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SPATIAL AND TEMPORAL RAINFALL VARIABILITY OVER SOUTHEASTERN CENTRAL AFRICA DURING EXTREMELY DRY AND WET YEARS

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Abstract: The recent drought of 1981-1984 which affected the African sub-region has increased interest in the causes and predictability of drought and rainfall variability. Striking contrasts in the rainfall distribution and intensity over this region during extremely dry and wet years require a diagnostic examination of atmospheric features which control these rainfall distribution patterns. The purpose of this paper is to highlight the rain features of dry and wet spells and relate them to large-scale circulation over Southern Africa.

The study compares rainfall variability at different stations during extremely wet and dry years and attempts to give some explanation in terms of synoptic systems during the contrasting periods. Dry spells are also defined from daily rainfall received over the country and the data are analysed to observe the characteristics of these spells.

INTRODUCTION

The recent drought episodes that have affected the African continent have prompted numerous papers dealing with rainfall variability and causes of drought. Most of the research work concentrated on the drought in the Sahel region (Winstanley, 1973; Bunting et al., 1976; Kraus, 1977 a,b; Nicholson 1980, 1981). Long-term rainfall series were derived for the region and several hypotheses have been put forward to explain the Sahelian rainfall fluctuations, and especially drought episodes. A high degree of coherence of rainfall variation was found to exist throughout the African subtropics, and the rainfall changes were basically a function of the position of the intertropical Convergence Zone. Teleconnections have also been observed over Africa, with two regions exhibiting either generally parallel or generally opposing fluctuations.

Few studies of rainfall variability have, however, been done over Southern Africa. Among the few studies carried out so far are those by Miron et al (1984), Tyson (1980, 1984) and Dyer (1976).

The spatial coherence of meteorological fluctuations over scales of thousands of kilometres has permitted the use of anomaly patterns in a variety of recent investigations of short term investigations (Walsh et al 1982, Tyson 1984). It has been shown that a simple comparison of wet and dry years suffices for determining the physical interactions which form the basis of at least some short-term climatic fluctuations.

This paper looks at rainfall variability during wet and dry episodes, over south-east central Africa (Fig.1). Physical explanations for the variability are given.

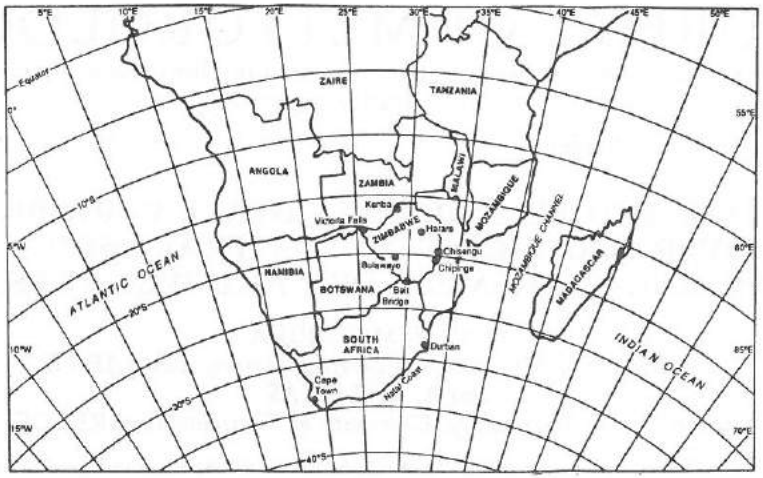

Fig.1: Locator map of the African subcontinent.

DATA AND METHOD OF ANALYSIS

Studies of rainfall variability over this region are hindered by a scarcity of modern and historical data. Few rainfall records are as long as a century. Very few meteorological stations were established in the 1980's. The most satisfactory data set was over Zimbabwe. Additional data, though much more limited, were obtained from Zambia, Malawi, Botswana, Mozambique and South Africa.

THE RAINFALL INDEX

An area average index was calculated for annual rainfall. Its value was given by Nichols on (1981) as follows:

$$I_j = 1/N_j \, \Sigma \, (r_{ij} - R_i)/s_i.$$

where I_j is area average index for year j; r_{ij} is that year's seasonal rainfall; R_i and s_i are respectively the mean and standard deviation of station i's seasonal rainfall for some base period, mostly 30 years; N_j is the number of stations with complete records in year j; and the summation is taken over all i from 1 to N.

A rainfall index was also calculated for daily rainfall to isolate wet and dry spells within individual rainy seasons. Its value for year j is given as $I_{ij} = +(r_{ij} - R_{ij})/s_{ij}$.

where I_{ij} = index at station i in year j; r_{ij} = daily rainfall for station i in the year j; R_{ij} = the mean daily rainfall for the season; s_{ij} = standard deviation of seasonal rainfall.

The aim of the index was to assess the severity and length of the dry spells. Limits on normalised deviations were, therefore, established as follows in Table 1 (Ogallo, 1985).

TABLE 1. Limits on normalised deviation.

Class type	*Normalised Index (I) limits*	*Classification*
3	greater than $-0.2\ R_{ij}/s_{ij}$	no significant drought
2	between class 3 and 1	moderate drought
1	smaller than $-\frac{1}{2}R_{ij}/s_{ij}$	severe droughts

This index enables us to do a cross-comparison of rainfall variation at different stations.

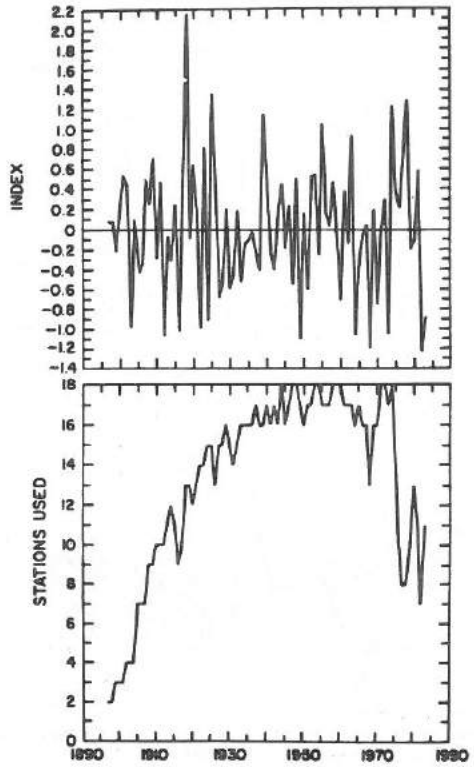

Fig.2: A time variation of the rainfall index over southeastern central Africa (top panel) and the corresponding number of stations used in computing the index (bottom panel).

RESULTS OF THE ANALYSIS

An annual variation of the area average rainfall index over the region and the corresponding number of stations used in the index are shown in Figure 2. The longest period when rainfall anomalies of a particular type were most persistent was between 1933 and 1938 when rainfall was below normal for about six years. Five and four consecutive wet years are observed between 1973 and 1977, and between 1954 and 1957, respectively. Most of the wet or dry periods are less than 4 years long. The year 1917/18 received the highest rainfall and 1982/83 the lowest amount during the period 1898-1984.

Figure 3 shows the spatial variation of the rainfall index for the three driest and three wettest years. Extremely deficient rainfall during drought years occurred over the northeast of the region. Using the axis of the highest index as the track followed by synoptic systems, we can conclude that the mechanism associated with the 1963/64 drought was centred over Zimbabwe. During the other two

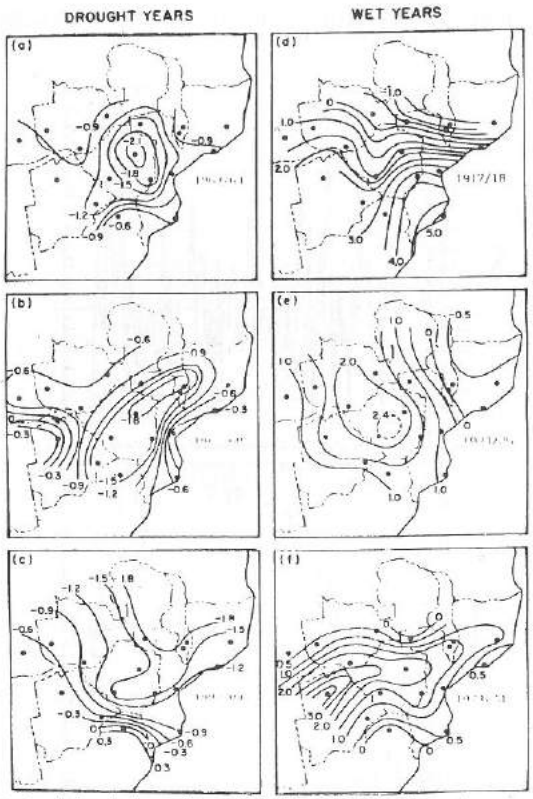

Fig.3: Spatial variation of the rainfall index during drought years (left panels) and wet years (right panels).

drought years, 1967/68 and 1982/83, the synoptic feature responsible for the drought was oriented in a northeast-southwest direction. In all three cases, the mechanism is a middle-level anticyclone, locally referred to as the Botswana Upper High. Subsidence at this level inhibits convective activity. If the same feature is situated to the southwest of Zimbabwe, a dry southwesterly flow emanating from this feature, affects most of the region, thus reducing the amount of rainfall received.

During the 1917/18 wet years, the rain-bearing systems moved in a northwest-southeast direction. Such weather systems are associated with middle latitude migratory anticyclones locally known as Guti regularly affect Central Africa as these anticyclones move around the South African coast into the southwest Indian Ocean (Krest 1973). When these anticyclones are located over Natal province of South Africa, outburst of cold but moist low level air may invade the entire southern half of Zimbabwe giving low stratiform clouds and outbursts of light rain or drizzle (Torrance 1972).

The 1924/25 season seems to have been dominated by weather disturbances from the northwest. These are cyclonic vortices which develop within the

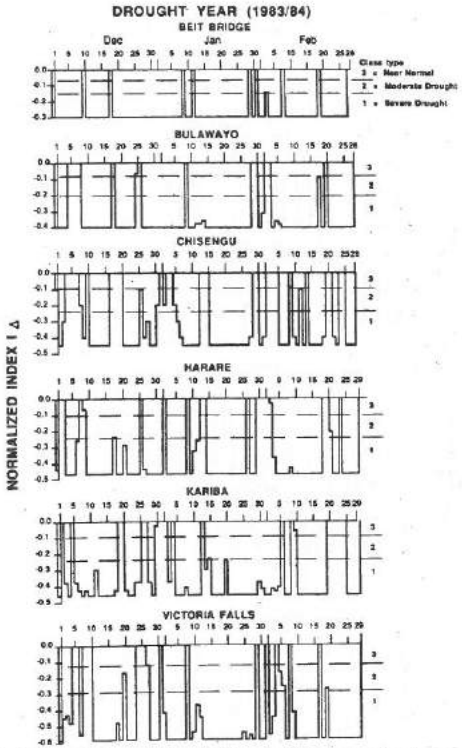

Fig.4(a): A time series of the daily rainfall index during a drought year.

Intertropical Convergence Zone. However, during the 1973/74 rainy season, the weather systems must be associated with middle-latitude induced instability. Such rain-bearing systems move from the southwest to the north-east, and are locally known as "cloud bands". Frequently the cloud-band weather occurs in association with middle-latitude induced instabilities in the middle levels of the atmosphere (Zinyemba 1984). These active weather zones (cloud band) are often oriented in a north west to southeast direction and affect Southern Africa as they move eastwards from the South Atlantic ocean.

Figure 4 shows a time series of the daily rainfall index during a 1983/84 drought and 1977/78 wet years. Clear differences emerge between dry spells during the wet and drought years. These tend to be longer, 10 – 20 days of severe drought during drought years; whereas the dry spells during the wet years are, on average 3 days of severe drought. Mechanisms which are associated with deficient daily rainfall seem to be more intense during the drought years, and therefore more persistent.

CONCLUSION

A simple index has been used to compare rainfall variability over southeast central Africa. It is clear the northeastern part of the region is affected more by the

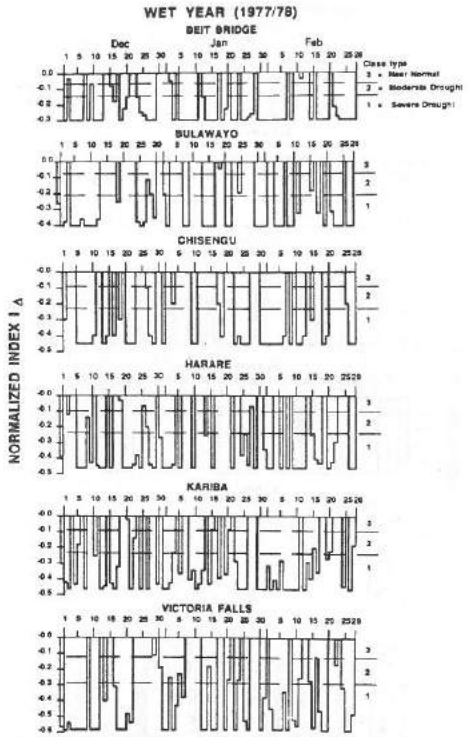

Fig.4(b): A time series of the daily rainfall index during a wet year.

mechanisms which initiate and sustain drought. The more potent weather systems tend to be from the northwest and southwest. These are respectively associated with tropical disturbance within the ITCZ and the cloud band within the middle level westerly wave.

The daily analysis of the rain index reveals the persistence of dry spells during drought years. Potent weather systems are more frequent during wet years.

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A STUDY OF THE EFFECT OF AIRCRAFT TRAILING VORTICES UPON A CEREAL-FIELD NEAR AN AIRPORT

By G. T. MEADEN
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Tornado and Storm Research Organisation.

Abstract: Damage areas in a barley field adjacent to Thruxton airport were inspected on 3 and 6 July 1987. It was deduced that the damage was caused by aircraft trailing vortices which had become detached from an aircraft when landing from the west against a very light easterly wind some three weeks earlier. Using landing information provided by airport staff and the relevant weather data it was concluded that the aircraft was an 8-seater Islander which landed at Thruxton five times between 1038 and 1320 GMT on the morning of Sunday 14 June against the light easterly wind. The nature of the damage to the crop is discussed.

INTRODUCTION

On 3 July 1987 I looked at some cereal-crop damage at Thruxton (Southern England) which had been spotted by private pilot Mr Fred (Busty) Taylor. I noted with interest that the field was west of and close to the airport, and that the damage was quite unlike any of the field damage of natural-vortex origin which I had been investigating since 1980. Nor was it a question of conventional wind or storm damage, and I realised that I was regarding, for the first time, ground traces of the aircraft-wake phenomenon known as trailing vortices. A half-hour investigation was made that day and a further examination lasting two hours was carried out on 6 July.

When in flight an aircraft disrupts the airflow and produces vortex patterns which trail in its wake (Figure 1). Although minor vortices are set up by the rudder, the tailplane, the undercarriage and the nose-wheel, the principal vortices emanate from the wing-tips. The vortices are the result of leakage flows around the wing-tips from the high pressure below the wing to the low pressure above it. As the wing-tip vortices stream behind the aeroplane, often for considerable distances, a dynamic equilibrium is reached in which the energy which is being

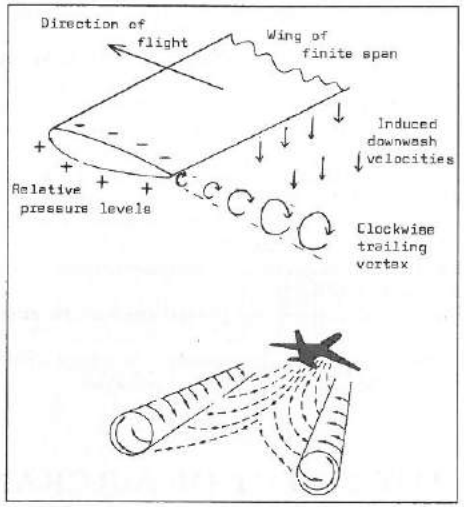

Fig.1: Sketches to indicate the origin of trailing vortices and why the vortex from the left-hand wing-tip is clockwise. The righthand wing-tip clearly produces a vortex spinning in the opposite sense.

continuously applied at the foremost ends of each vortex close to the wing-tips, is steadily lost at the trailing ends through turbulent mixing. The vortex generation begins as the aeroplane leaves the ground and persists until the plane touches down again. The vortices usually separate from the wing-tips at the moment of touchdown but earlier detachment can be induced under certain conditions.

Early disengagement is most frequent at that moment in the landing manoeuvre when the angle of attack of the wings and aerofoils takes place. In some cases, depending on a combination of aircraft type and local wind-field conditions, the energetically-spinning vortices float away from the wing-tips. Lifetimes of liberated vortices are often brief except when winds are light or calm and then they may last for many minutes during which time they pose risks to other aircraft. This aspect of the problem has been made the subject of an information advisory circular issued by the British Civil Aviation Authority, entitle *Wake Turbulence* (no 90/1986). To illustrate the dangers, in one documented case an aircraft (BAC 111) flying 30 kilometres behind a Boeing 747 was struck by a long-lived vortex produced by the 747.

Many of the trailing vortices dissipate harmlessly in the open atmosphere whereas others when they peel off head towards the ground. But if they plunge rather than float down, they constitute genuine hazards not only to other aircraft but to domestic and industrial buildings as well. The civilian dangers have been studied for many years by Mr John E. Leech of Cranford, with particular regard to housing affected by aircraft approaching the main runways of Heathrow Airport, London. Hundreds of cases of roof damage have been catalogued, together with lesser yet disturbing reports of slammed doors, curtains dragged through window gaps, trees bent double, fruit shaken off, and garden furniture thrown about. These

Fig.2: Oblique view of crop-damage west of Thruxton airport, looking S.S.E. Besides the damage areas in the main field there is an additional path of damage in the unripe barley to the left of the row of trees. Photograph by Colin Andrews from Cessna piloted by Mr Fred Taylor (4 July).

destructive vortices are usually accompanied by a high-pitched note or scream, like an ethereal whine, which is also said to resemble the passage of an artillery shell. At other times, though, no noise is reported and it may be that some vortices are silent. Vortices can also become detached at or shortly after the take-off of aircraft, but this appears to cause lesser problems than rapidly-descending vortices which disengage from aeroplanes as they prepare to land.

Although a considerable amount of aerodynamical research has lately been performed on trailing vortices, almost wholly with regard to the efficiency and safety of aviation flight, and Mr John Leech has privately assembled much household damage evidence, the information that crop-damage patterns can offer has never been considered. Accordingly, the opportunity is taken in this paper to examine the Thruxton evidence in order to deduce the primary vortex characteristics pertaining to this special case.

THE THRUXTON FIELD-DATA

An oblique view of the five crop-damaged areas and their relative locations are provided in the air photograph of Figure 2. Their shapes in plan are given in Figure 3, together with an inset figure which illustrates the proximity and position of Thruxton airport.

In each case the straws of the winter barley were forcibly bent or broken by the application of what must have been almost vertical airflow. Besides the three patches clearly visible in the photograph there is a patch of crop-damage beneath

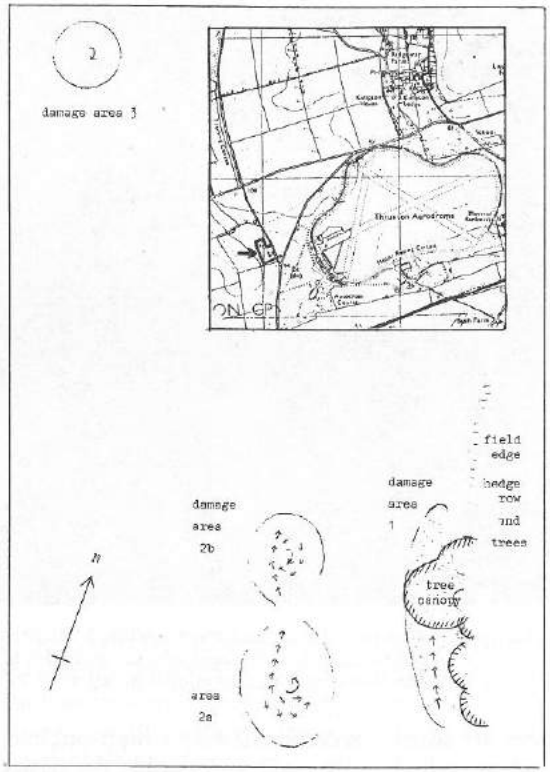

Fig.3: Plan of primary areas of crop-damage west of Thruxton Airport. Inset: Map showing their location in relation to the landing-strips.

the oaks at the east of the field and another patch in the green spring barley east of the trees. The most interesting areas for vortex-study are certainly the overlapping twin ovals and the isolated nearly circular area, but our attention is first directed at the crescent-shaped region on the eastern edge of the field (Figure 3).

(1). This region is 36 metres long and up to 5 metres wide. Around the circumference the bent or snapped straws all lay inwards. This suggested a simultaneous convergence as well as sudden descent of an impressed force with quasi-conical symmetry. Away from the edges the damage was chaotic except for a narrow near-axial swathe some 18 – 20 metres long laid down in a unidirectional S.E. to N.W. sense.

Being on the margin of a field bordered by oak trees, the damaged crop was partly overlaid by the tree canopy. One tree was largely responsible for this (see Figure 3 and 4) yet investigation showed that its presence had seemingly done little to reduce the effect of the downburst of energy on the crop beneath, for the damage to the latter was as severe as elsewhere. Proof that the downward burst of air had been almost vertical came from the fact that oak leaves and twigs from this tree strewed the ground exactly below its canopy but nowhere else (Figure 5). The

Fig.4: Part of the oak tree through which at least one trailing vortex descended.

violent rush of air had plunged straight down and had passed through the oak tree without obvious loss of force.

(2a, 2b). The second area of damage, 12 metres to the S.W., was 42 metres in length. In having the shape of twin ovals, it may represent two independent, overlapping areas (Figure 3). The orientation of the main axis was measured as 145 – 325 degrees. Around the perimeter the straws lay bent or broken and were directed slightly inwards (Figure 6). Most importantly, the southern oval displayed unmistakeable signs of vortical circulation at its centre where the barley had been twisted into something of a twisted pyramidal form. Its rotational sense was anticlockwise, an effect which extended for a radial distance of one or two metres into the flattened barley as well. Various damage swathes of flattened barley were apparent within this great oval, but elsewhere the stalks of barley remained upright despite being broken or snapped.

The barley in the northern oval was chaotic. Some evidence for a clockwise rotation seemed present over a limited region near the geometrical centre but this was not so clear that we can make a definite statement about it. In parts of the northern oval the barley lay flat, in places with two overlying layers. Both this oval and its companion had prominent longitudinal swathes running south-north.

(3). The third area of damage was nearly circular with a diameter of some 12 metres. At the centre was a quasi-pyramid of barley-stalks twisted in a clockwise direction. Over the remainder of this area the barley was broken or bent as if by a powerful vertical force, the damaged barley at the perimeter being directed slightly inwards.

(4). A fourth damage area was noted on the other side of the hedge and lane in the corner of the next field and closer to the airport. It measured 7 metres by 3 metres, and can be seen in the aerial photograph (Figure 2). No further damage

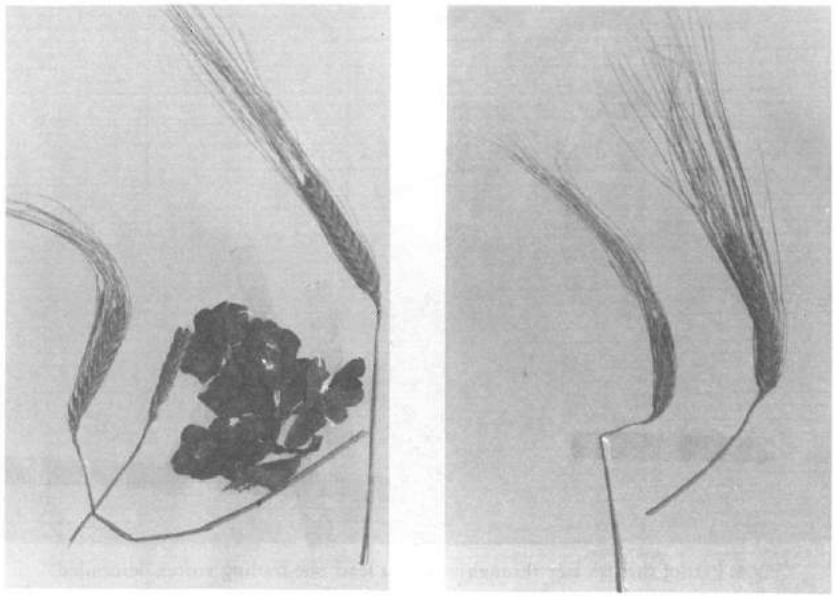

Fig.5: Comparison between growing barley (6 July, right hand side of each photograph) and barley whose growth had been arrested some three weeks earlier at the time of the incident. Also shown is a twig with oak-leaves typical of many dozens which littered the damaged crop beneath the tree.

areas were noted, but it is possible that additional vortices could have struck the hedgerows, road or the no-mans-land adjoining the airport.

On 6 July samples of barley were collected from the various damage areas and compared with samples of growing barley (Figure 5). The barley whose growth had been arrested appeared to be about three weeks younger, indicating a single date close to the middle of June for the accident. No significant age difference was noticeable between the various areas. This implied that all areas were probably damaged on the same day.

DISCUSSION

A study of the damaged barley crop permits us to deduce that the crop was struck by intense vortices. The insufficient shielding provided by the oak tree emphasises the strength of the vertical component of the wind-field, while the inward angling of stalk damage at the peripheries and the limits defined by the fall of oak leaves demonstrate the verticality, combined with conicality, of the aerial forces. Proof of rotation was definite but slight. The evidence therefore points to the origin of the damage as slowly spinning conical vortices which plunged almost vertically to earth and owed their destructive power to their speed of descent. In view of the proximity of Thruxton airport and for the other reasons detailed here an origin in terms of aircraft trailing vortices seems likely.

Firstly, we note that the orientation of the main runway is 246 – 66 degrees. This is exactly perpendicular to the main axis of the twin-oval system. It implies

that the twin-ovals represent the ground traces of the principal vortices ejected from an aircraft upon its approach to the runway from a west-south-westerly direction. In turn, this indicates that because aircraft make their landing approach into a head wind, the wind must have been, at least initially that day, from the easterly quarter. This wind direction was rare in June 1987, the only date being Sunday 14 June when the wind was light easterly all morning, then variable (and probably calm for a while) becoming westerly in the afternoon. The records from my own weather station at Bradford-on-Avon, Wiltshire, are helpful in this connection. At 09 G.M.T. (10 B.S.T.) I noted the wind direction as light, westerly, and the stratocumulus-cloud direction as being the opposite – easterly. At Thruxton about 60 kilometres to the south-east both wind and cloud were from the east. This unusual situation appears to be the key to understanding the conditions for vortex-formation that day, for it is now clear that during the course of the morning the light easterly wind fell even lighter, before becoming calm, and eventually light and variable, before rising again from the west.

Vortical effects were apparent in the twin ellipses. The southerly ellipse, or for an aircraft approaching from the west the starboard ellipse, had an anticlockwise centre and its companion seemingly the opposite. *These directions correspond with the known senses of rotation of pairs of aircraft-wake vortices* (Figure 1), and would lead one to think that the ground patterns represent a twin-pair rather than that they were formed at different times. Moreover, the smaller size of the northerly ellipse accords with what one would expect of the shorter trajectory for a vortex coming from the port wing of an aeroplane which had banked to the left (in changing from a southerly bearing towards an easterly one). The non-circularity (ellipticity) of the crop traces would again have been the result of the aircraft's inclination to the ground at the time of vortex detachment. The similarity of shape of the ovals, and their juxtaposition, further confirms their simultaneity of origin.

Fig.6: Close-up of perimeter showing broken stalks of the smashed crop angled inwards away from the undamaged barley.

The single clockwise (area 3) circle would have come from the left-hand wing vortex. As the right-hand one is missing, one may suppose it dissipated before ground level was reached.

Flight and landing information at Thruxton for the whole of June were obtained from air traffic control with the help of Mr Taylor. Only at weekends did a plane of any size land at the airport; this was an 8-seater Norman Garrett Islander used in the training of parachutists, and which usually made about a dozen sorties on Saturday and another dozen on Sunday. Apart from Wednesday 10 June the only June day with winds from *any* easterly direction was Sunday 14 June, and this was a day when the Islander was operating.

On the weekend of 13/14 June an 8-seater Islander had made repeated flights in connection with the parachutists. The six landings made in the first session on 14th June were at 10.38, 11.26, 11.43, 12.02, 12.55 and 13.20 B.S.T. (G.M.T. + 1). The six later flights, when the wind had veered to westerly, spanned the period 14.40 to 18.35. The Islander's wing-span was 49ft 6in or 15.2 metres. This is rather less, as one would expect, than the centre-to-centre distance of the twin ellipses which due to axial drift and divergence of the trailing vortices amounted to about 21m. At the time of vortex detachment aircraft speed would have been about 100 knots (110 m.p.h., 50 m/s) at a height of some 200 feet (60m) above ground level, so the descent time for those vortices directed at the ground must have been over 1.2 seconds and probably less than 2 seconds. Such rapidity of descent allows little time for rotation of the vortex as it collapses into the crop. This factor accounts for the comparative lack of rotational and spiral effects in the crop in marked contrast with what has been observed elsewhere in crops damaged by natural atmospheric vortices. This conclusion, together with the evidence of the snapped and broken stems in the present instance, indicates that the speed of descent of these other vortices must be much smaller than 100 knots (50 m/s).

Finally, we point out that the evidence shows that the descent of the vortex pair was the result of a nearly straight landing approach in which both detached trailing vortices went groundwards, whereas each isolated crop-mark was the result of a single vortex plunging from the port wing-tip as the aircraft banked to the left as it approached the strip from the north. In this attitude the starboard wing-tip is raised upwards so that instead the anticlockwise vortex is projected harmlessly skywards.

It seems probable that it was because of the near-calm conditions that the vortices were able to reach ground-level and cause the quasi-circular damage areas. In the presence of stronger winds Mr John Heighes has seen trails of crop damage left by vortices ejected from low-flying aircraft (South Dorset in the years around 1950 – private communication). At Heathrow Mr Heighes has carried out experiments below the flight path of aircraft coming in to land (Heighes 1972). "Subsequent to touch-down an audible whine above the observer was sometimes followed by a visible circular disturbance pattern upon the grass-covered surface. Loose paper and debris were raised in a spiral manner in a natural whirlwind or dust-devil. Peak gusts of 30-33 mile/h (about 35 knots) were registered on a portable omni-directional anemometer as the diameter of the circulation decreased, but this could have occasionally been exceeded since the observer was several times blown off his feet".

We take the opportunity of putting on record a report from a farmer at Longbridge Deverill, West Wiltshire, that some five years ago he was witness to two small areas of circular damage formed in his cereal crop from a moving helicopter. These would appear to be the result of twin trailing vortices ejected from the main rotor blades.

It may be argued that the crop-damage areas studied at Thruxton are larger than might be expected if one tries to judge solely on the basis of the size and power 'expected' of the trailing vortices from an Islander. But the difficulty is that in the absence of controlled experiments one does not know what the 'typical' area of crop-damage might be from these or any other trailing vortices. The weather conditions on 14 June 1987 were certainly unusual, so it is thought they probably contributed to an abnormal increase in the lifetime of the vortices trailing behind the aircraft and produced long-lived vortices with a higher-than-normal total energy content. We must emphasize that the character of the damage in the trailing-vortex circles is entirely different from, and can never be confused with, the damage occasioned by the atmospheric vortices that produce the crop-circle patterns which have been the subject of several earlier papers.

CONCLUSIONS

We have shown that the crop damage reported in this paper can be explained as arising from the rapid descent of aircraft trailing vortices. Moreover, it proved possible to deduce the date of occurrence and the aircraft responsible.

It was evident that the vortices were literally 'fired' into the ground and they damaged the crop in a characteristic fashion. At least one vortex passed through a tree. The imprints displayed sufficient evidence of rotation to suggest that the port wing-tip issues a clockwise-spinning vortex and the starboard tip an anticlockwise vortex; this conforms with observational and experimental evidence elsewhere. The wind was light easterly on the morning of vortex formation, falling to calm later in the morning and then picking up again as a light westerly breeze. It is plain that useful information regarding the vortices can be obtained by studying vortex ground traces, so it should be possible in the future to devise controlled experiments to test vortex production and their intensities under practical operating conditions.

Acknowledgements. Helpful conversations with private pilots Mr Fred Taylor and Mr John E. Leech are acknowledged. Mr. W. S. Pike kindly told me of the CAA document and Mr Colin Andrews helpfully provided the photograph for Figure 2. Mr John Heighes contributed useful comments having witnessed travelling vortices at Heathrow and elsewhere.

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WEATHER AND BUTTERFLIES IN AVON COUNTY, 1988

By A. H. WEEKS
Yatton, near Bristol, Avon County.

Since this series began with a review of 1981 (Vol. 7 No. 67), we have experienced extremely varied summer weather. The relative merits of each year is a subject I hope to discuss next year, but let me comment now that 1989 will have to be extremely bad if it is to oust 1988 as the worst of the eighties. However, as we shall see, there were a couple of compensations.

Let me, then, commence with the usual summary of weather by month and by season (Table 1). The winter of 1987/88 was mild and damp, conditions which are less favourable for butterflies, whichever stage of their life cycles they may be in, than cooler and drier weather. Most notably, there was not one day of lying snow in Yatton in the whole winter. A cool and relatively dry December (1987) gave no clue as to the upturn that was to follow. January was exceptionally warm and provided a single day with a trace of snow (falling with rain), a single night with air frost and only five ground frosts. Despite a mean maximum a little higher than January's, February moved a shade nearer to being a winter month with five days when snow was seen to fall (all of a showery nature with winds from a westerly or north-westerly direction) – even so, the incidence of frost was still low – four air frosts, including the coldest of the season, and fifteen ground frosts. Only on 10th was there a real threat of winter, when we could see snow lying on the Mendip Hills in late afternoon. However, the percentage of sunshine was amazingly high and there were only three sunless days. Monday 15th was one of those priceless winter days. Brilliant sunshine, a very light southerly breeze, a screen maximum of 15.1° and a black-bulb in vacuo reading of 29.5° combined to rouse all four common hibernating species of butterflies in this area, and for the second year in succession, I received a report of a Painted Lady seen on that day near Chard, in south Somerset. Also on this day, I counted 23 different plants in flower in my garden (all heathers counting as one and helebores similarly), perhaps the most precocious being a cowslip.

Spring was, overall, pleasant enough, but it was short on sunshine. The night of 1st – 2nd March gave us the sharpest ground frost of the year, yet on 3rd, which was not distinguished for either a high screen temperature or long sunshine, came another report of a Painted Lady, seen in Bristol.

On 9th, another rather mediocre day, a Red Admiral was seen sunning itself in a Bristol city-centre nature reserve in company with several Small Tortoiseshells and Peacocks. The 14th saw the first emergence of a Small White here. Otherwise, a high number of rain days (21) put a damper on this month. April was rather more agreeable, with temperatures, rain and sunshine nearer to normal. April is perhaps the key month, when those species which have overwintered as adults need warmth for their mating flights, those in the pupal stage (notably Orange Tip, Speckled Wood, Green-veined White, Holly Blue, Green Hairstreak) need warmth to make the final change and those as larvae need warmth for feeding up. In the first category, Small Tortoiseshell, Peacock, Comma and Brimstone were

active on 3rd, on which day the first Swallows were seen here and the mining bees began to throw up their "volcanoes" on the lawns. In the second category, the first Orange Tip was seen on 22nd and Speckled Wood on 23rd but it was not until 5th May that I saw a Holly Blue – a welcome sight, as it was the first to come into my garden for nearly three years (the last had been on 23rd July 1985) – thereafter there were several more sightings until early August. Meanwhile, the Swifts had arrived and our House Martins had taken up residence, both on 3rd May. There was a long dry spell from 4th to 22nd, during which several Painted Ladies visited gardens locally. The year, at that point, seemed to be going along text-book lines and a good summer would certainly make 1988 one to remember. It was not to be.

Statistically, June does not now look too bad, except for the low sunshine. The start was not encouraging, especially for one going on holiday. A few patchy days were followed by a period of dull weather with a cool north-easterly. Then, towards mid-month, the miracle happened and from then to month end, there was some brilliant weather, with 13 days with maxima over 70°F. Holidaying on the Isle of Wight, I was unable to watch the emergence of the summer browns in Avon during this fine spell. The highlights for me while away were seeing the Glanville Fritillary flying in its natural habitat and the sight of numbers of Painted Ladies, rather pale and worn had obviously newly arrived from over the Channel: these raised hopes for further sightings in Avon later on – hopes which were, for once, not dashed. I was also able to make some interesting comparisons which led me to believe that the Island was not ahead of Avon in its season.

As can be inferred from the Table, July was a dreadful summer month. 26 rain days restricted activity by insects and humans alike. The extreme maximum temperature was a mere 21.7° on 20th – in fact, this was one of only two days with

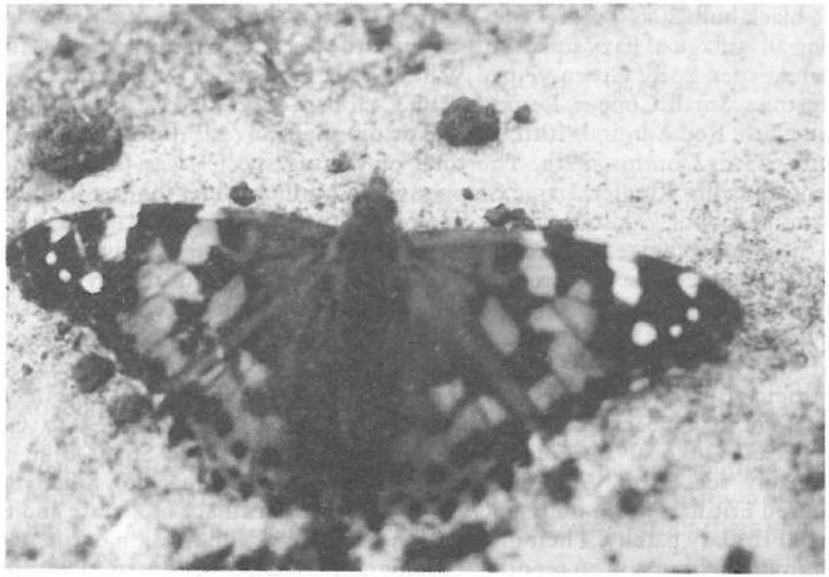

Fig.1: A Painted Lady in August 1988.

over 70°F. It was not until the last week that butterflies, other than the ubiquitous whites, meadow browns and gatekeepers, appeared: then, Painted Ladies, Red Admirals and Commas came regularly to my previously little-visited buddleias. Slowly, as August proceeded, Peacocks increased in numbers to a peak of fifteen in the garden at any one time on 16th. August turned out to be only slightly better weather-wise than the preceding months, boasting the highest mean temperature of the three and giving us the only two days of the summer with maxima over 80°F. But there was still a shortage of sun and 19 more rain days, bringing the summer total to 55. Evidence that summer was now slipping away was the disappearance by mid-month of the Swifts. The season had been marked by low populations of Meadow Browns, Gatekeepers, Ringlets and Marbled Whites and, especially the Skippers, all probably the outcome of poor conditions for breeding in 1987 and the mild, wet winter, as much as present conditions.

The first week of autumn started wet but otherwise pleasant, and 7th September was the fourth warmest day of the year with 26.0°. There was then a good showing of butterflies in the garden but the numbers of individuals appearing each day declined quickly from mid-month. The Painted Ladies left, presumably responding to an urge to go south, and the Peacocks decided that hibernation was now their best option. The only regular visitors were Small Tortoiseshells and cabbage whites. On 22nd, I had an astonishing glimpse of a Red Admiral flying in quite a heavy shower – the only butterfly I saw on the wing that day.

The first slight ground frosts occurred on 30th September and 1st October, and a few days later came the rains. The butterfly season was effectively over and even a succession of seemingly suitable days in early November failed to entice into activity anything other than wasps. Yet, strangely, as late as 21st November (max 5.2°, black bulb 20.5°) came a report from Weston-super-Mare of a Red Admiral taking advantage of hazy sun. As usual, I give the last dates for my garden:– August – Gatekeeper, 23rd; Green-veined White, 26th; September – Painted Lady, 5th; Brimstone, Small Copper, Peacock, 7th; October – Speckled Wood, 2nd; Small White, 5th; Red Admiral, 10th; Small Tortoiseshell, Silver Y (moth), 18th; Large White, 23rd; Comma, 29th. The total of visiting species was fifteen, notable absentees being Ringlet, Large Skipper and Common Blue, the last despite the proximity (about ½ kilometre) of a colony which was abundant in August.

Through no choice of my own, I was much restricted in my activities in 1988. Some sites which I have visited regularly in past years, I was unable to reach at all; others I saw on relatively few occasions. For information on what the situations were at those sites, I am very much indebted to the staff of the Bristol Regional Environmental Records Centre at the City Museum, for observations made during their field visits, and to others of their contributors for more general comments on the season. It appears that most of the earlier species, e.g. Orange Tip, Green Hairstreak, Duke of Burgundy Fritillary, Brown Argus and Small Blue were reasonably successful. Among summer species, the numbers of Small Pearl-bordered Fritillary were quite good, Silver Washed Fritillary moderate and Dark Green Fritillary patchy. Their observations confirm my impression of the state of the browns. There was no report of the migrant Clouded Yellow from within the county.

Butterflies were not, of course, the only insects to be severely affected by the poor summer, e.g. ladybirds were extremely scarce, and it seemed to me that dragonflies and damselflies were not as numerous as usual, especially in the case of the Ruddy Darter (Sympetrum sanguineum). Mining and leaf-cutting bees were active before the worst of the weather arrived, but other bees seemed to be fewer. And flies? – with a field of grazing cattle only yards away from my Stevenson screen, there is always a problem keeping it clean of fly-spots. What that problem would be like without our House Martins, I hesitate to think. How efficient they are at sweeping the air clear is amply demonstrated every year, for when the birds depart (5th October in 1988), my task increases by many times – and this was true even in 1988!

This picture of 1988 is a dismal one, so what were the two compensations mentioned in the opening paragraph? The first was the return of the Holly Blue. The second was the presence of more Painted Ladies over a longer period than for several years – since 1985 or perhaps 1984. These butterflies gave me the greatest pleasure of the season. Now, only a little past mid-November, the first Redwings and Fieldfares are descending on to the hedgerows and I can look forward to other, if rather lesser, pleasures. For me, almost the only redeeming feature of a cold winter is the variety of birds which appear, and – I fear – need support.

	Monthly Differences			*Seasonal Differences*	
	Max. Temp.	*% Rainfall*	*Approx. % Sun*	*Max. Temp.*	*% Rainfall*
December 87	-0.4	41	55		
January 88	+2.9	180	90		
February	+2.3	102	190	Winter +1.6	108
March	+0.6	173	85		
April	+0.1	86	90		
May	+1.2	84	100	Spring +0.8	112
June	+0.5	81	80		
July	-3.5	280	85		
August	-1.4	134	85	Summer -1.5	140
September	-0.9	96	105		
October	+0.3	87	98	Autumn -0.1	75

WORLD WEATHER DISASTERS: JUNE 1988

1–3: Typhoon "Susan" hit the Philippines and Taiwan, brief details below:–

Philippines: hit on the 1st, then again late on the 2nd and 3rd, winds gusted to 120km/h accompanied by heavy rains which caused floods and landslides on Luzon Island, 178 homes destroyed in Cavite province just south of Manilla by floods, a small tornado on the 1st, destroyed 111 houses in town of Cainta, injuring one person. Around 56,000 people evacuated from their homes, at least five deaths reported.

Taiwan: hit late on the 1st and early on the 2nd by high winds and up to 250mm of rain on southern areas of island, the rains touched off floods and

landslides, rail and road communications disrupted, no casualties reported. *Lloyds List.*

1–5: Torrential rains and floods in central Cuba left at least four people dead and thousands homeless, parts of railways and roads washed away and at least 3000 hectares of recently planted sugar cane lost, floods described as worst in 30 years. *International Herald Tribune.*

1–8: Floods in Assam state, India, have left 22 dead, flooded 1800 villages and destroyed crops worth £40 million. *Daily Telegraph., Birmingham Evening Mail.*

1–30: Storms and floods in Bangladesh.

1st: Floods in eastern districts of sylhet and Sunamgarij left at least 20 dead and 150,000 homeless.

13th: Storm hit west of country, destroying 2000 mud huts in the Kushtia district, about 100km west of Dhaka, leaving five dead, 200 injured and 5000 homeless, storm hit in evening.

21st to 28th: Flash floods throughout country left 27 dead and caused extensive damage to crops, roads and communications. *L.L., D.T.*

1–30: Serious drought in areas of U.S.A. and southern Canada.

10th – 13th: Brush fires in Arizona, U.S.A. and over the border into Mexico, one fire burned 6000 acres on border of two countries, another fire, in eastern Arizona, started by lightning on the 10th, burned through 250 acres.

19th: Drought in Canadian provinces of Alberta, Saskatchewan and Manitoba described as worst since the 1930's; lakes up to 32km long have dried up and farmland is cracked and parched, dust storms developing in some areas, meanwhile in the U.S.A. the drought has scorched a vast expanse of farmland from the Mid west to the Pacific coast a drought emergency declared in 18 states.

21st: Some rain fell on the northern plains of U.S.A.

23rd: More than 40% of U.S. declared a disaster area because of drought, which extended from New Mexico to New Hampshire, 1231 counties in 30 states declared disaster areas, temperatures up to 38°C recorded in many areas.

24th: More than 400 forest fires reported in the prairie provinces and northern Ontario, Canada, between the 24th and 27th brush and forest fires burned in U.S. states of Montana, South Dakota, Nevada, Arizona and California, the fires in Montana and South Dakota burned through more than 60,000 acres, fires started by lightning.

28th: Reported that rivers in many areas have dropped to their lowest levels for decades, the combined flow of the three largest U.S. rivers, the Mississipi, the St. Lawrence and the Columbia fell in May to the lowest point in 37 years.

29th: Up to 50mm of rain fell in many areas of U.S. Mid West. *L.L., D.T., I.H.T., B.E.M.*

2: Storms and floods in south-west Kashmir left at least 10 dead and 14 injured and destroyed homes. *D.T.*

2–3: Wind, hail and tornadoes in areas of Texas and Oklahoma caused damage of $130 million to insured properties, damage in Texas put at $125 million, heaviest damage reported in and around Abilene, San Antonio and surrounding

also affected. *L.L.*

7: Thunderstorm in Moskva, U.S.S.R. in evening broke heatwave in which temperature had reached 35°C, a record for June. *I.H.T.*

8: M. bulk carrier *Pacific Breeze* collided with MV *Eastern Orchid No.2* in dense fog about 16km north east of Ulsan, South Korea, *Eastern Orchid No.2* sank, leaving one dead and one other missing. *L.L.*

9: Winds, hail and tornadoes in North Carolina, U.S.A., caused insured property losses of $20 million. *L.L.*

10–12: Heavy storms and floods in provinces of Sichuan, Jiangxi and Zhejiang, China. Heavy rain from the 10th to the 11th in Shizhu county, Sichuan province, left 11 dead and 32 others injured, nearly 12500 acres of crops destroyed along with 150 homes and two electric power stations. Rains and floods which began on the 11th in Jiangxi and Zhejiang provinces flooded more than 700,000 acres of farmland and left 50,000 people homeless, at least 70 deaths reported, with another 74 injured. The floods in Jiangxi province destroyed or damaged more than 7000 homes, 20 hydro electric stations and about 80km of roads. *L.L.*

10–13: Torrential rains in El Salvador, a landslide, caused by the rain, on the 13th buried part of village of Agua Escondida, on slopes of the Conchagua mountain, La Union province, in east of the country, leaving at least 22 dead, others believed to be missing. *L.L.*

11–12: Mud slides caused by heavy rains killed at least three motorists in southern Colombia, several people reported to be missing. *D.T.*

12: Heavy rains and flash floods in Shanty towns in Ankara, Turkey, flooded 550 homes and shops and left 13 dead. *D.T.*

13: Mudslide at tin mine near Ipoh, Malaysia, left one dead, three missing. The mudslide buried a two acre area in 15 metres of mud at the New Lahad Tin Mine. *L.L.*

15: Five tornadoes struck in or near the city of Denver, Colorado, U.S.A., roofs torn off buildings, vehicles and storage sheds overturned, seven people injured, three tornadoes in east of city. *I.H.T.*

16: Storm hit the Saratov region of the U.S.S.R. leaving one dead and several injured; the storm tore roofs off houses, barns, schools and hospitals and toppled telegraph poles, the Saratov region lies on the river Volga. *L.L.*

17(reported): Heavy rain and hail in North Osetia, Caucasus region of U.S.S.R., destroyed roads and bridges and seriously damaged crops and buildings, but caused no casualties. *L.L.*

21: A landslide, caused by torrential rains, hit village in Jiangxi province, south China, demolishing or burying 59 houses, leaving 21 dead and 34 seriously injured. *L.L., B.E.M.*

23: Two vessels sank in stormy seas at east Nusa Tenggara Timur island, Indonesia, no casualties reported. *L.L.*

23–25: Typhoon "Thad" hit the northern Philippines and Shikoku island, Japan, details below:–

Philippines: hit on the 23rd with winds of 113km/h and heavy rains to northern provinces of Luzon island.

Japan: hit Shikoku island on the 24th and 25th with heavy rains, floods and

156 landslides which left four people dead and 16 injured, 900 homes also flooded. *L.L.*

23–30: Heavy rains caused a series of landslides in northern Turkey, one, on the 23rd, engulfed restaurants, houses, vehicles and a school at Catak at about 0800 hours leaving 63 dead, one missing and 18 injured, most of dead in a restaurant where people from vehicles, held up by a smaller landslide earlier, were sheltering. Between the 23rd and the 30th more than 200 other homes in the four provinces of Giresun Gumusane, Rize and Trabazon damaged by landslides brought on by heavy rains. *L.L.*

24–26: Torrential rains, hailstorms and floods in Sichuan province, China, left 65 people dead, with another 1420 injured, some of the worst hail storms to hit Sichuan in more than a century struck Yibin county. Over 305mm of rain fell, causing floods and landslides which affected 1100 villages; 140,000 homes collapsed and 78,800 acres of crops flooded or damaged, also over 100 small hydro-electric power stations destroyed. Road links cut by floods and landslides. Meanwhile, storms in southern Guangdong, Fujian and Zhejiang provinces are reported to have left at least 209 dead. *L.L.*

26: Heavy rains and floods in eastern Yugoslavia, at least 800 homes flooded, six bridges destroyed, cut roads and power and telephone communications. Two people died in floods, with a further three reported missing, thousands of acres of farmland flooded and livestock drowned in the Leskovac region, the town of Vlasotince worst affected, worst of floods along the Vlasina river. *L.L.*

26(reported): Storms sank at least two dhows, one in the Gulf of Oman, with a cargo of chick peas, the other sank in the Gulf of Aden, with a cargo of 959 goats, all crew rescued from both dhows. *L.L.*

ALBERT J. THOMAS

TORRO TORNADO DIVISION REPORT: January to May 1988

The first few months of 1988, as in the previous three years, were almost devoid of whirlwind activity in Britain. No whirlwinds were reported in Britain in *January* or *February*, but a tornado and two funnel clouds occurred in the Netherlands on 3rd January. *March* was wet and unsettled, and on 24th eddy whirlwinds occurred on Loch Lomond and a tornado near Skegness. No whirlwinds were reported in *April*. For *May* we know of two funnel clouds and a tornado.

NLTN1988January3. *Schoonebeek, Netherlands*

This tornado struck the south-east part of Schoonebeek about 1335 GMT. It damaged 15 houses, removing television aerials and tiles, as well as branches from trees. The mayor of Schoonebeek spoke of a "curtain of water" which passed with "a terrific roar" *(een geweldig geloei)*. The known path length was about one kilometre, from W.S.W. to E.N.E. Force: T1, possibly T2 (*Weerspiegel, 15*, 173-174, March 1988).

A strong westerly flow, with minor troughs, covered much of Europe, associated with a complex low over Scandinavia (966mbar at 1200). At 500mbar there was a low near northern Scotland.

NLFC1988January3. *Wolfheze, Netherlands*

Two funnel clouds were seen by Stephen Jak about 1345 GMT, hanging from a roll cloud. The funnels were small and lasted about two minutes. The passage of the roll cloud was accompanied by severe squalls *(Ibid., 172)*.

TN1988March24. *Ingoldmells, Lincolnshire (TF 5668)*

The *Lincolnshire Standard* of 25th March (sent by Mr. I. Trowsdale) told how a "freak wind" ripped through caravan sites at Ingoldmells, tearing over 30 caravans apart. On the Eastgate site about 20 caravans were damaged, and one was dumped on top of another. Mr. Colin West described the tornado as "just like a mist. It had sucked water out of the dyke". On the Mayville site Mrs. Jane Medcalfe said 11 caravans had "completely gone" and five others were damaged. Force: T3. Another tornado caused severe damage to caravans at Ingoldmells on 14th January 1984.

A deep low lay off N.W. Scotland, 978mbar, at 1200. The 500mbar chart was broadly similar. The tornado was probably on the cold front, which passed through Ingoldmells about 0900 (the time of the tornado according to a note in *COL*, March 1988, p.15).

EW1988March24. *Ben Lomond, Loch Lomond, Central (NN 3401)*

Four eddy whirlwinds were seen from Firkin, on the western shore of Loch Lomond. The whirlwinds, about 15 feet (5m) high, appeared at the same time and moved up the loch. They were near the eastern shore, under the slopes of Ben Lomond. The day was very windy. One of the witnesses, Mr. Campbell, said it was the first sighting he had had, although he had lived by the loch for 20 years (information from Mrs. Marion Colyer).

FC1988May8. *Hillingdon, Greater London (TQ 0782)*

A funnel cloud was seen from Heathrow, looking north towards Hillingdon, from 1730 to 1738 GMT. The observer, John Heighes, took several photographs of the funnel, which could be seen to be rotating cyclonically. Mr. A.J.E. Barty of Hayes also observed the funnel, and estimated its position as about one mile (2km) to the N.W., which would put it over Hillingdon. It did not reach the ground, and disappeared after a couple of minutes. There was a thunderstorm in the area at the time, but very little rain fell.

Southern England was dominated by a shallow low which had moved north from Spain, bringing severe thunderstorms to parts of S.E. England. At 500mbar there was a ridge from Italy to Denmark and a broad trough to the west of Ireland, with a southerly flow over Britain.

FC1988May19. *Cardiff Airport, South Glamorgan (ST 0667)*

A funnel cloud was seen from Cardiff Airport at 1258 GMT. It reached to within 100 feet (30m) of the ground. There had been thunder at 0900, then continuous rain till 1200, with cumulonimbus in the afternoon. The surface wind

had been light N.E. from 0900, then light and variable, becoming S.W. 5-6kt in the afternoon. The temperature at 1258 was 9°C, dew point 6°C (information supplied by Mr. Simon Barber).

Britain lay in a slack north-easterly airstream between a high well to the west of Ireland and a shallow low over France. At 500mbar there was a low over Norway with a small secondary over Scotland.

TN1988May29. *Stockton-on-Tees, Cleveland (NZ 4119)*

Mr. R.A. Powell was watching a superb lightning display at Thornaby-on-Tees (NZ 4516) when at 1823 GMT a tornado appeared. "It certainly reached the ground, and was visible for about 90 seconds before dissipating . . . It appeared to be thin and was intensely black. It was a magnificent sight. The thunderstorm tracked northwards and continued to be very active, with numerous ground strikes". Mr. Powell appealed for further witnesses in the local press and received two accounts. Mr. D. Tunney, of Fairfield, Stockton-on-Tees, wrote: "We watched the tornado for about five minutes and then the 'spout' lifted as the clouds moved over Fairfield/Hardwick" (NZ 4119/4121). Mr. D. Bannister, at Carlton (NZ 3921), saw "a great massive black cloud come over from the south with what looked just like a tornado . . . It headed north towards Sedgefield" (NZ 3528).

A low was centred over Northern Ireland 990mbar, at 1200. The 500mbar situation was similar.

Additions to previous reports

TN1982August30. *Bourn, Cambridgeshire (TL 3256)*

Ms. Doris Bridge was attending a market at Bourn when it was struck by a tornado. "In the distance there was a pitch-black area of sky moving slowly across the landscape . . . In the centre of the blackness was a light area which I would describe as teardrop-shaped with a slight tail". When the tornado struck the market sand was thrown "all over the place" and stalls were blown down, injuring a child. The tornado was accompanied by heavy rain. The date was during the August Bank Holiday, probably Monday 30th August. On this date all areas were covered by a cool, showery, northerly airstream in the rear of a low centred between the Faeroes and Norway (995mbar) at 1200.

FCc1983Summer. *Penmorfa, Gwynedd (SH 5440)*

Mr. Robert Sacré saw a funnel cloud suspended roughly over Penmorfa. It reached about a fifth of the way to the ground, and after three or four minutes shrank upwards into the cloud base.

WS1984(before). *Maryport, Cumbria (NY 0336)*

This waterspout, which appeared during the afternoon, resembled "a column of smoke". It was moving east towards the coast (Mrs. H. Featherstone).

FC1985June24/II. *Rattlesden, Suffolk (TL 9758)*

Mr. Alan J. Davidson has sent TORRO two photographs of this funnel cloud, which "was whirling fairly rapidly but only seemed to reach about a third of the way down to the ground".

M. W. ROWE, G. T. MEADEN

TORRO THUNDERSTORM REPORT: March-April 1988

By ADRIAN C. JAMES
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Although March was generally a wet month, the frequency of thunder was only a little above the average over the country as a whole. The most thundery region was Norfolk, where up to four thunder-days were recorded locally as showery westerly airstreams were slightly warmed by their passage over land. Much of Britain, however, had no thunder during the month.

MARCH: Thunder-days in March 1988 were as follows: (Averages refer to the period 1951-1980).

March 1988	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	31	Total	Ave.
England	X					X									X	X					X		X	X	X	X				X	X	11	9.2
Wales																								X								1	4.2
Scotland			X			X																			X	X						4	4.7
Ireland																						X	X	X								3	5.0
Total	X		X			X									X	X					X	X	X	X	X	X				X	X	13	12.0
Netherlands	X	X		X	X	X		X															X	X	X	X	X			X		12	5
Belgium	X					X	X																X		X	X	X			X		8	

Cold, unstable northerly winds covered Britain on 1st, when thunder was heard at Carlton-in-Cleveland around dawn, and also at Binbrook (Lincolnshire) in the course of a snowfall during the morning. A renewed burst of arctic air delivered a thundery snow-shower to Abbotsinch (Glasgow) on the afternoon of 3rd. There was thunder at Stornoway in the early hours of 6th, and an unconfirmed report of thunder in the London area during the afternoon of the same day. As a deep depression approached western Britain on 15th, scattered thunder over Avon and Gloucestershire in the morning was followed by a brief storm at Loughton (Essex) in the afternoon, while sheet lightning was seen from Mt. Russell (Co. Limerick) late in the evening. The low traversed Britain early on 16th, when thunder occurred in Guernsey overnight along with a few places in south-west England. In the unstable, westerly airstream of 21st, thunder was noted in afternoon showers over East Anglia and Lincolnshire and also at Eastwood Park (Gloucestershire). Very disturbed weather, with strong westerly winds, subsequently prevailed for several days and produced the month's most thundery spell. There was thunder in Co. Galway towards dawn on 22nd, and further storms in several parts of western Ireland the following night, with two houses being hit by lightning near Westport (Co. Mayo) early on 23rd. This day over England was blustery and showery with some thunder, mainly in East Anglia during the afternoon. A solitary stroke to earth struck and damaged a train near Chigwell (Essex) and the accompanying crack of thunder was audible over a wide area. Lightning brought down a ceiling and detonated two television sets at a house in Martham near Great Yarmouth, while heavy hail fell on the Magdalen Estate at Gorleston (Norfolk). Northern Ireland and south-west Scotland had some thunder on the morning of 24th. During the afternoon, as a trough moved quickly east in the turbulent westerly winds, storms

affected many places in a line from Lancashire across Derbyshire and South Yorkshire to Norfolk. Driving sleet showers with storm-force gusts assailed the Pennines and lightning tore the roof from a house in Donington (Lincolnshire). Thunder was also heard in Clwyd. Windy, showery weather continued on 25th, with thunder being reported from Laurieston (Dumfries & Galloway) in the afternoon and from some localities across central northern England in the evening. A further outbreak of thundery showers occurred in Derbyshire late on 26th, on which day there was also a little thunder in south-west England. With a pronounced upper trough situated over Britain on 30th, some thunder was heard from the West Midlands to Hampshire in the afternoon, and although showers were less extensive on 31st there was thunder at Godalming (Surrey) late in the day.

APRIL: Thunder-days in April 1988 were as follows:

April 1988	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				6	11.3
Wales																										X	X				2	4.8
Scotland	X																			X											2	5.9
Ireland																		X	X	X											3	5.5
Total	X		X															X	X	X						X	X				7	13.6
Netherlands								X								X	X	X	X									X		6	9
Belgium																X		X	X	X									X		5	

There were two short-lived thundery spells in April, and the days from 18-20th and 26-27th accounted for almost all the month's thunder. Many places in south-east England and East Anglia, together with central northern England, recorded one or two thunder-days during this time; elsewhere, the distribution of thunder was mostly very sparse.

A cold front became slow-moving over southern Scotland through the afternoon of 1st when lightning was reported to have damaged an aircraft near Glasgow. Thunder on 3rd was associated with the remnants of this frontal trough as convergence near the Pennines initiated scattered storms in Yorkshire, Lincolnshire and Nottinghamshire during the afternoon. No further thunder was observed anywhere in Britain until 18th, when isolated thundery showers over parts of north-east England in the afternoon were followed by more widespread storms over south-east England in the evening. The storms were caused by two cold frontal troughs, the first of which crossed eastern England in the early evening, while its successor generated an area of thundery activity over the Isle of Wight which subsequently moved north-east. This contained medium-level thunderstorms which produced the kind of vivid and prolonged lightning display more usually associated with the summer months, and some torrential downpours left roads and fields awash. Buildings at Canterbury and Southend were struck by lightning, while a house near Basildon (Essex) was holed through the roof by a lightning discharge which melted a copper water-pipe in the loft, and was then observed by the householder to streak out of the toilet and through an open lounge window. Severe thunderstorms also occurred during the afternoon and evening in Co. Mayo; widespread power failures resulted as thunder rumbled continuously for over an hour, and marble-sized hail fell at Swinford. Thunder cleared from the

coasts of Suffolk and Essex after midnight, but lightning was seen from Herstmonceux (East Sussex) in the early hours of 19th. Late in the afternoon there were again thunderstorms in western Ireland; a child escaped injury when she was struck by lightning at a farm in Culleens (Co. Sligo) where however a bullock was killed, and electricity supplies were interrupted. An intense storm with large hail affected the north of Co. Mayo, whilst in England thunder appeared over North Yorkshire and Cleveland in the evening. A showery trough was crossing northern Britain on 20th when thunder occurred around the north and east of Ireland, the highlands of Scotland and the North Yorkshire coast. A thunder-free period supervened until 26th, when thunder broke out late in the day over south-east Wales, north London and (Staffordshire). By 27th, the small frontal depression attending an advance of cold air into southern Britain had become a very complex feature, and as cold air began to undercut relatively warm air at the surface, cumulonimbus clouds developed with scattered thunderstorms ensuing in the late morning and afternoon. Most of these were located in central southern England, but a few occurred in south Devon, Gwent and the West Midlands, while over East Anglia there was heavy rain.

Acknowledgements. The Directors would like to thank all TORRO observers who have contributed to the compiling of these monthly reports. Sincere thanks are also offered to observers of the Thunderstorm Census Organisation, the Climatological Observers Link and also to the London Weather Centre for information published in the *Daily Weather Summary.*

LITERATURE REVIEWS AND LISTINGS

Book Reviews

WEATHER FORECASTING IN NEW ZEALAND. By A. A. Neale. New Zealand Meteorological Service, Wellington 1987, 73pp.

This well-written and presented little book is aimed at New Zealanders wanting to understand and interpret weather maps and satellite photographs appearing in newspapers and on television. In successive chapters it also describes how the weather is observed and how forecasts are made, including an attempt to explain simply numerical weather prediction. In addition to many clearly drawn maps and photographs there is a useful pull-out section of weather maps superimposed on infra-red satellite pictures.

For the British reader there is the fascination of comparing the weather patterns affecting a country in a similar latitude, but where everything is happening "upside down" – cold invasions move in from the south and "back to front" – with winds blowing clockwise around depressions. A visitor with any interest in the weather, or perhaps a weather-buff with family or friends in New Zealand would find this clear account of particular interest. It is good to know that the New Zealand Meteorological Service, like our own, sometimes gets caught out and is prepared to admit it, since the author notes that "it is unfortunate that it is very difficult or impossible to predict systems that come with some of the most violent weather phenomenon and which leave a lasting impression on the public".

A. H. PERRY

THE IMPACT OF CLIMATIC VARIABILITY ON U.K. INDUSTRY. Edited by M. L. Parry and N. J. Read. University of Birmingham, Birmingham 1988. 83pp.

In a period of weather extremes this text has a definite relevance. The first report of the Atmospheric Impacts Research (AIR) Group, it discusses the effects that climatic variability has on the output and efficiency of various sectors of the British industrial structure. It is basically a summary of a workshop on the subject at Birmingham University on December 3-4 1987.

The purpose of the workshop was to identify the impact of variability and recommend responses and it is in this light that the success or failure of the report should be seen – does it fulfil the two objectives?

The choice of industrial sectors is interesting. Impacts on the water, construction, energy supply, transport and insurance industries allow the reader to assess clearly the enormous losses under consideration which amount to thousands of millions of pounds. Although there is some mention of losses to primary industries in terms of supplying raw materials it is a pity that a whole section could not be dedicated to a member of this sector, perhaps coal. The energy supply chapter comes close to this but tends to view problems in terms of effects on power distribution rather than getting the power sources actually to the supplier. As it stands, however, the contents are constructive and thought-provoking.

The introduction clearly differentiates between climatic variability and climatic change. This is vital in making the publication more than just another 'scare story' about CO_2 or the depletion of the ozone layer. These topics are mentioned but, wisely, are not developed to any great extent and remedies to the topic are not given. The report is therefore practical and realistic.

The layout of the report is clearly aimed at conciseness and easy reading. There are no mathematical formulae and the diagrams and graphs can be assimilated quickly. The figures and tables add to the text and make their point clearly. This report is not aimed specifically at meteorologists but to anyone who has to plan against climatic variability within industry.

Each chapter is organised in the same way. Firstly there is an introduction which reveals the particular production and supply problems involved within the sector in question, further enhanced in the second section on Sensitivity to Climatic Variability. Inter-relationships with Other Sectors is the third section and does a lot to emphasise that the industrial framework of a modern industrial system cannot realistically be broken up and looked at in separate parts. If this report had not emphasised this inter-relatedness it's relevance would have been less. The final section is Management, Policy and Research Needs. This is the most important element of the report and is carried off well, ensuring the success of the report as a basis for making weather a more important consideration in industrial planning. Needs are listed and take the form of suggestions rather than dogmatic answers.

The report is an important piece of weather literature. It is straightforward and encourages ideas on the matter. Perhaps a textbook could stem from the AIR report which could go into far more detail than is possible in this publication. What is clear is that British Industry can learn a lot from planners abroad who have taken the weather more seriously than we have.

ANTONY CLAY

WEATHER: WE LIKE IT OR NOT – 70 YEARS OF WEATHER AT RYDE. By Kenneth J. Hosking. Isle of Wight Teachers Centre, 72pp. £3.60 inc. postage from the author.

Recent years have seen a significant increase in the number of books written by amateur meteorologists about the climate of their locality. This book is yet another – but with a difference – it is the Eighth edition in 12 years.

The author is well known to readers of the *Journal of Meteorology* by virtue of his frequent, and interesting, accounts of weather on the Isle of Wight. A number of these have been included in the book.

Weather records for the Isle of Wight have been maintained continuously for over a century, and at Ryde since 1918. Mr. Hosking's interest began in 1934. The data used over the 70 year review period is chiefly his own, other than the first 16 years. Because of its location off the south coast of England, the islands' climate is perhaps one of the more equable in the British Isles. Nevertheless, the author catalogues an impressive series of extremes which have occurred during the last 70 years, as well as extensive details of the day-to-day climate.

The first chapter gives an in-depth picture of rainfall on the Island. Individual extremes are given as well as many instances of groups of days, both wet and dry, including monthly and annual figures. Holiday visitors will be interested to note that the driest week of the year appears to be the week ending 29th June. As befits a book of this nature, the data are up-to-date, noting that October 1987 was the wettest calendar month in the review period with 9.31 inches (236mm). Despite the opinions of many meteorologists that the British climate is deteriorating, the author proves by way of a chart that at Ryde there has been no discernable change in the rainfall pattern since 1918.

The second chapter deals with sunshine records, again with copious tables. The area is one of the more favoured for sun in the British Isles, and it is a pity that one more table was not included to make a comparison with other locations. An interesting chart in this chapter shows an exceptionally sunny year in 1949 since when the annual total has shown a steady decline. The third chapter deals with temperatures, although the main chapter heading has been omitted. This again illustrates, with many charts and tables, the pattern on the island. The author then proceeds into chapters each dealing with a specific matter: Summer Holiday Weather; Contrasting Summers at Ryde; 1976 Summer at Ryde; Incidence of Snowfall; 1976 Heatwave, to name but a few. The second part of the book is a series of Annual Summaries covering the period 1964 to 1987.

Overall, I found the book to be an interesting volume. My only real criticism is that temperatures and rainfall data are in deg F and inches, although the author explains in a note on p5 why he opted for this decision. I understand this edition improves both the quality and content of previous editions, certainly the printing is very clear and a number of black and white photographs break up the text. Despite being well into his seventies, the author's proof reading has eliminated most obvious errors. Clearly, books of this nature have a limited, mainly local circulation, although they often deserve better. For those who are collectors of statistics or would like to add a detailed summary of weather in one of Britain's most favoured holiday spots, I would certainly recommend this well-presented volume.

GERALD ROLFE

LETTERS TO THE EDITOR

TEMPERATURE EXTREMES IN SOUTHERN EUROPE

The European summer of 1988 was predominantly warm, with the notable exception of the British Isles and other coastal parts of N.W. Europe. Some long-term extremes were broken that are worth putting on record:

1. On 3rd August, Algiers noted a 1200 hr temperature of 47°C (117°F), a clear 5°C higher than the previous record of 42°. Other nearby areas were also extremely hot at this time: Ajaccio 39°, Malaga 39°C.

2. On 9th September Madrid recorded 39°C at midday and Lisbon 36°C in a warm southerly flow. Several long-period records were broken especially in Portugal.

3. On 8th July Athens recorded 44°C (111°F). The 1988 heatwave was shorter than in the previous year in Greece but if anything even more intense because the highest 1200 hr temperature in 1987 was 41°C on 23rd July.

4. In total contrast rain and cool conditions arrived early in the eastern Mediterranean with a persistent cold trough in November. This same region produced record low temperatures in the Middle East. On November 13th Damascus (Syria) reported a record low minimum of –7°C, which was 5 degrees C below the previous record, and new records were established at stations in Israel and Saudi Arabia.

University College of Wales, Swansea. ALLEN H. PERRY

IDEAS FOR THE MAGAZINE

In enclosing this year's subscription, I wonder whether you might welcome one or two suggestions for the magazine, which I have taken and greatly enjoyed ever since its inception.

Naturally I can only speak from the point of view of my own tastes and preferences, but why not invite readers' accounts of personal involvement in notable past weather events, e.g. the east coast floods of 1953, the winter of 1963, the Great Smog of 1952, etc . . . As a pharmacist working in the 24-hour pharmacy in Piccadilly Circus at the time, I remember that one only too well! I am sure that, like myself, many keep diaries with descriptions and cuttings relating to exceptional thunderstorms, blizzards etc., going back possibly many years. Other people's notes might throw illuminating sidelights on one's own versions . . . On other occasions, there may have been local events of an extreme nature, carefully recorded, but never publicised, as some of your fascinating investigations into ball lightning well illustrate. Accounts taken from papers of strange or extreme conditions in historical times can make absorbing reading, and I would count among these the wonderfully detailed account you published in January 1979 of the day in July 1797 when due to mirage conditions, a great stretch of the French coast was visible from Hastings. More of these, please!

Perhaps, without interfering with the ethics of science, some readers might be encouraged to dabble in a little long-range forecasting of seasons ahead, giving reasons, of course (*vide* G. A. Southern, *J. Meteorology*, May/June 1985). Who knows, some great discovery might come of it! Stranger things have happened in the history of research!

I should like to see overseas writers submitting personal descriptions of day to day life in extreme conditions in addition to purely technical details. The words of the man who described the effect on his car when it was left parked in the sun in Nairobi are apt to stay in the mind far longer than a table of temperatures for the same place!

Finally, has anyone who has the facilities considered publishing a book made up of items from your magazine which might appeal to the general public? If *Weather* cooperated as well, might not such a book, if reasonably priced, attract plenty of sales and generate a lot of interest and better understanding of meteorology? One example could be the Hastings phenomenon mentioned above.

With very best wishes for yourself and the future of the magazine now in its fourteenth year.

69 Sandown Road, Thundersley, Benfleet, Essex. R. W. SELFE

WORLD WEATHER REVIEW: July 1988

United States. *Temperature:* mainly warm; +2degC from C. Arizona through N. California to New Jersey. Cold in much of S.; –2degC in W. Texas. *Rainfall:* wet in about half the area S. of a line from Arizona to S. Michigan; over 200% in isolated patches; more widely in S.E. New Mexico, S.W. Texas and on N.E. coast from Long Island to Maine. Under 50% from N. Florida to S. Carolina and round Cape Hatteras. Dry almost everywhere N. of the line; under 50% general; under 25% from California through S. Washington to S. Minnesota.

Canada and Arctic. *Temperature:* mostly warm; +2degC in interior and W. Alaska and near Great Lakes. Cold in Canadian Rockies, Newfoundland to S. Baffin Island and S.W. Greenland; E. Iceland (all –1degC); Franz Josef Land. *Rainfall:* wet in much of Canada; N. Iceland; locally in N. and E. Greenland. Over 200% in N. and locally in S. Canadian Rockies; locally in Maritime Provinces. Dry in most of Alaska; Canadian Arctic Islands, S. Alberta to L. Winnipeg; S. Iceland, Spitzbergen; much of Quebec; most of Greenland. Under 50% locally from S. Alberta to L. Winnipeg; fairly widely in the other areas, except perhaps Iceland.

South and Central America. *Temperature:* warm from C. and E. Mexico to Honduras; extreme N.W. Mexico; Bahamas; +1degC in parts of N.W. and N.E. Mexico; extreme S. Mexico to Honduras. Cold almost everywhere in S. America 15-40°S.; S.W. and most of N. Mexico; –2degC from C. Argentina to E. Bolivia; near Buenos Aires and Sao Paulo; interior N. Mexico. *Rainfall:* wet from much of Mexico to W. Honduras; locally in N. Argentina and E. Bolivia. Over 200% in interior N. Mexico; very locally in N. Argentina. Dry in parts of Mexico, especially on coasts; S. Guatemala, El Salvador; almost all of South America 15-40°S. Under 50% generally in last area; at least locally in the others, especially N.W. Mexico.

Europe. *Temperature:* mainly warm; +2degC from S. Italy to N. Romania and S. Czechoslovakia; Finland; most of European Russia; +5degC in C. Urals. Cold from N. Portugal to British Isles, Netherlands and West Germany; –1degC widespread; –2degC in N. France. *Rainfall:* wet from Portugal and W. Spain through N. France, British Isles, Low Countries and Germany (except S.E.) to Scandinavia, N. Poland and Baltic Republic; N. Urals, Ukraine, Caucasus. Over 200% in all of Portugal; W. and N. Spain, N. France, Eire, United Kingdom, Belgium, N. Poland, S. Sweden, Gulf of Bothnia, S. Ukraine, Caucasus. Dry elsewhere; under 50% in all Mediterranean areas, N. to S. Czechoslovakia and E. Romania. Provisional sunspot number 113.

Africa. *Temperature:* warm from Madeira and Canary Islands to Egypt; most of South Africa; +2degC widely from N.E. Morocco to N. Egypt. Rather cold in Orange Free State; locally in Cape Province and very locally in coastal N.W. Morocco. *Rainfall:* wet (over 200%) in and near Natal; otherwise dry in and near South Africa; under 50% from S. Cape Province to N. Transvaal. Rainless almost everywhere from Madeira and Canary Islands to Egypt.

Asiatic U.S.S.R. *Temperature:* mostly warm; +4degC near Sverdlovsk and E. of Lena basin. Cold from Taimyr Peninsula to Mongolian border (–2degC widely); N. Kamchatka, S. Sakhalin (–1degC). *Rainfall:* wet near Caspian Sea; S. Urals to L. Balkhash; Severnays Zemlya to L. Baikal and upper Yenisey basin; New Siberian Islands to lower Amur basin. Over 200% in W. Turkmenistan; around Karaganda; upper Yenisey basin to L. Baikal and W. Lena basin. Dry elsewhere; under 50% from N.W. Kazakhatan to Uzbekistan; Ob and lower Yenisey basins; much of Pacific coast.

Asia (excluding U.S.S.R.). *Temperature:* warm from most of Turkey to Israel and coastal Arabia; W. Pakistan, S.W. and N.E. India, Bangladesh, E. China, E. Burma to Malaya and Philippines; +2degC in S.E. China; locally in Philippines. Cold in interior Turkey, E. Pakistan to S.E. India; W. and C. China, Korea, Japan; –3degC in E. Japan. *Rainfall:* wet in S. and E. Turkey, Oman. S. and extreme N. India, Korea, C. Japan; most of Pakistan; much of N. China. Over 200% at least locally in all these areas. Dry in N.W. Turkey, Middle East, N.W. Pakistan, N. India, S. China, large area N. of Peking/Beijing, N. and S. Japan. Under 50% at least locally in all these areas, especially S. China. Middle East largely rainless. South-east Asia and Philippines mixed.

Australia. *Temperature:* warm everywhere; +1degC in N. and E. *Rainfall:* wet in E. quarter (over 200% widespread) and locally N. of Perth; elsewhere mostly under 50%.

M. W. ROWE

WEATHER SUMMARY: September 1988

Mean temperatures in September were not far from the early autumn normal over the whole of Great Britain, with a tendency towards a little below over England and Wales and a little above over Scotland and Northern Ireland. Temperatures were at their highest during a short-lived very warm spell at the end of the first week, particularly on 7th when maxima reached 27.3° at Carlton in Nottingham, 26.9° at Northolt, north London, 26.5° at Buckingham and 23.3° at Turnhouse airport, Edinburgh. The following night was also the warmest of the month with minima of 17.3° in central London, 17.2° at Plymouth (Devon), 17° on the Moray Firth and 16.5° at Rhoose airport, Cardiff. Lowest maxima were generally recorded at the end of the month with 10.3° at Okehampton (Devon) on 28th and with 7.5°C at Glenlivet (Grampian), 7.8° at Inverdruie (Highland) and 9.1° at High Bradfield (South Yorkshire), all on 29th. At Fylingdales (North Yorkshire) 11.0° was recorded on 13th and 10.4° on 14th. Almost without exception temperatures fell to their lowest values on the morning of 30th. Among the lowest recorded were –2.7° at Eskdalemuir, –1.1° at Rannoch School, Dall and Churchdown (Gloucester) –0.9° at Hurn airport, Bournemouth and –0.7° at Kettering (Northamptonshire) and Inverdruie. On the grass –7.3° was recorded at Glenlee (Dumfries and Galloway), –5.1° at Low Etherley (Durham) and –4.8°C at Straide (Co. Mayo), all on 30th. On 29th –6.1°C was reported from Laurieston (Dumfries and Galloway). Most parts of the U.K. had a dry month, particularly in southern counties of England where totals were locally below 40 percent of the normal. There were wide variations, though, with some southern and western areas of Scotland having quite a wet month. The highest daily total reported was 50.8mm at Nantmor (Gwynedd) on 1st while in Cumbria the 22nd was also a wet day with 50mm at Ulpha and 44mm at Boot. At Fort William 30.6mm fell on 2nd and 37.7mm on 3rd. Straide (Co. Mayo) recorded 32.5mm on 4th. Sunshine totals were also very variable. It was a sunny month over south and east Scotland and over many central and northern areas of England but much of north-west Scotland and south-east England, on the other hand, saw less than the normal sunshine.

September was quite a pleasant autumn month but began with rain and strong winds, particularly in the north as a deep depression tracked slowly north from Northern Ireland to the west of Scotland. Showery conditions predominated for a couple of days but on 5th pressure rose across the U.K. and on 6th and 7th, with an anticyclone over the Baltic, very warm southerly winds gave all parts a belated taste of summer. During the night of 7th/8th considerable medium-level instability, ahead of an advancing cold front produced some spectacular thunderstorms in the north and west but these died out on 8th as the cold front moved east across the country. With pressure now rising again south-eastern counties became dry on 9th and 10th but rain spread to all parts on 11th followed by showers, and the 12th and 13th were much cooler, showery days with some local thunder. With an anticyclone close to the south-west of Britain the period 14th to 20th was dry and cold with frost in many places at night but by 20th, as the high drifted away eastwards into the Low Countries frontal systems began to encroach towards western parts from the Atlantic. Rain spread from the west on 21st and 22nd, as a cold front moved slowly east across the U.K., and on 23rd there

was further wet and windy weather as a depression crossed southern Scotland. Further rain fell in most parts on 24th and over the highest parts of the Scottish mountains the first snow of the season fell. The 25th was another quite stormy day in the north, where there was fair amount of rain, and slow-moving frontal zones produced further rain in the south on 26th and 27th. On 28th and 29th it became colder and showery everywhere and over Scottish mountains some snow was reported. Finally, on 30th, after a widespread ground frost and local air frost, England and Wales had a dry, sunny day. Scotland and Northern Ireland had a lot of cloud but also with some sunny spells, especially in the south.

K.O.M.

TEMPERATURE AND RAINFALL: SEPTEMBER 1988

	Mean				*Grass*					
	Max	*Min*	*Max*	*Min*	*Min*	*Rain*	*%*	*Wettest*	*RD*	*Th*
AUSTRIA: Innsbruck	20.0	9.8	26.0(1)	6.6(8)		28.6		8.7(6)	12	0
BELGIUM: Uccle	17.6	11.1	24.3(9)	4.5(30)		79.4	113	15.4(13)	21	–
„ Rochefort	17.7	9.0	24.6(9)	4.2(22)		55.4	78	13.6(3)	18	–
„ Houwaart	18.4	8.8	25.9(9)	0.5(30)	–2.0(30)	66.2	100	14.6(16)	18	3
DENMARK: Fanø	16.9	11.4	21.1(9)	5.4(30)		131.2	168	47.5(13)	15	3
„ Frederikssund	17.6	10.4	23.8(1)	5.7(15)	1.9(15)	67.0	120	18.2(13)	16	1
GERMANY: Berlin	18.3	10.0	25.4(1)	6.4(30)	5.9(30)	26.2	54	5.8(13)	17	0
„ Hamburg	17.8	10.0	23.7(10)	4.5(30)	3.2(30)	54.8	81	9.8(23)	19	1
„ Frankfurt	19.1	10.9	27.4(1)	5.1(22)	1.6(3)	58.0	118	18.9(3)	14	2
„ Munchen	18.6	9.2	27.0(1)	5.4(9)	2.2(9)	63.2	87	11.8(16)	15	1
ITALY: Casalecchio	24.2	14.4	30.0(6)	10.0(v)	8.0(6)	37.1	72	31.0(15)	3	2
MALTA: Luqa	27.9	20.5	36.4(1)	17.0(19)	13.4(10)	77.7		46.8(20)	6	4
NETH'NDS: Ten Post	17.2	10.5	23.8(9)	4.6(30)	2.1(30)	107.7	153	18.7( )	21	2
„ Schettens	17.2	11.3	22.8(9)	7.1(30)	4.4(30)	72.9	97	9.2(13)	18	6
„ De Bilt	17.8	10.4	24.8(9)	3.0(30)	–0.3(30)	86.0	132	17.7(24)	17	2
„ Lemmer	16.9	10.7	22.8(9)	4.6(30)	2.8(30)	106.4	132	14.2(3)	17	4
SWEDEN: Valla	17.5	7.9	21.2(7)	2.2(15)		31.8		7.2(3)	16	1
SWITZ'LAND: Basel	20.6	10.6	27.7(1)	6.1(17)		74.3	94	28.0(30)	10	1
EIRE: Galway	15.5	10.6	20.1(6)	4.1(30)		120.8	109	23.6(5)	19	0
„ Straide	15.4	9.5	19.5(6)	0.4(30)	–4.8(30)	130.1	125	32.5(4)	24	0
SHET'AND: Whalsay	13.1	9.2	16.2(5)	5.0(11)	1.5(24)	86.8	110	12.8(25)	25	0
„ Fair Isle	12.7	9.9	15.7(7)	5.2(30)	1.4(23)	61.8	62	10.2(25)	25	2
SCOT'AND: Braemar	14.4	7.2	19.7(15)	0.3(30)	–1.4(30)	70.5	87	23.7(1)	–	2
„ Inverdruie	15.1	7.0	21.1(7)	–0.7(30)	–4.1(30)	62.9	82	9.9(28)	19	2
„ Rannoch	14.2	6.6	19.9(8)	–1.1(30)	–1.1(30)	106.8		25.1(1)	18	1
WALES: Pembroke	16.7	10.4	23.3(7)	3.8(30)	–0.7(30)	70.2	66	17.5(22)	12	0
„ Velindre	16.8	8.7	24.8(7)	0.4(30)	–4.7(30)	46.8	58	11.8(24)	12	1
„ Carmarthen	16.2	10.4	24.1(7)	3.9(30)	–1.3(30)	74.5	60	15.3(22)	16	4
„ Gower	16.7	10.5	23.9(7)	5.0(30)		77.7	65	19.5(24)	15	2
GUERNSEY: Airport	16.9	12.2	24.0(7)	8.3(v)		65.4	92	24.6(2)	10	1
ENGLAND:										
Denbury, *Devon*	18.1	10.1	22.4(9)	3.8(30)	2.8(30)	40.5	51	12.2(27)	9	1
Gurney Slade, *Somerset*	16.8	8.6	25.3(7)	0.8(30)	–0.8(30)	165.8	195	28.8(24)	13	0
Yatton, *Avon*	18.1	10.2	26.0(7)	1.0(30)	–0.9(30)	81.1	96	16.8(1)	11	3
Corsham, *Wiltshire*	17.6	9.9	25.0(7)	1.4(30)	–1.6(30)	62.5	88	14.9(24)	12	2
Mortimer, *Berkshire*	17.7	9.5	25.5(7)	2.0(30)	–2.1(30)	36.7	59	10.3(27)	11	1
Reading Univ., *Berks*	17.9	9.9	25.3(7)	2.0(30)	–2.0(30)	29.5	52	8.1(27)	10	1
Sandhurst, *Berkshire*	18.5	9.2	26.1(7)	0.0(30)	–0.1(30)	37.7	71	11.4(27)	10	1
Romsey, *Hampshire*	18.8	9.0	25.7(7)	–0.4(30)	–1.6(30)	38.6	75	15.7(27)	8	0

	Mean Max	Mean Min	Max	Min	Grass Min	Rain	%	Wettest	RD	Th
Horsham, *Sussex*	18.6	10.3	25.0(7)	2.0(30)	-1.5(30)	42.4	61	15.3(1)	10	0
Brighton, *Sussex*	18.2	11.1	24.8(7)	5.0(30)	4.5(30)	51.9	81	22.8(1)	12	1
Hastings, *Sussex*	18.1	11.6	23.5(7)	7.0(30)	2.9(30)	57.6	78	18.4(1)	-	2
Dover, *Kent*	18.3	10.5	24.2(7)	4.2(30)		53.6	90	14.2(2)	15	2
East Malling, *Kent*	18.5	10.3	24.8(7)	1.6(30)	-1.4(30)	40.5	67	12.5(1)	11	2
Epsom Downs, *Surrey*	17.4	9.7	23.6(7)	0.4(30)	-3.1(30)	49.6	77	13.6(27)	12	1
Reigate, *Surrey*	18.6	9.6	25.8(7)	1.6(30)		48.5	74	12.0(27)	13	1
Guildford, *Surrey*	18.3	10.8	25.6(7)	3.8(30)	0.5(30)	40.0	59	11.2(22)	11	0
Sidcup, *London*	19.0	10.7	26.3(7)	1.8(30)		38.0	61	7.1(28)	12	1
Hayes, *London*	18.3	10.2	26.1(7)	1.7(30)	0.2(30)	37.1	76	10.3(27)	14	1
Hampstead, *London*	17.7	10.7	25.1(7)	4.8(30)	-2.2(30)	38.4	59	9.3(27)	13	0
Royston, *Hertfordshire*	18.1	10.4	25.0(7)	4.1(30)	-1.4(30)	43.2	82	17.9(24)	10	0
Loughton, *Essex*	17.9	9.9	25.1(7)	2.0(30)	-1.3(30)	34.1	80	9.9(24)	11	2
Buxton, *Norfolk*	17.6	9.8	23.3(7)	1.8(30)	-0.3(30)	40.0	77	13.0(22)	8	1
Ely, *Cambridgeshire*	17.9	8.7	24.9(7)	1.2(30)	-2.0(30)	32.2	74	9.5(27)	9	0
Luton, *Bedfordshire*	18.0	9.4	25.9(7)	-0.4(30)	-4.0(30)	46.6	78	15.0(24)	10	0
Buckingham, *Buck'shire*	17.8	8.7	26.5(7)	0.6(30)	-4.7(30)	50.9	91	12.2(24)	10	0
Oxford University	17.9	10.4	25.4(7)	3.3(30)	-1.5(30)	39.6	65	16.7(24)	10	-
Churchdown, *Glo'shire*	18.5	10.1	26.1(7)	-1.1(30)	-4.4(30)	21.5	39	8.3(24)	11	0
Stourbridge, *W.Midla'ds*	16.7	9.7	24.4(7)	2.3(30)	-3.0(30)	39.1	63	10.4(24)	11	2
Birmingham Univ'sity	16.5	9.4	24.9(7)	1.9(30)		39.7		10.0(24)	13	1
Wolverhampton	16.0	9.5	25.0(7)	3.6(30)	-0.2(30)	44.2		9.4(12)	11	1
Kettering, *Northants*	17.8	9.5	26.2(7)	-0.7(30)	-3.5(30)	26.9		8.8(1)	11	1
Louth, *Lincolnshire*	17.1	9.6	24.0(7)	2.8(30)		41.7		15.1(1)	12	0
Keyworth, *Nott'shire*	17.3	9.8	25.1(7)	3.0(30)	-2.5(30)	23.3		6.9(27)	10	1
Nottingham *Nott'shire*	18.2	9.7	27.3(7)	2.3(30)	-0.1(30)	33.0	69	6.9(27)	10	1
Derby, *Derbyshire*	17.1	10.2	25.8(7)	4.0(30)	2.6(30)	44.2		20.9(27)	7	0
Middleton, *Derbyshire*	14.2	8.4	21.8(7)	3.3(30)		86.5	111	19.3(1)	12	0
Keele University, *Staffs*	15.5	9.0	24.7(7)	4.1(30)	-2.0(30)	41.3	55	7.9(12)	13	1
Liverpool, *Merseyside*	16.6	9.9	25.6(7)	4.6(30)		60.9	78	15.9(1)	14	1
Lathom, *Merseyside*	15.8	10.0	25.0(7)	3.2(30)		68.4		18.2(1)	13	-
High Bradfield, *S.Yorks*	12.9	8.2	18.8(7)	2.7(30)		77.4		18.4(23)	15	-
Cottingham, *Humb'side*	17.8	9.6	25.2(7)	2.1(30)	-2.0(30)	34.4	60	7.9(1)	10	0
Carlton-in-Cleveland	16.2	9.3	24.0(7)	1.5(30)	-1.4(30)	33.4		8.8(1)	11	2
Durham University	16.6	8.5	23.7(7)	1.6(30)	0.9(25)	44.3	87	11.5(1)	15	-
Sunderland, *Tyne/Wear*	16.5	10.3	24.3(7)	4.2(30)		40.8	60	12.0(10)	11	0
Carlisle, *Cumbria*	15.5	9.2	24.0(7)	-0.5(30)		82.6	88	12.0(23)	9	1
CANADA: Halifax	17.5	9.1	24.0(2)	4.8(30)		73.1	84	22.0(5)	11	0
U.S.: Bergenfield, *NJ*	24.2	12.2	28.3(10)	6.7(16)		75.7		35.3(4)	5	1
AUSTR'LIA: Leopold	17.6	7.7	23.5(23)	3.5(14)		66.8	127	20.6(28)	9	3

CUMBRIA RAINFALL:

Seathwraite, 255.0mm (79%); The Nook, Thirlmere, 255.2mm (100%); Coniston, 277.1mm (113%); Hawkshead, 204.7mm (111%); Grange, Merlewood 140.0mm (110%).

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FRONT COVER:
Sunshine after Storm. Weston-super-Mare, Avon County. March 1984.
Photograph by Geoffrey A. Smith (Bradford-on-Avon).

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