of the wetter, the month was the nineteenth driest in the list of 1560 monthly entries.

TABLE 1: Mean monthly, absolute maximum and absolute minimum rainfalls (in mm) for Sunderland. The data are based on the continuous record covering the period 1859 to 1989.

	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*year*
mean	51	39	45	41	51	50	64	70	53	63	63	58	647
max.	167	173	179	115	162	137	174	188	182	207	180	166	936
min.	6.6	1.0	0.5	3.6	5.1	0.8	8.1	8.4	8.1	7.1	8.6	4.6	417

Such observations are undoubtedly remarkable, yet possibly not unexpected. Autumn is the wettest season in north-east England, yet the long term means (Table 1) reveal September to stand out as significantly drier than

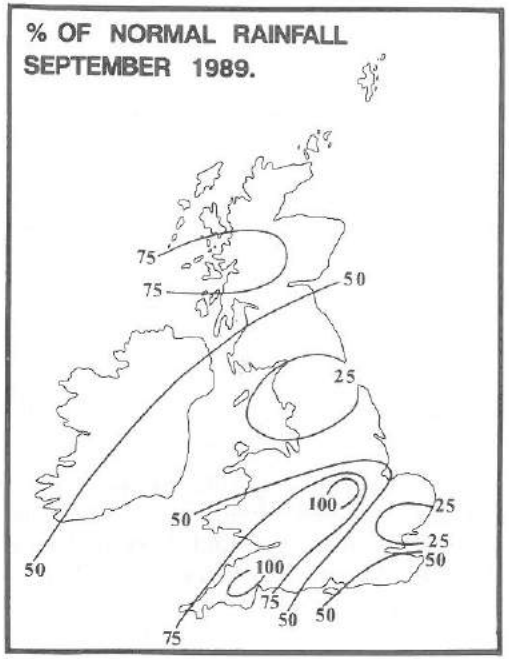

Fig.1: Rainfall anomalies for September 1989 based on the Climatological Observer's Link network and reproduced by the permission of the Secretary.

August, October and November. This feature can be recognised in many station records, yet is particularly well-developed here and also in the nearby, and even longer, Durham record. The month is, in general, likely to yield spells of dry and pleasant weather; our ever-popular "Indian summers", never better exemplified than as recently as 1986 when the region enjoyed some spectacular weather (Wheeler, 1988). Manley's excellent *Climate and the British Scene* sums it up with typical clarity, ". . . in September the march of Atlantic lows is frequently arrested for some time, and one or more spells of fine, quiet dry weather are regularly experienced . . .". Indeed, and by way of a footnote, it can be added that while September is the month of the autumnal equinox, in Sunderland, and in many coastal locations, the average daily mean temperature is higher than in June; in Sunderland's case by 0.6 degrees Celsius. This feature disappears as one moves inland and away from the influence of our sea's 'thermal inertia'.

RAINFALL IN SEPTEMBER 1989

Over the country as a whole the month has been unusually dry. Scarcely any area experienced above average falls (Figure 1) and large areas had less than half the normal amount. The Climatological Observer's Link report

estimates the England and Wales rainfall to have been 49% of the average with eastern areas generally being the most severely deficient. In many other areas a large porportion of the monthly total was attributable to thundery outbreaks that occurred between 12th and 14th with further heavy falls on 16th. At that time several stations registered daily totals in excess of 20mm. Typically for the area, Sunderland had no thunder that month and escaped such events. The cool waters of the North Sea can often be remarkably effective in reducing instability and the opportunity for thunder. The distribution of the rain with regard to the direction of the winds on which it was carried is also typical. Table 2 shows how, despite the abundance of west and south-west winds, which in so many other parts of Britain are regarded as likely to yield rain, it was the on-shore northerlies and north-easterlies which, in far fewer hours, contributed the bulk of the rainfall total.

TABLE 2: Distribution of winds during September 1989 in Sunderland. The record is based on anemograph traces, and includes also the corresponding volumes of rain and their durations.

	N	*NE*	*E*	*SE*	*S*	*SW*	*W*	*NW*	*calm*
duration (hours)	59	90	0	29	20	183	187	26	118
rainfall (mm)	3.7	1.7	0.0	0.0	0.0	0.0	0.8	0.0	1.9
duration of rain (hours)	8.1	2.2	0.0	0.0	0.0	0.0	1.1	0.0	3.2

It is commonly, but not exclusively, the case that months dominated by west and south-west winds are dry in this east coast area with its maze of high ground in the form of the Pennines to its immediate west. On this occasion that situation was intensified by the frequently anticyclonic nature of the westerlies that further reduced the possibility of rain, and led also to a national tendency to dryness. Both the beginning and close of the month were marked by high-pressure systems to the west of Ireland, a favoured location for 'blocking' systems. Figure 2 shows the tracks of major depressions and 'highs' during the month; the frequency of the latter and the absence of the former in the area around the British Isles should be noted. The degree to which such a situation was abnormal is shown in Figure 3 which depicts North Atlantic surface air pressure anomalies for the month.

A large proportion (44%) of the month's rain fell on 12th from light north-easterly winds along the southern flanks of an anticyclone over Denmark. The air mass itself was, interestingly, part of a large northwards displacement of warm and moist Mediterranean air that a week earlier had unleashed some of the heaviest rain that the Spanish coast had received for several years. At this stage the feature was all but moribund yet still capable of bringing very 'close' and occasionally wet weather to east coast districts.

In other respects the month was unexceptional. Sunderland temperatures, as elsewhere, were above average by rather more than one degree (Celsius)

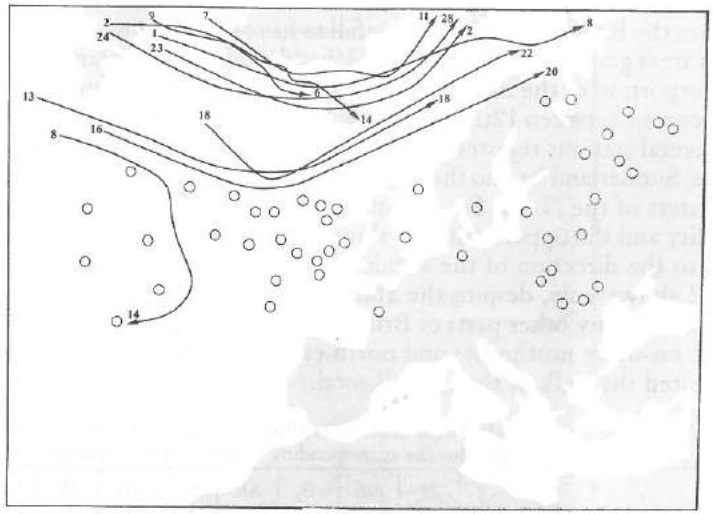

Fig.2: Map showing the pathways of principal depressions active during September 1989 (solid arrows). The numbers indicate the first and final dates of the depressions as clearly recognisable elements. The daily centres of high pressure activity are shown by hollow circles. The segregation of the two pressure systems is noteworthy.

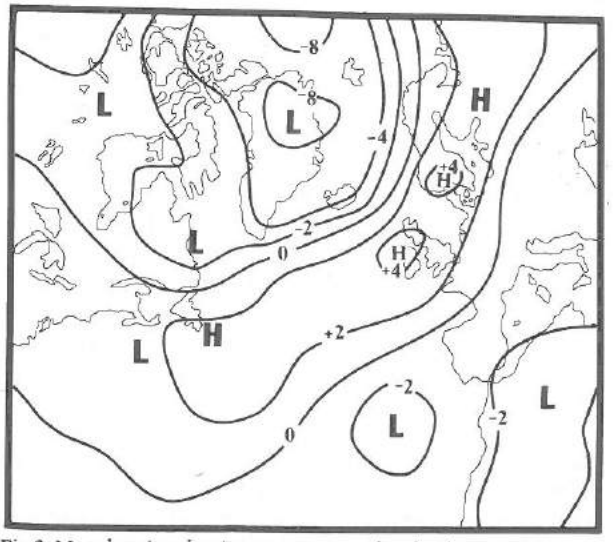

Fig.3: Map showing the air pressure anomalies for the North Atlantic during September 1989. The isobars are in mb differences from the long-term surface means. The belt of positive anomalies extending eastwards from the mid-Atlantic towards Britain reflects the frequency of anticyclonic activity in that area which forced depressions along more northerly routes.

and followed the trend of the past eighteen months. Sunshine, on the other hand, was below normal for only the second time in thirteen months. In part at least this reflected the frequency of the phenomenon so appropriately described as 'anticyclonic gloom', a layer of stratus or stratocumulus cloud which though rarely yielding rain will mask the sky for long periods. It is often associated with locations that are on the periphery of anticyclones. And whilst the anticyclones of September did indeed exercise an important role in our weather, they were rarely centred over the British Isles and were often some distance away.

Given the rarity of such low September rainfalls it is appropriate to ask if its frequency can be quantified. Taking all 130 September figures on record they follow a log-normal distribution. This is not unusual for monthly totals where the effect of zero (below which there is, of course, no rainfall) is to 'compress' the distribution over the lower magnitudes of the range. This influence can be removed by logging the data and then fitting a Gaussian distribution. When this is done the September 1989 total has a z-value of –2.56, which translated into everyday terms gives it a 1 in 500 years return period.

COMPARISON WITH OTHER YEARS

Only the Septembers of 1971 and 1907 came close to matching 1989's rainfall. In both the former cases the general situation appears to have been similar, being dominated by anticyclonic activity which encouraged depressions away from Britain leaving not only the east, but all areas, extremely dry. The Meteorological Office's *Monthly weather report* for 1971 showed the England and Wales rainfall to be 34% of the average. But on this occasion the focus of high pressure activity was more firmly located over Britain and the sunshine totals were far higher than in 1989. Again, however, it was the north-east coastline of England which had the lowest rainfall totals, and to Sunderland's 8.9mm can be added Tynemouth's 7mm, Durham's 13mm and Hartlepool's 9mm.

The situation in 1907 was again strikingly similar, dry not only in the north-east of England but over the nation as a whole. In Sunderland a record of 10.4mm was set which was to last until 1971. On this occasion the dryness was very welcome following one of the wettest summers for many years; "the salvation of the harvest" is how it was described in the volume of *British Rainfall* for that year, and many reporters took special note of the sunny, dry and settled weather of the month. That same publication summarised the month thus: "The meteorological conditions which prevailed during that time were anticyclonic, a large area of high pressure resting over the British Isles and producing weather of the pleasantest kind possible at the season, bringing as was natural, frequent light fogs, the condensation from which, rather than rain in the ordinary sense, was probably the cause of an absolute drought not being recorded at many stations. A prolonged drought has rarely been so welcome, as it came at the season when the farmer required dry weather for harvest, and after months of frequent if not excessive rainfall had reduced the

risk of deficient water supply".

For those who seek patterns in our weather this observation provides no help, for the dry September of 1989 follows a succession of dry months, at least in the north-east region, that has left even the massive resources of Britain's largest reservoir, the Keilder scheme, sadly depleted. The running 12-month total (September 1988 – September 1989) amounts to only 443.5mm (the annual average is 647.0mm), and it remains at the time of writing to be seen whether winter rains will offset what may yet be the driest year in Sunderland's long record.

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SOUTH WALES RAINFALL, TEMPERATURES AND SUNSHINE IN 1989

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Reference is made to my article about the South Wales rainfall 1955-1988 in the April issue of *J. Meteorology, UK.,* volume 14, number 138. The 1989 rainfall at Cardiff-Wales Airport amounted to 880.3mm (94% of the 1955-1988 average of 933.8mm), which means that the 1955-1989 average rainfall has now decreased to 932.3mm, reversing the trend of an increasing annual rainfall during the 1980's. This total of 880.3mm made 1989 the driest year since 1977 and the ninth driest year since records began at Cardiff-Wales Airport at Rhoose in 1955 for rainfall, temperatures and sunshine. Regarding the rain days (0.2mm or more) for 1989, there were 165 raindays at Rhoose, the average is 182 for 1955-1988, with the most 216 in 1974 and the least 145 in 1964. The summer rainfall total of 168.7mm for June, July and August was the eighth wettest since 1955, the driest summers being 88.2mm in 1976, and 102.1mm in 1984. But the 1989 four-month rainfall for the period May to August was only 179.1mm. The driest month was May with 10.4mm, and only two months had more than 100mm when there was 129.8mm in December and 123.7mm in October.

This wet October certainly saved the Welsh Water Authority great embarrassment. As the local newspaper was saying on the 11th October, "Within the next few days there could be further water rationing in drought-stricken areas and by the weekend rota cuts are a possibility. Welsh Water said yesterday it was 'quite likely' that there would still be hosepipe bans at

Christmas. Senior managers at Welsh Water are now meeting daily to monitor the situation to decide whether to impose further restrictions on the non-essential use of water, which would mean that car washing and cleaning of buildings would be banned". And then on 14th October we read about even greater threats in our local newspaper, "But continuing fine weather means that Welsh reservoirs are still drying up, particularly in the south-east, and new restrictions will come into effect from midnight on Monday in Cardiff, the Vale of Glamorgan, Torfaen, Cwmbran, Monmouth, Newport and other areas. A spokesman for Welsh Water said that if people flouted restrictions, water stocks would run so low that standpipes might have to be introduced. Anyone caught washing their car or watering their garden could face fines of up to £2000, and Welsh Water says it will welcome anonymous calls reporting ban-breakers. 'If you know someone is breaking this code, give us a nudge', a spokesman said". But consider the October rainfall at Cwmbargoed, near Merthyr Tydfil, not far from the reservoirs in the Brecon Beacons, where there was 225.8mm at the altitude of 1220ft amsl, with 11.4mm 1st-18th, 132.8mm 19-22nd when 80.0mm fell on the 20th being the wettest day since 26th December 1979, and 60.5mm 27-29th. The corresponding rainfall at Rhoose for these days in October were 41.5mm 19-22nd, 50.8mm 27-29th, and at Cardiff Llandaff my records showed 72.2mm 19-22nd and 65.6mm 27-29th.

Temperatures too were a prominent feature of 1989. At Rhoose April was a colder month than March, but the following month of May was such a contrast having an average maximum of 18.5°C, compared with April only being 10.3°C. November's temperatures were also noteworthy. The lowest minimum temperature was –5.0°C on the 26th, which was also the lowest temperature for the whole of 1989, yet there was also a November heatwave at Cwmbargoed. Usually the extreme highest temperatures at Cwmbargoed are one to three degrees C lower than those at Rhoose, but in 1989 Cwmbargoed enjoyed higher maximum temperatures than those at Rhoose by 0.4 in June, 0.9 in October and 3.4°C in November when their maxima of 15.5°C on Monday 13th, and 17.7°C on Tuesday 14th exceeded the previous highest November maximum of 14.6°C in that area with records going back to 1950.

1989 as a whole has been the warmest year at Rhoose since their records began in 1955, with a mean maximum of 14.4°C (previous warmest year was 14.1°C in 1959, with the long term average being 13.0°C), and a mean minimum of 7.7°C (the previous warmest year was 7.1°C in 1959, with the long term average being 6.7°C). Another interesting pattern in the temperatures shows that each year has been warmer than the previous year from 1986 onwards, whilst the three previous years before 1986 showed the opposite trend. So will 1990 make it five in a row?

Such a warm year also produced the sunniest year on record at Rhoose with 1885.9 hours, being 119% of the 1955-1988 average of 1574.9 hours, exceeding the previous sunniest year of 1836.2 hours in 1955, whilst the

dullest year was 1335.0 hours in 1958. It was in fact on 26th November that the 1955 yearly total was exceeded. The summer sunshine of June, July and August was 823.1 hours, more than the 791.7 hours of 1976, and if you take this year's total sunshine from May to August there was a total of 1102.0 hours.

The Davis index for Rhoose for June, July and August this year was 832, compared with 680 in 1988, 751 in 1987, 712 in 1986, 665 in 1985. The outstanding years since 1955 have given an index of 878 in 1976, 846 in 1983, 845 in 1975, 835 in 1959, 832 in 1989, 800 in 1955, 751 in 1987, 746 in 1981, whilst in the poorer summers we have had an index of 736 in 1977, 728 in 1972, 714 in 1971, 712 in 1966, 710 in 1960, 689 in 1956, 666 in 1985 and 665 in 1965. For more detailed information of the Davis index see page 23 of the book, "Weather, we like it or not – 70 years of Weather at Ryde" by Kenneth J. Hosking. This index is calculated by adding 10 times the mean daily maximum temperature in °F for the months of June, July and August to 20 times the average daily sunshine duration in hours for the period, and subtracting 7 times the total rainfall in inches. At Ryde in the Isle of Wight from 1918 to 1987, the highest index has been 915 in 1976, and the lowest one of 695 in 1920, with the average over these 70 years being 787.

P.S. This warm year of 1989 has continued into 1990 as my 10cm soil temperature here at my home in Cardiff (read daily at 0900 GMT and in complete shade all the time) was 9.2°C on Tuesday 16th January, which was higher than any time in January last year when the highest was 8.6°C. In February 1989 the highest was only 8.7°C. In March it reached 9.3°C on the 28th, but in April the highest was only 8.8°C. On May 1st it was 9.2°C, on the 2nd 9.3°C and thereafter increasing. Regarding the 30cm soil temperature, it was 8.3°C on the 16th January 1990, and last year the highest monthly readings were 8.3°C in January, 8.3°C in February, 8.5°C in March, 8.7°C in April, and on the 1st May 8.4°C but thereafter increasing. However by 0900 on Wednesday 17th January this year the overnight passage of the cold front and clear skies had lowered the soil temperatures at 10cm to 7.6°C and the 30cm reading to 8.2°C.

THE WEATHER AT OXFORD DURING 1989

By T. P. BURT and PETER VENTERS
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1989 had been the warmest year on record in Oxford since continuous records began in 1815, and for the first time the mean air temperature reached 11C. The winter of 1988/89 was the warmest for 120 years and the summer was unusually warm, dry and bright; both spring and autumn were unusually warm too. 1989 was also a dry year; only a deluge in the middle of December – which produced one of the wettest Decembers since 1767 – prevented this

from being one of the driest years on record, 8 of the previous 11 months having had below average rainfall.

January was unusually mild. The mean air temperature of 6.1°C was 2.5C above average, the warmest since 1983 though only 0.6°C warmer than January 1988. The mean minimum and maximum temperatures were also well above normal. Unlike January 1988 which recorded 100mm rain, January 1989 was quite dry, continuing the run of dry months since August 1988 during which time there was only 55% of normal rainfall. In the last 221 years, only four August-January periods have received less rainfall, the most recent being in 1964 (this is a significant period for groundwater recharge and a rainfall deficit at this time may lead to drought conditions later on). January was sunnier than normal; there was only one day with fog and none with snow lying. The mild January weather, dominated by high pressure over central Europe, continued for most of *February*. Although not as mild as January, the month was still more than 2C warmer than usual, and the 6th was the warmest February day since 1961. The pressure at Oxford, reduced to mean sea level, remained over 1000mb until the 24th, as it had done since 1st December 1988. On the 23rd/24th, however, the high pressure moved away and a very deep depression crossed the southern half of the country. The pressure at Oxford fell to below 955mb, lower than was recorded here during the great gale of October 1987, and the lowest since at least 1953. Accompanying the depression were strong winds, gusting to 47 knots on the 26th, and heavy precipitation, some of which fell as snow. There were 107 hours of bright sunshine, even more than in February 1988, making it the fifth sunniest since records began in 1881, and the sunniest since 1970

It is appropriate here to comment briefly on the *winter* of 1988/89 which, by convention, includes December of the previous year: it was unusually warm, and rather drier and sunnier than normal. This was the warmest winter for 120 years, 2.6C above average, and exceeded by only 1869 and 1834. Although the warmest temperature of 14.6°C (6th February) was not unusual, the average maximum of 9.7°C was the highest in 109 years of records, and the average minimum of 4.0°C has been exceeded only once before (1974/75). It followed that soil temperatures were well above average too, with temperatures at 30cm the warmest on record. There were just nine air frosts; only two winters have had fewer. Snow was never observed to be lying at 0900 hours, and fog was recorded only once. It was also a rather dry winter. Sunshine was well up on the long-term mean, making it the sunniest winter since 1952.

March was another warm month; like January and February, mean air temperatures were more than 2°C above average, making it the tenth warmest March in 175 years of records, and the warmest since 1981. The mean maximum temperature was the warmest since 1961, and there have been warmer mean minimum temperatures in only four years this century. There was only one air frost and no days with fog. Although there were five more raindays than normal, the total rainfall was only slightly above average.

April was a cold month, the only month in 1989 to be colder than normal. The warmest day was the 15th when the temperature reached 15.6C; in 109 years of records this is the third equal lowest. The average daily maximum was 2C below the April mean, but minimum temperatures were generally only slightly below average. There was only one air frost and no fog. April was somewhat wetter than usual and less sunny. Snow fell on the 4th and 5th, and was recorded as lying on the morning of the 5th, the only occasion this happened in 1989.

May 1989 was unusually warm and dry, and saw the beginning of the sunniest four-month period since records began in Oxford. The mean air temperature was 2.3C above average, the highest since May 1952; the 23rd was the warmest May day since 1953. In 109 years of records, the average daily maximum of 19.7C has been exceeded only twice (in 1922 and 1893). The average minimum temperatures were also above average, the highest since 1970, although there was a ground frost on the 31st. It was the driest May since 1970, and almost all the month's rain fell during one thunderstorm on the afternoon of the 24th, when the rainfall intensity exceeded 40mm per hour between 1400 and 1430 GMT; on average, such heavy rainfall occurs in Oxford only once every 50 years. A total of 27.2mm fell during this storm, during which time the temperature fell by about 10C in one hour. In recent years there has been an unusually large number of days when over 25mm rain have fallen in one day; this was the only such occasion in 1989 although two days came close in December. The total sunshine of 300.8 hours was the highest for May in the past 109 years of records, giving an average of 9.7 hours per day. Such an average has been exceeded only three times in any month over the past 109 years – June 1957, June 1975 and July 1911. The total was

TABLE 1: Summary of observation made at the Radcliffe Observatory, Oxford University during 1989.

	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*year*
T	6.1	6.1	7.9	6.9	13.8	15.4	19.2	17.4	15.6	12.1	6.3	5.7	11.1
Diff	+2.5	+2.1	+2.3	-1.3	+2.3	+0.6	+2.8	+1.4	+2.0	+2.1	0.0	+1.2	+1.5
Max	12.5	14.6	17.7	15.6	27.2	29.5	32.4	28.2	26.2	18.9	15.1	13.8	32.4
Mean	9.1	9.9	12.0	11.0	19.7	20.8	24.9	23.4	20.1	15.9	9.8	8.2	15.4
Diff	+2.5	+2.7	+2.1	-2.0	+3.1	+1.1	+3.4	+2.4	+1.6	+1.8	+0.1	+0.9	+1.6
Min	-2.7	-3.2	-0.6	-1.3	3.4	2.8	9.5	7.1	6.0	3.5	-4.5	-3.5	-4.5
Mean	3.6	3.0	4.6	3.6	8.6	10.5	14.0	12.3	11.9	8.9	3.2	3.2	7.3
Diff	+2.4	+1.8	+2.4	-0.5	+1.5	+0.4	+1.9	+0.5	+2.2	+2.3	-0.5	+1.3	+1.3
Grass	-8.0	-7.5	-7.7	-7.5	-2.4	-2.2	4.1	1.2	-0.3	-2.0	-11.0	-8.3	-11.0
Rain	8.2	14.5	7.9	14.9	27.9	11.0	15.5	16.7	9.6	10.5	7.5	24.8	27.9
Rain	33.5	55.1	47.0	63.8	29.2	45.9	29.4	43.3	23.8	53.1	32.5	141.5	598.1
Diff	-18.4	+14.1	+5.7	+21.0	-23.0	-8.0	-31.1	-15.3	-36.7	-11.6	-28.8	+86.6	-45.5
Sun	68.2	107.0	100.9	133.9	300.8	244.4	280.4	269.5	141.6	90.8	104.1	26.5	868.1
Diff	+15.4	+39.2	-12.9	-16.7	+111.3	+48.0	+92.1	+94.2	+3.4	-10.1	+40.7	-21.8	+382.8
A.F.	5	4	1	1	0	0	0	0	0	0	7	4	22

T = mean temperature (°C); Max = extreme maximum; Diff = difference of mean from long-term mean etc; Grass = grass minimum; A.F. = air frosts.

more than twice that for April!

The first half of *June* was cool and damp, but thereafter the weather improved markedly and the rest of the month was warm and dry. Overall, mean air temperatures were 0.6C above average. There were three ground frosts in the first week, the highest number since June 1962 and the second highest in 109 years of such records. The air temperature fell to 2.8C on the night of the 2nd, the coldest June night since 1962. The warmest day was the 20th with a temperature of 29.5C, the hottest June day since 1976. June was sunny too, and despite the return to cooler and wetter weather for the last five days of the month, the total sunshine of 244 hours gave the sunniest June since 1976. Rainfall was just below average. Although not quite as sunny as May, *July* 1989 was the second sunniest July on record, three hours a day above average, and a total of 26 hours above July 1976. Temperatures too were unusually high, nearly 3C above average. The mean air temperature was the 6th warmest in 175 years of records, reaching a maximum on the 22nd when the air temperature reached 32.4C, the warmest day in Oxford since 1976; in all there were four days in July when the temperature exceeded 30C. Overall, it was the warmest July since 1983. Minimum temperatures were also the highest since 1983, and the second highest overall. The warmest night was the 22nd when the temperature fell only to 19.6C warmer than even the warmest July 1983 night; this minimum temperature has been exceeded only once in the last 109 years, on 5th August 1975 – 20.1C. Overall, the period May-July 1989 was the sunniest three-month period on record and the first to receive over 800 hours of bright sunshine; the total of 826 hours exceeded the next best – 1949 with 738 hours – by a massive 88 hours, almost an extra hour per day. It is also worth noting that in the year August 1988 to July 1989 inclusive, only 464mm rain fell, 72% of normal. Had this been a calendar year, it would have been the 15th driest on record, although it was still much wetter than the same period 1975/76 which had only 338mm.

August was another remarkably sunny month, the second sunniest on record. Since May there had thus been 1094 hours of bright sunshine, the highest ever recorded for a four-month period, 115 hours more than the previous record in 1899. Although not as warm as July, August temperatures were well above normal (+1.4C), the warmest since 1984. The frequently clear skies did lead to low grass minimum temperatures, however, and the mean grass minimum was the lowest since 1976. Taking the *summer* (June-August) as a whole, the summer of 1989 was unusually warm, dry and bright. It was the warmest since 1983, the driest since 1984 and the sunniest on record. The mean air temperature for the summer was 1.6C above average; mean maximum temperatures were 2.4C above average, with the warmest day since 1976. Although there were some notably warm nights, some were unseasonably cold too; there were three ground frosts (all in June), a total exceeded only in 1962 when there were six. Total rainfall for the summer was just over half the normal amount, the driest since 1984, and still twice as wet as in 1976. By far the most remarkable feature of the summer weather was the

total sunshine of 793 hours, the sunniest on record, exceeding 1976 by some 24 hours and 1899, the previous record, by 17 hours. According to the Poulter Index, which takes into account rainfall, sunshine and temperature, this was the fourth best summer in the last 109 years, bettered only by 1909, 1975 and the best ever, 1976.

September was the fifth month in succession to have a mean air temperature above average; its value of 15.6C was the fourth equal warmest in 175 years and the warmest since 1949. Although the extremes of temperature were not remarkable, the mean maximum (warmest since 1964) and mean minimum (warmest since 1980; third warmest on record) temperatures were also well above normal. This was reflected in soil temperatures; the temperature at 30cm was the highest since 1959. Unlike the previous four months sunshine was not significantly above average. The trend of lower than average rainfall continued, however, with less than half the average amount falling. It was the mildest *October* for twenty years, the seventh month in 1989 when mean air temperatures exceeded the mean by at least 2C. The high average air temperatures were reflected in other measurements. Mean minimum temperatures for October were the fourth highest on record, and the number of frosts was less than usual, there being no air frosts and only three ground frosts, the most severe of which reached only -2.0C. Sunshine and rainfall were both slightly below normal. *November* differed only slightly from the long-term mean, although the return of the seasonal cold weather may have seemed unusual following the succession of warm months. For much of the month, November was dominated by slow-moving high pressure systems. This gave an unusually sunny month, the sunniest November since 1925 and the third sunniest on record. It was another dry month too, with only about half the long-term average amount. The clear skies also led to lower than normal grass minimum temperatures, the coldest on the morning of the 26th being the lowest November grass minimum since 1923. There were five days with fog, only slightly above average, though two less than in 1988. Unlike 1988, there was no snow recorded at Oxford.

The cold, dry weather continued into early *December* and barometric pressure reached 1040mb on the 2nd. However, an abrupt change in weather on the 11th heralded one of the wettest spells on record in Oxford. Barometric pressure fell to 963.3mb at 0900h on the 17th, giving a remarkable range for one month. It was a dull month, the 6th dullest on record. 141.5mm rain fell in only 15 days, making this the third wettest December since 1767. Since the end of July 1988, 13 of the 16 months had received below-average rainfall, a cumulated deficit of 273mm compared to the average, and the driest 16-month period since May 1975 – August 1976 when the cumulated deficit was almost 400mm below average. An unusually wet December has gone some way to restoring the balance; without this rainfall, 1989 would have been one of the driest on record and drought conditions would have been very likely in 1990.

1989 has been the warmest year in Oxford since continuous records began

in 1815, and the first year when mean air temperature has reached 11C. This is not surprising in that seven of the twelve months have had mean air temperatures at least two degrees above average and only April was colder than normal. All four seasons in 1989 fell within the top 20 on record – a remarkable occurrence: given the warmest winter for 120 years (third warmest on record), a mild spring (18th), a hot summer (11th), and one of the warmest autumns on record (9th), it is not surprising that the year as a whole has been exceptional. Despite a dull December, this has also been the sunniest year at Oxford since records began in 1881, beating the record set in 1959. Total rainfall was only a little below average; without the exceptionally wet spell in mid-December, 1989 would have been one of the driest years on record.

Looking at the complete *decade*, eight of the ten years in the 1980s have been above average temperature, and it has been the warmest decade on record (9.9C), equally the 1940s. Both decades were very similar in terms of mean air temperature, the only difference being the number of warm springs in the 1940s and the number of mild autumns in the 1980s (every one above average). Though nothing in the 1980s matched the cold winter of 1947, February 1986 was a notable and extended cold spell. Five of the six warmest decades since 1820 have occurred in recent times: 1930s (3rd warmest), 1940s (2nd), 1950s (6th), 1970s (4th) and the 1980s (1st). However, the 1960s were only 10th warmest of the 17 decades and the 1820s were the fifth warmest. Whether the 1980s do indeed mark the beginning of significant global warming remains to be seen. Although there is a tendency for warm decades to be dry, the 1980s were only the eighth driest of the 22 decades since the 1770s, but, perhaps surprisingly, a little drier than the 1970s. Dry decades are much more randomly spread through the climatic record, however, with the driest occurring early on – 1780s (1st) and 1800s (2nd).

In summary, 1989 has been the warmest and sunniest at Oxford since records began. It has also been one of the driest years, with the exception of the remarkably wet spell in mid-December which alone may have prevented a drought in the Oxford region in 1990.

WORLD WEATHER DISASTERS: MAY 1989

1: A storm in Texas, U.S.A., caused insured losses of $30 million, heaviest losses occurred in Kerr County. *Lloyds List.*

2: Heavy thunderstorms, floods and landslips in Hong Kong, between midnight and mid afternoon nearly 100mm of rain fell, floods up to 1.5 metres deep reported in areas. Two people died in storm, one by lightning, one by drowning. *L.L.*

3: Storm, with heavy rains and 97km/h winds, hit Bogra, an industrial area 145km north of Dhaka, Bangladesh, leaving three people dead and 230 others injured. 30 of them seriously, 600 homes in area destroyed. *L.L.*

3-20: Heavy rains and mudslides in Bahia state, Brazil; worst of mudslides occurred in the city of Salvador on the 18th and 19th where at least 66 people died and some 6000 people were made homeless, throughout Bahia state some 55,000 made homeless by floods and mudslide. *L.L., Daily Telegraph.*

3(reported): Hailstones have killed at least 157 people and injured more than 6000 in Sichuan province, China, in past week. The hail has destroyed more than 170,000 houses and 650,000 tonnes of grain in Luzhou prefecture and Zigong City, the hailstones have lashed 105 of the provinces 175 counties. *L.L.*

4-6: A series of thunderstorms, high winds, tornadoes, rain and hail hit a wide area of the United States, from the Gulf of Mexico to New York, at least 21 deaths reported, hundreds injured and damage running into hundreds of millions of $'s. More than two dozen tornadoes reported, some on the 5th in Texas, Louisiana and Mississippi, hailstones as big as baseballs fell near Lufkin in eastern Texas, also on the 5th. *D.T., International Herald Tribune.*

4(reported): Torrential rains, heavy snow falls, hail and below freezing temperatures in the Soviet Central Asian republics of Kirgiziya, Tadzhikistan and Uzbekistan, caused immenses losses in livestock, cotton and other cropts, the bad weather destroyed virtually the entire cotton and grain crop in Shaartuz region in south-western Tadzhikistan. More than 60,000 head of sheep and goats died in heavy snow, with falls of 100 to 120mm in Fergana region of Uzbekistan, meanwhile in republic of Kirgiziya below freezing spring temperatures and unseasonable snow and frost have caused an estimated 100 million rubles worth of damage to cotton, tobacco and flower crops. Temperatures in the republic have fallen to as low as –12°C in recent days, normally temperatures this time of year are in the range 12°C to 14°C. *L.L.*

5: Tornadoes in North Carolina, U.S.A., have caused insured losses of at least $100 million, $50 million of which occurred in Forsyth county. *L.L.*

7: Lightning killed 11 people in Malabar hill region, Kerala state, southern India. *Birmingham Evening Mail.*

8(reported): Four month drought in Tamil Nadu, Karnataka and Kerala states of southern India, threatening the areas tea crop. *L.L.*

8(reported): Heatwave in Nepal described as worst in several decades, in the Terai flatland towns of Bhaairua and Birgunj, the temperature has passed 111°F (44°C), in Kathmandu, which is 1525 metres high, the temperature is around 93°F (34°C). *D.T.*

9: High winds, heavy rains and floods reported in the west of the Ukraine, S.S.R.. Forty towns flooded, with eight evacuated in the Carpathia region near the city of Luou. The river Dnestr burst its banks, flooding 40,000 hectares of farmland, houses and roads, the strong winds bought down power lines, five people died in the winds and floods. *L.L.*

9(reported): Drought in Uruguay threatening beef livestock industry. *L.L.*

9(reported): Drought has caused crop losses in Argentina. *L.L.*

10: Tornado, accompanied by rain and hailstorms, swept through Anhui province, eastern China, leaving five people dead, with a further 157 injured, the tornado destroyed 1800 houses and left a large area of farmland flooded in Yuexi and Tongcheng counties in western Anhui province. *L.L.*

12(reported): A storm, variously described as a dust devil, a mini-cyclone or minature tornado damaged a radar balloon, worth $18 million, at Sierra Uista, Arizona, U.S.A. *L.L.*

13: Storm in Bangladesh, with winds up to 80km/h and heavy rains, left 8 people dead and at least 100 injured, the winds destroyed hundreds of thatched homes, uprooted trees and disrupted power supplies, the heavy rain however substantially eased the drought in 25 districts of mainly northern Bangladesh, the drought has damaged nearly two million tonnes of rice and jute, a heatwave in the midst of the drought left at least 60 dead. *L.L.*

13-14: A storm, with winds of 153km/h, caused at least $600 million damage at Fort Hood, Texas, U.S.A. *L.L.*

13-19: Insured losses from wind, hail, tornadoes and flooding in Texas, Louisiana and Oklahoma, U.S.A., estimated at $120 million, $100 million in Texas alone, a further $70 million loss from floods reported from Texas. *L.L.*

15: Heavy rain, hailstones and high winds in Ruse and Razgrad areas of north-eastern Bulgaria leaving six people dead. Damage to vineyards and crops in the 30 minute storm late in the night estimated at about 15 million leva, rail and road links blocked by floods up to two metres deep, forty towns and villages blacked out by power failures. *L.L.*

15-20: Typhoon "Brenda" swept from the Philippines to China, brief details below:–

Philippines: hit on 15th to 17th, with winds up to 110km/h and heavy rains, a number of ships sank in heavy seas around the central Philippines, exact casualties not reported, but 19 people reported dead with possibly 53 others missing.

Hong Kong: hit on 19th and 30th with gale force winds and torrential rains, 314.1mm fell in period, five deaths reported, including two buried in a landslide, and at least 62 other were injured. Winds gusted to 140km/h, trees uprooted, buildings damaged and considerable damage to farmlands and fishponds reported.

China: "Brenda" lost strength as it went inland south of Hong Kong on the 20th and 21st. *L.L.*

15(reported): Drought threatening water shortages in Damascus, Syria. *I.H.T.*

17: Violent storms in northern Texas, U.S.A., killed at least two people flooded hundreds of homes and demolished a number of buildings. Hailstones smashed car windscreens and winds of more than 160km/h were recorded in several areas, floods reported from a number of towns. *L.L.*

17(reported): Forest and bush fires in Canadian provinces of Manitoba and Saskatchewan, in Manitoba fires so far this year have destroyed more than a million hectares of forest and bush and destroyed dozens of houses and buildings; at noon on the 16th 76 fires still burning. In Saskatchewan, the worst forest fire season on record has consumed thousands of hectares and killed one man. *L.L.*

19-24: Thunderstorms in areas of United Kingdom, brief details below:–

19th: Flash floods following storms in Yorkshire, in village of Luddenden, near Halifax, one house swept away and roads flooded up to 1.5 metres deep, thunderstorms also flooded roads in north Staffordshire.

21st: Rainstorms in West Yorkshire and Cornwall.

23rd: Storms in the Midlands flooded roads, up to 25mm of rain fell in morning during the start of the rush hour, many homes left without electricity as power lines hit by lightning, other storms in the West Country and Wales, two thatched cottages destroyed by fire after being hit by lightning at Lychett Maltravers, Dorset, one climber hurt by lightning near Caernarvon, Gwynedd, Wales. Lightning left one dead at Bassingham, Lincolnshire.

24th: Thunderstorms, with flash floods in areas of United Kingdom, two died in flash flood at Chorlton-cum-Hardy, Greater Manchester, when small boat sank in culvert, elsewhere in Manchester 300 flood calls received by the fire brigade. Storms in Surrey, three injured by lightning in Camberley, heavy rain in Woking, hail the size of golf balls fell in Guildford. Storms also reported from Hampshire and city of York. *D.T., B.E.M.*

21: Heavy rains touched off landslide in Tretes area, east Java, Indonesia, leaving five people dead. *Jakarta Post.*

25: A coastal ferry boat capsized in storm off coast of Jambi province, Sumatra, Indonesia, leaving 16 people dead. *J.P.*

25-27: Typhoon "Cecil" struck provinces of Quang Nam-Da Nang, Binh Tri Thien and Nghe Tinh, central Vietnam, leaving 78 dead, 364 others missing and making 150,000 people homeless. Quang Nam-Da Nang province worst hit where storm destroyed 150 schools, and 9000 houses, a further 14,500 houses unroofed, more than 3000 boats sank by high winds and large waves whipped up by storm, heavy losses to rice crops reported from all three provinces. Up to 508mm of rain fell in some areas. After hitting Vietnam, the storm lost force as it crossed Laos and Thailand to dissipate over Burma. *L.L.*

26: Heavy rains caused widespread flooding in Eastlake, Ohio, U.S.A., nearly 100mm of rain fell between 0100hrs on the 25th to 0330hrs on the 26th and worst of flooding occurred in early morning of the 26th, homes and businesses flooded. *L.L.*

26-27: Cyclone hit Orissa state, India and Bangladesh with winds up to 137km/h and heavy rains, at least 60 deaths reported, 33 in India and 27 in Bangladesh. 2000 injuries reported in Bangladesh, in India some 50,000 left homeless in Orissa and West Bengal, extensive damage in coastal areas of both states. *L.L., D.T.*

27: Avalanche on Mt. Everest, Nepal, left five climbers dead and one injured. *I.H.T.*

28-30: Heavy rains in areas of Bangladesh, in some parts of the country 285mm of rain fell in the 24 hour period up to morning of May 29th, a 61 metre section of embankment of river Tista washed away by the heavy rains causing floods in the Gangachara area in the north of the country which lft 10,000 homeless, some 2000 homes flooded and damaged crops. *L.L.*

29(reported): Floods in southern Somalia have submerged villages and devastated farmland. *D.T.*

30: Flash floods in Sri Lanka have left 25,000 homeless. *B.B.C. News.*

30-31: Monsoon rains touched off landslides which hit gold mine in Balite region, Davao del Norte province, southern Philippines left eight people dead and a further 21 missing, reports that up to 400 people remained trapped in mine could not be confirmed. *L.L.*

31(reported): Drought conditions in parts of the Mid west and Great Plains area of U.S.A., Iowa and Kansas especially hit. *L.L., I.H.T.*

End: Insured property damage resulting from wind, hail, tornadoes and flooding which hit parts of U.S. states of Iowa, Missouri, Wisconsin, Illinois, Indiana and Ohio during may has been estimated at $100 million, Indiana suffered $35 million losses and Illinois, largely in the south central portion of state, suffered losses of $30 million. *L.L.*

ALBERT J. THOMAS

LETTERS TO THE EDITOR

RECORD WIND GUST AT SANDHURST 25 JANUARY 1990

At 1349 GMT 25 January I recorded my highest-ever wind gust of 80kt from due west which is 13kt greater than the previous record of 67kt obtained during the October 1987 storm.

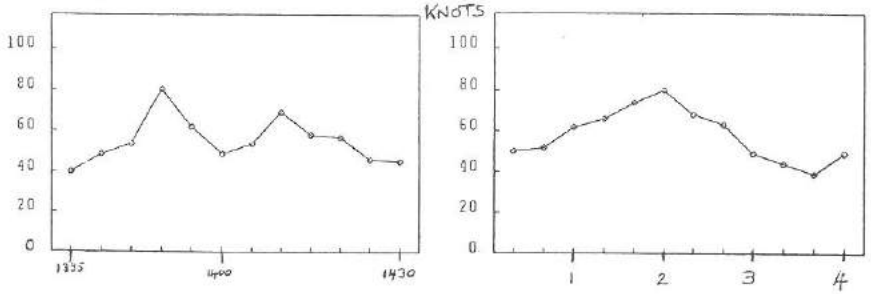

Fig.1 shows the maximum gusts in 5 minute steps during the height of the storm for which Fig.2 is a profile of the peak gust over its 3.5 second lifetime.

As the synoptic situation looked promising the previous day I made arrangements to video-tape the complete display from my Heathkit Digital Weather Computer which provides a continuous record of wind speed and direction as well as temperature and pressure information. If any person cares to forward a blank VHS or Beta cassette plus stamps for return postage I'll be happy to make a copy.

60 College Road, College Town, Sandhurst. J. M. HEIGHES

DISRUPTION CAUSED TO BRITISH RAIL SERVICES IN THE WEST OF ENGLAND BY THE GREAT STORM OF 25 JANUARY 1990

The storms of 25 January 1990 brought some of the highest winds ever recorded in the centre of Bristol. Gusts of up to 90mph were recorded and much damage caused. In St. Annes Road several hundred feet of hoarding bordering the old Mardon's site was blown over, one section striking a passing car. Union Street was closed for several hours whilst hoardings around the "Galleries" building site were made safe.

As the winds gusted across the city, several sheets of glass were blown from the vertical end screen at the west end of the Digby-Wyatt overall roof at Temple Meads railway station. These sheets struck a "Sprinter" train standing at platform six, but luckily fell on to the track, avoiding passengers on the platform itself. The overall roof has been under repair for the last eighteen months and work has yet to be completed. It was masonry falling from an east end-support which confirmed beliefs that further damage could result from the winds, and the decision was taken to evacuate the station. Trains were prevented from entering or leaving the station for approximately six hours. Eventually, after inspection by the railway civil-engineer's department, when the wind had dropped, platforms seven and eight were re-opened for a Bristol to London hourly service.

At Bradford-on-Avon, a local train was de-railed due to debris on the line, while at Highbridge a two-car diesel multiple unit train on a Taunton-Bristol shuttle, was derailed when a lineside cabin was blown on to the track in front of it. Both derailments were fortunately at low speed and there were no injuries reported. Local train services were suspended from mid-morning onwards, and as a result of the station being closed, other services ran very late or were cancelled altogether; the 07.20 Penzance-Glasgow service eventually arrived in Bristol over seven hours late!

On a more personal note, wind damage around the 'TANNASG' office was restricted to a few television aerials being bent over and several adjacent houses losing ridge tiles. Strange to report, but the buildings on top of the hill in Pucklechurch were the least affected by the wind. Houses just below the hill suffered extensive roof damage; a cottage in Abson Road lost a large roof section. Similar effects were noted in Yate, where houses in the shelter of the railway embankment suffered greatly, losing tiles and fences. In one street a garage collapsed on to a new car. Farther afield, in Staple Hill, Page Park lost approximately thirty mature trees blown over by the wind, while in Mangotsfield Road a large mature tree blew over on to the roof of a bungalow in Charnhill Brow. This latter tree was eventually removed by means of a large road crane on the afternoon of the 29th January.

TANNASG Research, Pucklechurch, Bristol. P. D. RENDALL

THE GALES OF 25 JANUARY 1990 IN EIRE

For three weeks January 1990 was mild but in the last week came a change which reminded us of the reality of the season in which we were. By 23rd the strong ridge from the Azores to Central Europe across the (dry) Alps declined quickly. This allowed the Atlantic lows to take more southerly tracks and bring severer weather to the British Isles. By early on 24th a deep storm was moving rapidly north-east off West Scotland with its cold front racing across Eire and bringing cold air into the country. On 24th the first winter snow and hail showers affected many areas with snow settling on the hills and with local thunder in the west.

A wave depression, 992mb deep by noon on 25th in mid Atlantic, deepened quickly as it approached S.W. Ireland in response to the unstable cold air aloft. By 2400 on 25th heavy rain was into southern Ireland with sleet over the midlands and heavy wet snow over County Donegal,

which thickly iced and snapped power cables and plunged 7000 consumers into darkness. Flooding resulted as well. In Southern Ireland a small warm sector moved eastwards from 0100 to 0500 on 25th with south-westerly gales and air temperatures rising to 10-12C in places. By 0600 the low was 959mb over the west of the country and cold air invaded all of Eire again bringing widespread rain, sleet and snow to northern areas. By 0900 the low was near Kintyre in S.W. Scotland, and the west and south of Eire was being swept by W. to N.W. gales with gusts above 70mph. Roofs were stripped, trees uprooted and a man killed in County Waterford when a tree fell on a trailer on which he and a group of hunters were travelling. Three others including his wife were injured. Two also died in Northern Ireland but of course it was in mainland Britain that the storm wreaked the most greatest damage with 47 people dying in the hurricane conditions. By the afternoon the storm was abating in western Eire, and had ceased everywhere by nightfall leaving wintry showers which led to local accumulations of snow or hail. Overnight the cold darkness was lit by frequent lightning as towering cumulonimbus brought thunder into western and south-western coastal counties. Lightning struck power and telephone lines in Counties Galway, Clare, and Kerry and the west of County Cork. ESB crews worked rapidly on the storm-damaged power lines and some ESB crews went to England on the following day or so to assist crews there in attending to the catastrophic damage.

Mount Russell, Ardpatrick, Kilmallock Co., Limerick, Ireland. DAVID MESKILL

CIRCLES IN MANITOBA, CANADA, 1989

On 4 November 1989 a Manitoba newspaper *The Chronicle-Herald* reported a circle found on Ray Crawford's farm, and mentioned others which had recently been discovered elsewhere in the province.

'Sometime in the last year, an almost perfect circle was gouged out of a remote patch of the elderly cattle farmer's property about 30 kilometres north of Winnipeg, on the edge of the rock-strewn scrub and bush that comprises the region between Lake Manitoba and Lake Winnipeg. There is no sign that anything human had a hand in its creation'.

The circle had a diameter of six metres. 'Crawford's sons found the ring in the midst of a field of naturally growing hay, 16 kilometres along dirt and gravel roads from their Hereford cattle farm. It didn't exist last year and there were no tracks leading into it'. 'Local teacher Brian Ramsay and a biologist friend spent four hours studying Crawford's ring one day and left mystified'.

It is doubtful whether the circle could have been there very long, otherwise there might have been some slight signs of plant recolonization of the scoured area. Ed Barker from the Winnipeg Planetarium's Centre for UFO Studies said that 'the ring was too trampled by the time he saw it to draw any firm conclusions'.

'Overlapping rings (i.e. circles) of swirled grain have been found just south of Riding National Park in western Manitoba and a 24-metre circle of dehydrated grain, with three tripod-like impressions in the ground, was discovered in an otherwise healthy field near Halbstadt, Manitoba. Another Manitoba farmer found a near-perfect circle close to a barbed wire fence'.

(Press clipping received from Ralph Noyes).

LITERATURE REVIEWS AND LISTINGS

Book Listings

Recent publications from the World Meteorological Organisation (P.O. Box No. 2300, CH-1211 Geneva 2, Switzeralnd):

1) LAND MANAGEMENT IN ARID AND SEMI-ARID AREAS. Anon. Technical note no.186, 1989, 149pp., SFR 30.00.

The report identifies the meteorological factors which influence land-use and management decisions in arid and semi-arid areas and their role in

desertification processes and control. It makes proposals and recommendations for further study and for the monitoring of agrometeorological aspects of land management in arid and semi-arid areas . . . The first section . . . deals with the assessment of (soil and climatic) conditions in arid and semi-arid areas, especially in rangelands where inappropriate land use, over-cultivation and over-grazing can lead to land degradation and desertification . . . The report then summarizes the data requirements for assessing the primary production of pasture vegetation. The next section . . . discusses the agrometeorological conditions affecting livestock production . . . The following section deals with major anthropogenic and agrometeorological factors which contribute to the diminution of vegetation cover, both in rainfed and irrigated agriculture. A description of the influence of meteorological hazards on desertification processes follows . . . The last section . . . is devoted to the application of remote-sensing techniques . . . for assessing and monitoring the state and productivity of vegetative cover, soil moisture, surface water supply and desertification . . ."

2) ANIMAL HEALTH AND PRODUCTION AT EXTREMES OF WEATHER. Anon. Technical note no.191, 1989, 181pp., SFR 29.00.

This collection of papers deals with "cold-and hot-weather stress on cattle, sheep, pigs and poultry. Other subjects covered are: cold and heat exposure and the immune function; animal parasites in cold and hot climates; effects of environmental requirements (including nutrition requirements) and the role of agrometeorologists in animal health and production. Some aspects of the meteorological forecasting of animal health and diseases are discussed".

3) AGROMETEOROLOGICAL ASPECTS OF OPERATIONAL CROP PROTECTION. Anon. Technical note no.192, 1988, 165pp., SFR 25.00.

"The first part of this report provides a general description of the meteorological influences on plant diseases, on insect and weed pests, and on pesticides that are of importance to operational crop protection. The consequent requirements for meteorological data in operational schemes are then presented . . . The results from a questionnaire . . . on the production and dissemination of crop protection information, form the basis of the following section . . . A short section on the economical benefits likely to be gained by the use of agrometeorological information precedes the final chapter which draws conclusions and makes recommendations".

4) AGROCLIMATOLOGY OF THE SUGAR-CANE CROP. By B. C. Biswas. Technical note no.193, 1988, 90pp.

"In the first chapter, a brief review of the origin, spread and progress of (sugar-cane) production is made . . . Areas where research is necessary are also indicated in this chapter. The second chapter reviews the climatic, soil and crop situations of 20 sugar-cane-producing countries situated in different geographical locations . . . The third chapter describes the influences of

various climatic factors on the growth and development of different phenophases of the crop . . . The microclimate within a sugar-cane crop differs significantly from that of an open area and plays a vital role in its growth and development. This aspect is addressed in the fourth chapter. The fifth chapter deals with the water needs of the sugar-cane crop at its different phenophases . . . The sixth chapter describes crop-weather relationships and the forecasting of yield . . . The seventh chapter treats the influence of weather on the occurrence of pests and diseases . . . In the last chapter, experiments are proposed whose results would fill the existing gap in the knowledge about the sugar-cane crop. Some important recommendations are made. How these findings could be used in the Climate Applications Referral Systems (CARS) is also indicated".

L. T.

TORRO THUNDERSTORM REPORT: June 1989

By KEITH O. MORTIMORE
Thunderstorm Division, Tornado and Storm Research Organisation, 77 Dicketts Road, Corsham, Wiltshire SN13 9JS.

Thunder-day totals across the U.K. and Eire were not all that far from the June normal but of the nationwide total of 19 days on only a very few was activity anything like widespread. Thunderstorms were mostly restricted to south-eastern counties where three to four days were quite widespread and with five in a few places, mostly in East Anglia and Sussex.

Thunder-days in June 1989 were as follows: (Averages refer to the period 1951-1980).

June 1989	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*	*30*	*Total*	*Ave.*
England	X	X	X	X	X	X	X	X				X	X	X							X	X					X	X		X	16	15.4
Wales	X					X						X	X																	X	5	7.7
Scotland					X	X							X							X								X			5	8.7
Ireland					X	X				X			X													X			X		6	7.5
Total	X	X	X	X	X	X	X	X		X		X	X	X						X	X	X				X	X	X		X	19	17.2
Netherlands			X	X	X	X	X	X	X	X											X	X	X			X	X	X			14	14.0
Belgium	X	X	X	X	X	X	X	X	X	X												X	X			X	X				14	

Under a marked upper cold pool heavy showers and thunderstorms developed over south Wales and southern counties of England during afternoon of 1st. Rainfall was often heavy and hail fell in a number of localities. At Wanstead (East London) a man was killed by lightning and an accompanying hailstorm produced an ice cover that remained unmelted in places until late morning on 2nd. During a Dorset storm wind damage was reported to roofs in Blandford Forum. On 2nd, 3rd and 4th isolated thunderstorms again affected some south-eastern parts of England and on 2nd

an airliner was struck by lightning whilst leaving Gatwick. From 5th to 8th storms developed much more widely over eastern counties. Activity was still mostly confined to southern and eastern areas of the U.K. but some scattered outbreaks were reported from parts of the north at times. On 5th a man was thrown through the air after being struck by lightning at Ipswich (Suffolk) where several houses were struck and on 6th storms in Kent were accompanied by copious amounts of hail particularly in the Gillingham area where several centimetres of hail accumulated and resulted in media reports of 'snow in June'. A house was damaged by lightning at Sendmarsh (Surrey) and several properties were damaged in West Midlands. At Stafford a golfer was unhurt when lightning struck an umbrella he was holding, melting the handle. He went on to win the tournament prize – a new umbrella. On 8th houses were struck and severely damaged by lightning at Canterbury (Kent) and power failures were particularly widespread in Norfolk. Apart from a report of thunder near Limerick in southern Ireland on 10th there was no further activity over the U.K. until the late morning of 12th when thundery outbreaks reached parts of Ireland and some other western parts of the U.K. ahead of an advancing cold front. During 13th these thunderstorms crossed north Wales and parts of northern England to clear the north-eastern coasts of England late in the day. No damage reports were received but rainfall was locally heavy and large hailstones fell at Rusherkin (Co. Antrim). On 14th a few scattered storms developed over parts of south-east England in early evening in association with a weak cold front lying over the area. There was no thunder anywhere for about a week but on afternoon of 20th the northern tip of the Scottish mainland and the Northern Isles were affected by thundery developments as a small depression and associated cold front crossed the region. The remnants of this low drifted slowly south down the North Sea over the following couple of days and as it did so it triggered off a few thunderstorms in East Anglia late in the evening of 21st and in east Kent in the very early hours of 22nd. Late in the afternoon of 26th local thunderstorms followed the passage of a frontal trough across Co. Down, Northern Ireland. A cold front crossed all parts early on 27th and during the late morning and early afternoon showers and thunderstorms broke out over many central and south-eastern counties. At Caister (Norfolk) a pole carrying electricity cables to the local lifeboat station was struck by lightning; the pole burst into flames and supplies were cut off for some 24-hours. The 28th saw just one or two isolated outbreaks and finally, on 30th, a more organised outbreak of thunderstorms developed near the triple-point of a depression as it crossed parts of Northern Ireland, north Wales and northern England during the day.

Acknowledgements: The Directors would like to thank all TORRO and TCO observers who have contributed to the compiling of this report. Sincere thanks are also offered to members of the Climatological Observers Link and also to the London Weather Centre for information published in the Daily Weather Summary.

WORLD WEATHER REVIEW: August 1989

United States. *Temperature:* warm from E. Montana and E. Wyoming to N.W. Michigan; Arizona, extreme S. Texas; marginally on N.W. and parts of N.E. coasts and in much of S.E.; +1degC from Dakotas to N.W. Michigan; C. Arizona. Cold elsewhere; –2degC in E. Oregon. Hawaii rather cold in S.E., normal elsewhere. *Rainfall:* wet from extreme W. Texas and S.E. Arizona to N.E. California, Oregon, E. Washington and W. Montana, then S.E. through Kansas to N. Texas; from Kansas N.E. to S. Michigan and S. Wisconsin; from there both N.W. to N.E. North Dakota and S.E. to E. Alabama and parts of Carolinas; N.E. coastal states. Over 200% from E. Oregon to N.W. Montana; E. North Dakota, N.W. Minnesota, N. Oklahoma to N.W. Missouri; locally in E. Nevada, N.E. California, C. Oregon and in N.E. Dry elsewhere; under 50% in coastal and S. California, interior Nevada, E. Utah to C. New Mexico; extreme S. Texas, N.E. Wisconsin, N.W. Michigan, C. Ohio to C. Pennsylvania; N. Arkansas to extreme N.W. Florida. Hawaii mostly unremarkable, but Honolulu 13%

Canada and Arctic. *Temperature:* warm in Alaska and most of Canada; +5degC from N. Alaska to Mackenzie estuary. Cold from Ontario and Quebec through Greenland and Iceland to Franz Josef Land; –2degC in S.W. Greenland. *Rainfall:* wet in much of W. Alaska; S. British Columbia to L. Winnipeg; E. coastal Canada (except Nova Scotia) to Iceland and Greenland (except N.E.); Franz Josef Land. Over 200% in S. British Columbia, S.W. Alberta, L. Winnipeg (but Winnipeg itself under 50%), St. Lawrence estuary, S.E. Greenland; locally in S. Alaska. Dry elsewhere; under 50% from E. Alaska to N.W. Quebec; Spitzbergen, Bjornoya.

South and Central America. *Temperature:* mostly warm in South America 15-40°S.; C. and N.E. Mexico to Honduras; West Indies, Bahamas, Bermuda; +2degC locally from E. Bolivia to C. Argentina. Cold in Paraguay (–2degC in interior), N.W. Mexico. *Rainfall:* wet from E. Bolivia and C. Brazil through Paraguay and Uruguay to C. Argentina and parts of C. Chile (over 200% very widely except perhaps in Chile); most of Mexico to N. Honduras; Cuba, Puerto Rico, Bermuda. Over 200% in N., C. and extreme S. Mexico, Puerto Rico; parts of Guatemala. Dry in S.W. Bolivia, N. Chile, N.W. Argentina, S.E. coastal Brazil, N.W. and N.E. Mexico, Lesser Antilles (under 50% widely in all these areas), S. Guatemala, N. Yucatan, El Salvador, Jamaica.

Europe. *Temperature:* warm in S. as far N. as Scotland, N. Germany and Ukraine (except Hungary to Greece); also N. Norway to N. Urals; +2degC locally in Spain, Portugal, S. France. Cold elsewhere; –1degC widely from S. Norway to S. Urals. *Rainfall:* wet from Faeroes, Ireland and W. Scotland through C. Norway, C. and extreme S. Sweden and Finland to most of European Russia (except N. Urals and in and near E. Ukraine), then through N.W. Romania to N. Italy; locally in Spain and Portugal. Over 200% in Faeroes, W. Scotland, S.W. Norway, extreme S. Sweden, C. European Russia and near S. Urals; locally from N. Italy to W. Ukraine. Dry elsewhere; under 50% in N. Urals, S. England, S. Spain, C. Poland, W. coastal Italy, S.E. Romania, N.E. Bulgaria, in and around E. Ukraine; much of France, Low Countries and Greece; locally in Germany. Provisional sunspot number 167.

Africa. *Temperature:* warm from Madeira and Canary Islands to Libya; in and near South Africa; +2degC in E. Botswana, N.W. Transvaal, E. Natal, N.E. Morocco and parts of N. Algeria. Cold in parts of Egypt and marginally in W. Cape Province. *Rainfall:* wet from Madeira and Canary Islands to N. Tunisia (over 200% widely); C. Transvaal, W. Cape Province. Dry from S. Tunisia to Egypt; in and near most of South Africa; mainly under 50%.

Asian U.S.S.R. *Temperature:* warm near Pacific coast and from Ob basin southwards; +2degC in E. Kazakhstan. Cold elsewhere; –2degC in upper Lena basin and S. of Taimyr Peninsula. *Rainfall:* wet in E. half (but under 50% in lower Amur basin); over 200% in Lena basin. Dry in W.; under 50% from Ob and upper Yenisey basins southwards.

Asia (excluding U.S.S.R.). *Temperature:* warm in N. Arabia, S.E. India, N.E. and S.E. China, E. Mongolia, Thailand, Cambodia, Malaya, Philippines; most of Turkey and Japan; rarely above +1degC. Cold from S. coastal Turkey to Israel; S. Arabia, Pakistan, W. and N. India, W. Mongolia; most of China; –2degC in interior S. China. *Rainfall:* wet in interior N. Turkey, C. China, Laos, Cambodia, Vietnam; much of Japan (over 200% locally in all these areas, especially Japan); N.E.

Thailand and parts of Sumatra. Dry from most of Turkey to most of India; S. and N. China; most of Mongolia, Korea and Philippines; much of Thailand; parts of S. Japan. Under 50% locally in last three countries; widely in the others

Australia. *Temperature:* cold everywhere except marginally in S.W.; -2degC in interior E. *Rainfall:* dry except in W. Victoria; mainly under 25%.

M. W. ROWE

WEATHER SUMMARY: November 1989

The persistent mild weather of recent months continued to affect the U.K. well into November but much colder conditions later in the month resulted in mean temperatures not too far from the seasonal average, being generally a little on the mild side. Highest values included 18.0°C at Nantmor (Gwynedd) on 13th, 18.2° at Dover (Kent) on 1st and in the region of 15° in parts of central Scotland on 14th. The highest minimum was 13.2°C at Guernsey (Channel Islands) on 11th while on the same night 12.8° was recorded at Exeter (Devon) and 12.4° at Stretton, Burton-on-Trent (Staffordshire). In Scotland 10° to 11° minima were recorded locally in the far west of the mainland and in the adjacent islands on 14th. Cold, Arctic air plunged southwards across all parts of the country during the last week producing sub-freezing maxima in some places. At Tummel Bridge (Tayside) the temperature failed to rise above -1.9° on 25th and Shawbury (Salop) recorded only -0.9°C on 30th. At Carrigans (Co. Tyrone) 0.1° was the maximum temperature recorded on 26th. Air frost was severe in places, particularly on 26th when -9.4° was recorded at St Harmon (Powys), -8.4° at Gatwick, -8.3° at Gurney Slade (Somerset) and Sandhurst (Berkshire) and -7.5°C at Velindre (Powys). On 27th Bastreet (Cornwall) recorded -7.3°C. In Scotland -8.5° was reached at Tummel Bridge on 25th. On the grass -14.2° was reported at Glenlee (Dumfries and Galloway) and at Beaufort Park (Berkshire) on 26th with -13.6°C at South Farnborough on 30th. November was a very dry month in all parts of the U.K. with less than 50 percent of the normal rainfall over much of northern and eastern Britain. Over the Midlands and south-west totals were in the region of 50 to 80 percent of the normal. Highest daily totals included 48.4mm at Trawsfyndd (Gwynedd) on 10th, 46.7mm at Nantmor on 1st, 39.9mm at Camborne (Cornwall) on 7th and 30.0mm at Eastbourne (East Sussex) on 2nd. November was also an exceptionally sunny month with more than 150 percent of the normal over many eastern parts and at Folkestone (Kent) 145.5 hours were recorded which was twice the average for this late autumn month. In many parts of the country this was one of the sunniest Novembers this century.

The first ten days of November were unsettled and mild with frequent spells of rain as a series of deep depressions tracked north-eastwards to the north-west of Scotland. Frontal systems were most active in the west where rainfall was quite heavy at times and winds reached gale-force on occasions, especially on 8th as a deep depression tracked north-east across central Britain.

On 11th an anticyclone over eastern Europe pushed a strong ridge across the U.K. and for the rest of the month high pressure was very persistent to the north and east. Between 12th and 14th it was very mild with some particularly high temperatures in sheltered parts of North Wales, but thereafter easterly winds set in over the country and temperatures returned to more normal levels. After a foggy spell around the 12th to 15th most parts were dry with periods of sunshine apart from some patchy rain in some western and northern areas on 18th. High pressure between Iceland and Greenland became the dominating feature from 18th and as this high transferred slowly south-east into the country colder weather moved south across all parts. With the anticyclone covering the British Isles during the final week frost formed widely at night and it was locally severe, especially between 24th and 26th, and day-time temperatures remained close to or even below freezing in the deeper valleys of the Scottish Highlands on 25th and in some other spots further south where freezing fog proved rather persistent.

K. O. M.

TEMPERATURE AND RAINFALL: NOVEMBER 1989

	Mean				*Grass*					
	Max	*Min*	*Max*	*Min*	*Min*	*Rain*	*%*	*Wettest*	*RD*	*Th*
BELGIUM: Uccle	9.7	2.4	15.9(2)	-4.8(26)		22.1	33	5.8(10)	10	-
„ Rochefort	9.2	-0.5	16.4(2)	-10.2(26)		31.2	47	16.4(1)	7	-
DENMARK: Fanø	8.0	1.7	13.6(1)	-9.5(24)		53.3	56	17.1(5)	13	1
„ Frederikssund	7.1	1.2	12.4(1)	-8.9(25)	-11.2(25)	17.1	28	4.8(4)	13	0
GERMANY: Berlin	5.9	0.5	13.8(1)	-7.0(25)	-10.4(25)	74.0	161	32.1(6)	14	0
„ Hamburg	7.3	0.6	14.0(1)	-7.0(25)	-9.6(25)	19.8	34	7.4(25)	11	0
„ Frankfurt	7.1	-0.2	13.5(1)	-9.0(26)	-11.0(26)	52.6	89	19.9(1)	7	2
„ Munchen	5.8	-2.6	16.9(1)	-14.5(26)	-22.7(26)	63.2	111	19.5(6)	12	0
ITALY: Casalecchio	10.5	4.6	20.0(3)	-2.0(v)		29.0	40	17.0(22)	9	0
MALTA: Luqa	20.8	14.5	24.0(18)	10.0(14)	4.9(14)	73.0		32.4(26)	10	4
NETH'NDS: Ten Post	7.7	1.3	13.9(1)	-6.2(25)	-10.3(25)	20.9	27	4.1(23)	14	0
„ Schettens	8.4	1.5	13.7(2)	-6.3(29)	-8.5(25)	29.8	35	13.0(5)	14	0
SWEDEN: Valla	4.5	-1.3	10.5(12)	-13.0(25)	-17.8(25)	29.1		9.4(4)	16	0
SWITZ'LAND: Basel	7.8	0.1	20.0(2)	-9.8(26)		46.7	83	24.6(3)	8	0
EIRE: Straide	9.2	3.8	14.3(13)	5.4(23)	-12.3(23)	55.3	46	10.9(4)	16	0
SHET'AND: Whalsay	8.6	5.2	11.0(3)	0.9(25)	-2.4(13)	54.3	41	15.9(10)	15	0
„ Fair Isle	8.7	6.6	11.2(13)	2.0(25)		55.7		11.9(10)	19	0
SCOT'AND: Braemar	6.9	1.0	13.7(14)	-7.2(25)	-7.7(25)	35.9	40	11.1(1)	15	0
„ Inverdruie	6.9	1.1	11.9(14)	-7.0(30)	-10.8(30)	16.5	19	2.9(24)	12	0
„ Rannoch	6.8	0.4	13.6(14)	-8.5(26)	-9.5(26)	49.9		13.2(1)	10	0
WALES: Pembroke										
„ Velindre	9.1	3.0	14.0(11)	-7.5(26)	-12.6(26)	62.8	66	12.9(7)	12	0
„ Carmarthen	10.5	4.3	15.8(12)	-5.0(26)	-9.5(26)	120.4	86	29.9(10)	14	1
„ Gower	10.7	5.9	14.7(12)	-0.7(30)	-7.4(26)	109.3	81	25.5(10)	14	0
GUERNSEY: Airport	11.8	8.1	16.0(13)	2.2(26)		63.3		14.7(9)	12	1
ENGLAND:										
Denbury, *Devon*	10.7	6.0	15.1(12)	-2.7(24)	-6.2(24)	74.8	69	21.9(7)	15	0
Gurney Slade, *Somerset*	9.7	2.4	15.3(12)	-8.3(26)	-8.5(26)	81.4	53	19.0(7)	9	0
Yatton, *Avon*	10.9	4.0	16.8(12)	-7.2(26)	-9.6(26)	58.3	69	21.2(7)	11	1
Corsham, *Wiltshire*	9.8	3.1	15.4(12)	-6.9(26)	-10.9(26)	64.9	76	23.2(7)	11	0
Mortimer, *Berkshire*	9.6	2.4	15.1(11)	-7.1(26)	-10.9(26)	34.1	46	13.2(2)	10	0

	Mean Max	Mean Min	Max	Min	Grass Min	Rain	%	Wettest	RD	Th
Reading Univ., *Berks*	10.2	3.1	15.9(17)	-6.4(26)	-11.5(26)	27.6	46	10.4(2)	8	0
Sandhurst, *Berkshire*	10.3	2.0	16.7(12)	-8.3(26)	-9.4(26)	29.2	40	10.7(2)	9	0
Romsey, *Hampshire*	10.4	2.5	15.4(12)	-8.5(26)	-10.4(26)	46.1	63	13.1(2)	10	0
Horsham, *Sussex*	9.8	3.1	15.5(11)	-6.9(26)	-9.5(26)	33.6	39	11.1(2)	9	0
Brighton, *Sussex*	10.5	4.5	14.5(11)	-4.1(26)	-5.0(26)	57.7	74	22.9(2)	11	0
Hastings, *Sussex*	10.8	4.9	14.9(v)	0.0(26)	-4.8(26)	66.4	76	15.8(2)	9	1
Dover, *Kent*	10.7	2.9	18.2(1)	-5.4(26)		74.7	77	16.4(2)	13	1
East Malling, *Kent*	10.6	2.4	16.3(11)	-6.4(26)	-9.6(26)	37.5	50	12.4(2)	13	1
Epsom Downs, *Surrey*	9.5	3.0	15.5(12)	-7.1(26)	-10.4(26)	37.9	53	12.3(9)	9	0
Reigate, *Surrey*	9.4	2.5	15.0(11)	-8.1(26)		41.6	57	13.6(2)	8	0
Guildford, *Surrey*	9.5	3.8	15.5(11)	-4.6(26)	-6.9(26)	31.4	45	10.1(2)	10	0
Sidcup, *London*	10.2	3.0	16.1(11)	-5.5(26)	-8.7(26)	27.8	47	8.9(2)	9	0
Hayes, *London*	10.4	2.3	15.9(12)	-6.5(26)	-7.9(26)	28.5	56	11.6(2)	10	0
Hampstead, *London*	10.1	3.9	16.2(1)	-3.8(26)	-10.2(26)	29.6	44	11.1(2)	8	0
Royston, *Hertfordshire*	9.1	3.5	14.8(12)	-3.8(30)	-8.4(30)	25.3	44	9.7(2)	8	0
Loughton, *Essex*	9.3	2.8	15.1(11)	-4.9(26)	-12.0(26)	26.3	50	9.8(2)	12	0
Buxton, *Norfolk*	10.3	2.6	15.2(11)	-3.4(29)	-4.5(29)	48.6	73	12.5(2)	14	1
Ely, *Cambridgeshire*	9.8	1.6	15.2(11)	-4.0(26)	-5.0(26)	37.1	70	13.3(8)	12	0
Luton, *Bedfordshire*	10.0	2.6	15.9(12)	-5.9(26)	-10.3(26)	34.0	49	11.2(2)	11	0
Buckingham, *Buck'shire*	9.5	2.2	14.4(11)	-6.6(26)	-11.5(26)	37.3	57	18.8(8)	9	0
Oxford University	9.8	3.2	15.1(11)	-4.5(26)	-11.0(26)	32.5	53	7.5(2)	9	–
Stourbridge, *W.Midla'ds*										
Wolverhampton	8.6	3.4	13.7(12)	-3.0(30)	-4.5(23)	46.4		22.4(8)	11	0
Louth, *Lincolnshire*	9.5	3.4	15.2(11)	-1.0(26)		52.8		30.9(8)	10	0
Keyworth, *Nott'shire*	8.9	2.5	15.3(11)	-4.5(27)	-8.2(27)	37.2		18.2(8)	9	0
Nottingham *Nott'shire*	8.9	2.9	14.7(11)	-3.5(27)	-6.3(27)	29.7	54	17.2(8)	8	0
Derby, *Derbyshire*	9.0	4.0	14.5(11)	-3.2(27)		30.4		17.6(8)	13	0
Middleton, *Derbyshire*	7.7	3.4	14.3(14)	-2.0(26)		52.8	57	20.9(8)	10	0
Keele University, *Staffs*	8.6	3.0	14.0(12)	-5.1(26)	-7.7(26)	72.2	99	26.5(8)	12	0
Liverpool, *Merseyside*	9.9	4.0	14.4(1)	-3.3(30)		73.6		17.0(8)	13	1
Lathom, *Merseyside*	9.3	3.8	14.8(12)	-1.6(30)		87.1		23.8(4)	12	–
High Bradfield, *S.Yorks*	7.2	3.8	14.1(13)	-1.2(26)		54.0		20.0(8)	15	–
Cottingham, *Humb'side*	9.8	3.7	13.7(1)	-1.2(26)	-5.0(26)	34.0	54	20.8(8)	10	0
Carlton-in-Cleveland	8.8	3.8	14.7(13)	-2.1(27)	-6.5(27)	38.3		10.8(8)	13	0
Sunderland, *Tyne/Wear*	9.9	5.4	14.3(1)	0.8(26)		22.7	33	9.9(8)	8	0
CANADA: Halifax *NS*	7.4	-0.5	16.2(1)	-11.2(26)		173.8	122	29.2(9)	22	1
U.S.: Bergenfield, *NJ*	12.3	2.2	21.7(14)	-8.9(24)	-15.6(24)	69.6		27.4(9)	10	1
JAMAICA: Kingston	32.6	24.4	34.8(11)	22.6(15)		29.3	48	16.9(11)	8	3
AUSTR'LIA: Leopold	21.4	11.5	34.8(23)	6.2(3)		37.2		9.2(30)	11	2
„ Mt. Waverley	22.7	11.6	34.8(23)	6.2(3)		37.2		9.2(30)	11	2

CUMBRIA RAINFALL:

Carlisle, 35.8mm (44%); Appleby Bongate, 63.2mm (74%); Seathwaite, 179.0mm (51%); The Nook, Thirlmere, 187.0mm (64%); Coniston, 143.9mm (52%); Hawkshead, 111.5mm (55%).

Correction:

January 1990 issue page 30.

In David Meskill's letter write SSE for NNW on line 11 and Crossmolina for Crossmouna on line 26.

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CONTENTS PAGE

FRONT COVER:
Orographic enhancement of snowfall probably resulted in heaviest fall on the North Downs area of Surrey during the morning of 5 April 1989. Jasper the cat sheltering from heavy snow accumulating to 13cm by 0930 GMT at Caterham (altitude 190m).
Photograph by John A. Chambers.

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