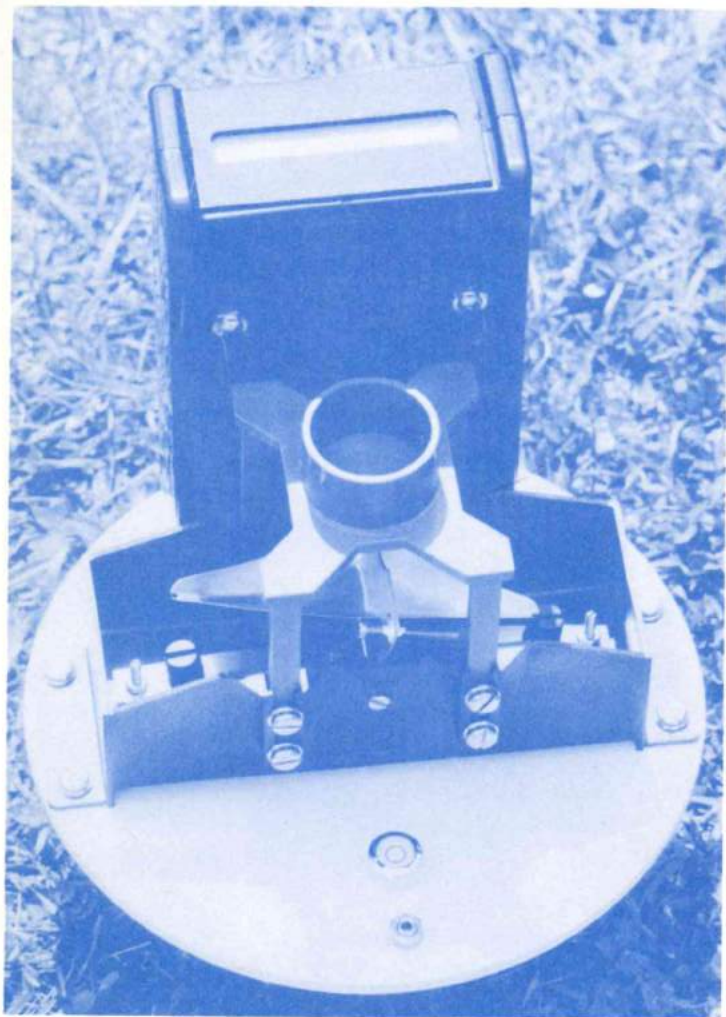


*The*  
*JOURNAL of METEOROLOGY*



*TIPPING-BUCKET RAINGUAGE FROM THIES-CLIMA*



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# JOURNAL OF METEOROLOGY

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## CHARACTERISING WINTERS: AN INDEX FOR USE IN APPLIED METEOROLOGY

By S. J. HARRISON and D. J. HARRISON

*Department of Environmental Science, University of Stirling.*

**Abstract.** A new index for intercomparing winter severities is proposed which makes use of the frequency of days with air frost and snow lying as convenient parameters.

## INTRODUCTION

The fluctuation of air and surface temperature around 0°C is typical of Scottish winters, which are variable in character and have considerable impact upon the Scottish people and its economy (eg Perry and Symons, 1980; Smith 1989). Frost damage to property, cancellation of sports events and the effects of fog, snow and ice on road, rail and air transport generate real, and to some extent measurable, weather-related costs. In order to relate such costs to the nature of weather events it is necessary to find an appropriate means of characterising the severity, or mildness, of winters. This assumes particular importance in the late 20th century when temperatures in western Europe appear to be ameliorating in response to atmospheric circulation changes over the North Atlantic (Houghton et al., 1990).

A full description of the weather during any winter could draw upon information on, for example, air and surface temperature, cloud amount, wind speed and direction, and precipitation, together with frequencies of days with snow (or sleet) falling, snow lying, fog and hail. However, any index of winter character based on so many inputs would not only be very cumbersome but could only be derived for the limited number of locations for which such data are available. Any attempt to characterise winter conditions is thus going to be a compromise between the number of descriptors and the availability of information relating to them.

## WINTER INDICES

Rackliffe (1965) described winter character using mean air temperature, total sunshine hours, and number of days with snow or sleet falling, to which Shellard (1968) added earth temperature and days with snow lying in his analysis of the 1962-63 British winter. In contrast, Lyness and Badger (1970) used air temperature alone to determine return periods of cold winters, for planning purposes in the gas supply industry. An early attempt to derive an actual *index* of winter character was made by Lyall (1971) who used the



number of days with snow falling (S), accumulated frost degrees below 32°C(0°F) (F), and the number of days having a maximum temperature of 34°F(1.1°C) or less (C). His index ( $I_{ws}$ ) was calculated using:

$$I_{ws} = 12S + F + 11C$$

Although such an index allows some degree of comparison between locations, it is essentially empirical and takes no account of the statistical distribution of and intercorrelation between the input variables. Hughes (1981) goes some way towards incorporating a measure of dispersion in climatological data in using the standard deviation of air temperature as a basis for identifying 'very cold winters', the criteria for which was a difference from the long-term mean of more than one standard deviation.

The principal variables employed in describing winters have thus been restricted to those most frequently available, that is, air temperature and some indication of the occurrence of snow. With regard to the former, mean air temperature alone is clearly too crude, given the highly variable nature of the Scottish winter weather. Although daily (0900-0900 GMT) minimum air temperature does have its limitations, not least of which is the problem of carry-over, the frequency of air frosts is recorded at all climatological stations and does provide some indication of temperature oscillation about the critical threshold of 0°C.

Snow observations are most frequently in the form of days of snow or sleet falling, or days with snow lying at 0900 GMT. Of these, the former gives no indication as to whether the snow is accumulating on the surface, which is the essence of the snow hazard, particularly on roads. While the latter does at least suggest that snow has accumulated on the ground surface, it is prone to subjectivity on the part of the observer and the originating snow fall may have occurred some time before the observation.

While accepting these limitations, an index of winter severity has been developed using the frequency data inputs of days with minimum temperature of less than 0°C, and days with snow lying at 0900 GMT. The main objective has been to produce an index which can be used in relation to socio-economic variables and which also provides a good degree of comparability between stations. Geographical variations in winter character were not an objective.

#### DERIVATION OF AN INDEX

Derivation of the winter index (WI) was based on the three core winter months December, January and February over winters 1971-72 to 1989-90 for climatological stations in Scotland. Frequencies of days with air frost (A) and snow lying (S) were extracted from the Met Office *Monthly Weather Report* for each of the contributing months and final totals determined for each winter. Although there was a significant correlation between A and S, both were included in the index on the grounds that either can, and do, occur independently of the other.

While A tended to be normally distributed, S was positively skewed and was

normalised using a  $\log_{10}$  transform. The WI index was calculated using deviations from the long-term mean (19 years) expressed in terms of numbers of standard deviations.

Thus:

$$WI_n = (A_n - \bar{A})/\sigma_A + (S_n - \bar{S})/\sigma_S$$

where  $\bar{A}$  and  $\bar{S}$  are the long-term means,  $\sigma_A$  and  $\sigma_S$  the standard of deviations of the two input variables, and n is any number from 1 to 19. Cold winters thus generate positive index values and mild winters negative. Using Hughes' (1981) criteria of one standard deviation to mark a significant departure from the long-term mean, with two input variables index values outside the range -2 > WI > +2 were regarded as notably mild or severe.

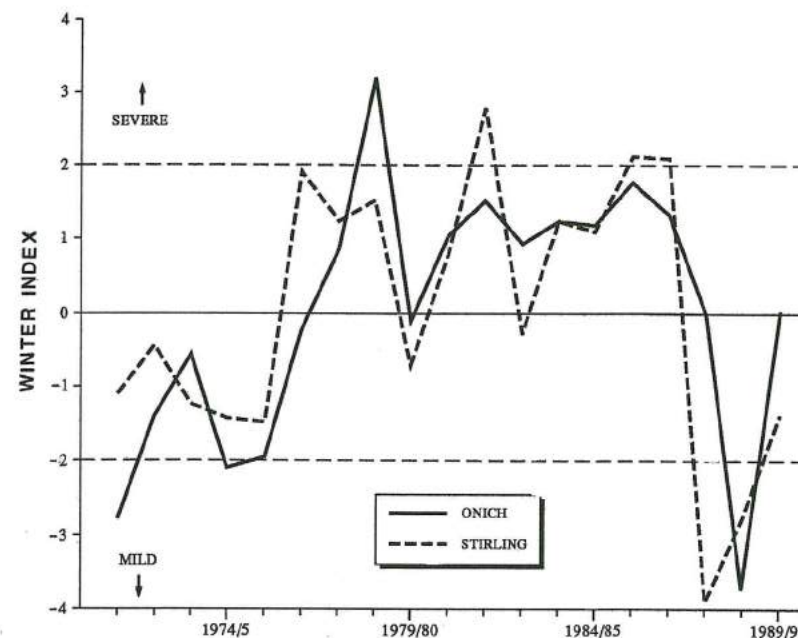


Figure 1: Variations in winter index values at Stirling (Parkhead) and Onich for winters 1971/72 to 1989/90.

#### APPLICATION OF THE INDEX

Index values derived for two Scottish climatological stations demonstrate that comparable values were generated while, at the same time, a basis is provided for correlation with local cost-of-impact variables. Stirling (Parkhead) (NS 815969) and Onich (NN 028630) are both lowland climatological stations at altitudes of 35 and 15m respectively. Both are sheltered by local topography and nearby trees. Onich is, however, 15 km south-west of Fort William in the milder west of Scotland while Parkhead is 3 km north-east of Stirling in the



colder eastern half of Scotland. The thermal contrasts between the stations is indicated by the mean numbers of air frosts (29.0 and 35.2 respectively) and days with snow lying (9.4 and 13.4 respectively) over the three winter months.

The sequence of index values for the two stations over 19 winters indicates a good degree of consistency and are highly correlated ( $r = 0.699$ ;  $P < 0.001$ ). Against a background of increases in mean winter temperatures in western Europe (Houghton et al, 1990), winters at the two stations clearly show a general increase in severity between 1971-72 and 1986-87, with a sudden and very dramatic shift to milder winters only from 1987-88 onwards (Figure 1).

This progression has been reflected in regional authority expenditure on winter road maintenance. Statistics for winters 1980-81 to 1986-87 in Central Region have been published by Brinham (1989), and for winters 1976-77 to 1983-84 in Highland Region by Edmond (1985). The cost of winter maintenance, including deployment of gritting and snow-clearing machinery, for all roads, both trunk and regional, have been expressed as a percentage of the total annual maintenance budgets for the two regions respectively. Both periods pre-date the very rapid growth in the use of road sensing systems such as Icelert and the introduction into Scotland of the Met Office's 'Open Road' forecast (1986-87). For both regions, alongside improvements in the efficiency of road clearing operations, there were increased demands placed on the road

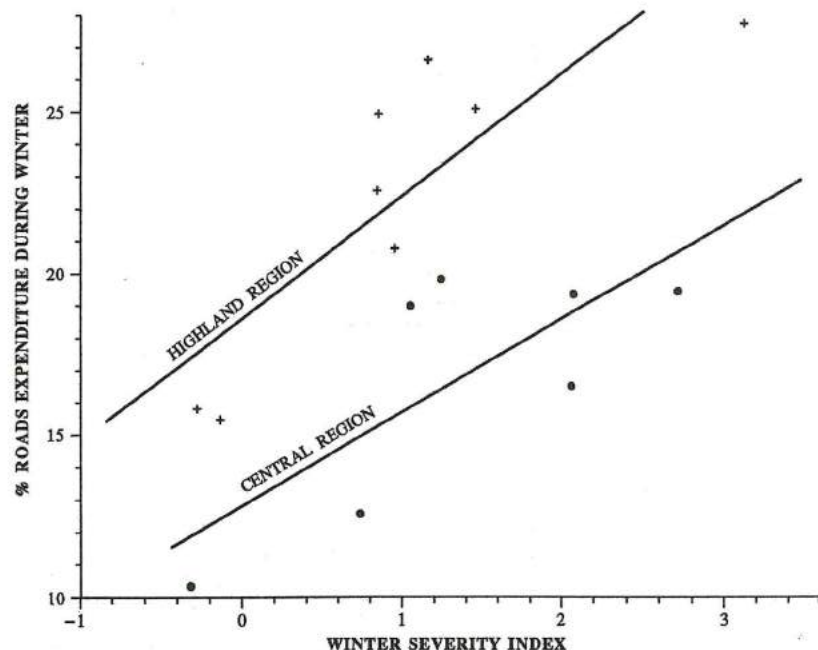


Figure 2: Relationship between expenditure on winter road maintenance and winter index values for Central and Highland Regions of Scotland.

system by an ever-growing social and economic requirement for mobility. Despite the complexity of such socio-economic variables and the complicated nature of local authority budgets, there is a highly significant relationship ( $P < 0.001$ ) between ALL% and WI for both Central Region (Stirling) and Highland Region (Onich).

## CONCLUSION

The winter index fulfils the demands made of it. It provides comparability in the long-term records for any set of climatological stations while at the same time providing a basis for relating socio-economic and weather-related variables. Its simple base, on just two frequency variables, and the accommodation of the statistical distributions of the values of such variables means that appropriate data are likely to be available, calculation is straightforward, and no arbitrary and limiting empirical coefficient needs to be introduced.

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## POSSIBLE CROP-CIRCLE PHENOMENA REFLECTED IN A FOLKTALE - THE SWAN MAIDEN (AT400)

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**Abstract:** In recent years there has been an attempt to both prove and dis-prove an historical basis to crop-circles through the use of folkloric materials. This article briefly examines the utility of so doing and presents a folktale in which, it could be argued, folk beliefs about the nature of circle-forming phenomena are expressed.



## INTRODUCTION

This paper looks briefly at an introduction to a folktale commonly known as "The Swan Maiden", Type AT400 in the Aarne-Thompson Type Index (Aarne and Thompson 1961). The introduction, printed below, describes a series of events during which various crops are flattened by an unusual phenomenon. The description of this phenomenon and its effect appears to show several features that are common in circle phenomena accounts. The tale is printed in *100 Favorite Folktales* where it is called "Maid Lena" (Thompson 1968).

## "MAID LENA"

Once upon a time there was a farmer who had three sons. The eldest was called Peter, the second Paul, and the third Ebson. Now Peter and Paul were a couple of strong, wide-awake lads; so they were very useful to their father. But the youngest was a poor sort of do-nothing fellow, who never had a word to say, but went mooning about like a man in a dream, or sat over the fire and raked up the ashes; so they called him Ebsen-ash-Rake.

The farm stood amid fertile fields and fair green meadows; but in their midst lay a tract of barren, worthless moorland . . .

. . . Peter and Paul, however, could not bear to see that bit of waste land, so their father gave them leave to see what they could do with it. True there was that old story about the land belonging to the fairies . . . They sowed it with wheat, and it did well all through the winter, and in the springtime gave promise of a splendid crop.

Not one of the other fields looked half so well, until Midsummer Eve when there came a sudden end to all their satisfaction – for on Midsummer Eve the whole crop was utterly destroyed. The entire field looked as if it had been trodden under foot; every blade of wheat was so crushed and beaten down that it could never recover or lift itself up again.

No one could understand how such a thing had happened. So there remained nothing to do but plow the field afresh, and let the grass grow.

Next summer there was finer and better grass there than in any of their meadows, but just the same thing happened again.

On Midsummer Eve all the grass was trodden down and beaten out as if with a flail, so they got no profit out of the field that year. Then they plowed it once more, let it lie fallow through the winter, and in the spring sowed their field with flax. It came up beautifully, and before Midsummer Eve was in full flower. It was a pretty sight, and Peter and Paul surveyed it with pride and joy, but, remembering what had taken place the two former years, they agreed that one of them should keep watch there on Midsummer Eve . . .

It was a beautifully mild evening, clear and still. Peter quite meant to keep awake. For all that, however, he fell asleep, and never woke to midnight, when there came a fearful rushing and roaring overhead, that made the ground beneath him shake and tremble; and when he tried to look about him the whole sky was pitchy black. But in the midst of it all, there shone something red that looked like a fiery dragon, and the whole field seemed to roll from side to side,

till he began to feel as if he were being tossed in a blanket; and there was such a roaring and buzzing in his ears that at last he became completely dazed. He could not bear it any longer, but was glad enough to escape with a whole skin, and get safely home.

Next day the flax lay there, trodden down and as bare as a deal board . . .

Late on Mid-Summer Eve [the next year, Ebsen] slipped out of the house (after having slept most of the day), for he meant to keep watch all that night. He wanted to know what it was that went on there every Midsummer Eve, and whether it was the work of fairy-folk or other folk . . .

Ebsen climbed up into [a] tree, sat very still, and kept awake until midnight. Then he, too, heard a roaring and a rushing that seemed to fill the air, and he, too, saw the sky grow as dark as if a carpet were spread out over it; and out of the black sky he saw a red gleam come. It came nearer and nearer till it took the form a fiery dragon, with three heads and three long necks. As the Dragon grew nearer, the storm increased, and a whirlwind rushed round and round the field, until each single blade and stalk lay there crushed and ground down, as if it had been trampled under foot . . .

Then all at once it grew quite still and quiet, the sky was clear again, and instead of a dragon with three heads, Ebsen now saw what looked like three large swans. But as they came nearer he saw they were three young girls, partly disguised in the form and plumage of swans, with great white wings and long, flowing veils; and they sank slowly down through the air to the foot of the old ash where Ebsen was. Then they cast aside their feathery disguise; the wings folded themselves together, and there, at the base of the tree lay three white veils as fine as cobwebs. They themselves, however, rose and danced, hand in hand, round and round the field, singing all the while.

The rest of the tale follows Ebsen's trial as he attempts to win and woo one of the swan maidens.

## DECONSTRUCTING THE TALE

Previous commentaries on possible circle-forming accounts (Reynolds 1990; Skinner 1990) have taken a de-facto feature-based analysis. Attempting to do the same for this leads to the following correlations.

*Time of year.* The story is set at midsummer. This is of course a common feature in folktale but it does fall right in the middle of the circle season.

*Time of day.* Midnight. Again a common folktale motif but also seemingly a popular time for circle formation.

*Description of circle-forming agent.* "Shone red". Associated roaring and buzzing. Participant left dazed. Meaden notes that the colour red frequently appears in reports of luminous phenomena and postulates a connection with the emission spectrum of nitrogen (Meaden 1990a; p.60).

*Meteorological concerns.* Association of the events with a whirlwind yet the weather is still and calm.

*Description of crop* as beaten down and flattened out. However there is no mention of circles *per se*. It seems that the maidens wanted the entire field



flattened for a dance floor. Note though that the whirlwind is described as rushing round and round and that the maidens dance in likewise fashion.

*Veils.* The veils described as being like cobwebs match a common feature in UFO close encounters in which strange cobweb-like growths are found.

## ANALYSIS

Obviously this does not purport to be an unearthing of a crop-circle formation. Instead it is useful to try to understand the relationship between this and such eye-witness accounts. First it should be noted that this is a folktale, a *märchen*, and that such narratives are usually considered to be told for the purpose of entertainment. This is in contrast to legends in which the issue of belief is supposed to be central (Bascom 1969). Using a folktale to address issues in folk belief may seem somewhat disingenuous.

However, a tale-telling is not a homogeneous event: the narrator may often make jokes, break frame, pause for a drink and so on. It is fair to say that tales retold in collections such as this often bear little resemblance to the way it may have been told to the collector. Thus one needs abstract away from the bare text. In this we are helped because the next story in the collection is also a version of AT400 which has a totally different introduction. In fact AT400 is so typed on the basis of the hero's actions after he first meets the swan maiden. It seems that tellers have a free choice about how exactly to arrange the initial meeting.

In this case it is possible to argue that this particular tale-teller may have used a local legend of the time or even a personal experience as the framework introduction. The teller draws on common folk beliefs, such as the existence of fairy ground, and, possibly, certain folk knowledge such as the occasional flattening of crops under mysterious circumstances. At this point speculation becomes meaningless without any further information about the context of the tale.

The parallels between this account and the "Mowing Devil" narrative are manyfold (Gerrish 1970). The descriptive cores differ with the Mowing Devil providing a description that appears to be much closer to the features usually associated with the current phenomenon. There is also a similar prescription against over-farming in both accounts. With the Mowing Devil a farmer loses a whole field of oats due to greed. In the above account an unwise attempt to cultivate fairy land leads to a similar disaster.

In summary this tale hints at possible folk knowledge concerning the existence of crop flattening. It provides an interesting parallel to the "Mowing Devil" account inasmuch as if the account were to stop at the discovery of the agent behind the damage would be little qualitative difference. Little heed should be placed on the specific use of place names in the Mowing Devil – such techniques function to point out the genre of the narrative not to give necessarily factual information.

There is still the question of the utility of using folklore to ascribe an historic basis to the circles phenomenon. Randles and Fuller argue that the association of many repeating areas with diabolic place names, such as the Devil's

Punchbowl at Cheesefoot may be indicative of folk knowledge that unusual things often occur thereat (Randles and Fuller 1990). However it should be noted that there are many Devil's Punchbowls scattered throughout the country and that most prominent natural features have some kind of migratory legend associated with them. Coincidence would seem a more natural explanation here.

The subject is further confused by the existence of fungal fairy rings. Meaden argues that the fairy rings described by Scott as "yellow and blasted" could actually refer to crop circles (Meaden 1990b). This is probably untenable. The fungus that causes fairy rings can lead to both a lush growth of grass and to the grass being left withered. Scott was a perceptive observer of natural history and would undoubtedly have described a crop circle more accurately if he had had reason to do so.

There is a lack of folklore surrounding crop circles *per se* and this is a problem for anyone who wishes to argue for the historicity of the subject. On the other hand there is a vast body of fairy lore which appears to echo many of the features postulated for a plasma vortex. That one can exist without the other would seem to indicate that there has been change in some other factors, whether due to climate or farming or social practices, that has led to a recent increase in the number of crop circles being found.

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## A DIVIDED NATION: THE NW-SE CLIMATIC ANOMALY ACROSS THE UNITED KINGDOM, 1988-1990

By JULIAN MAYES

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*Abstract:* The intensity and persistence of climatic anomalies favouring south-east Britain in contrast to the north-west are investigated with reference to monthly anomalies of rainfall, sunshine and temperature. The implications of rainfall deficiency over E. England being combined with above average sunshine and temperature levels are discussed in the context of future climatic change.

## INTRODUCTION

The concept of a spatial gradient in weather and climate is a familiar one,



whether applied to rainfall, sunshine or temperature. In a typical synoptic situation in which westerly winds are dominating, a NW-SE gradient of rainfall and sunshine is usually observed; rainfall usually increasing towards the north-west and sunshine decreasing as a function of increasing proximity to the centres of passing depressions and onshore westerly winds. This type of average gradient was clearly shown by Hatch (1973) who combined several climatic elements into what was, in effect, a single index of climatic favourability.

In any particular period of time, an above average frequency of westerlies will tend to enhance this gradient. A northward movement in depression tracks will often have the same effect, and is often, of course, the cause of changes in the frequency of westerlies. Examples of enhanced gradient years are 1921, 1976, 1989 and 1990. 1968 and 1987 are two recent examples of the opposite situation when the south-east was less favoured than usual.

Much of the weather experienced in Britain since the middle of 1988 can be summarised in terms of an enhanced gradient: very wet spells in the north-west in conjunction with an extended period of dry and often warm and sunny weather in the south-east. As well as producing an enhanced gradient of the elements across the country, we can also refer to a gradient in the *anomalies* of temperature, rainfall and sunshine. The aim of this article is to identify the magnitude and persistence of these anomaly gradients, to find whether the whole period can be justifiably described in these terms. All quoted anomalies are with respect to averages for the period 1951-80.

## RAINFALL ANOMALIES

Several writers have analysed the rainfall fluctuations from 1988 to 1990. Marsh (1991) has examined the regional hydrological implications, whilst Eden (1991) has highlighted the cumulative deficit over England and Wales as a whole from September 1988 to December 1990. The purpose of this section is to examine the rainfall anomalies over smaller areal units to identify regional contrasts.

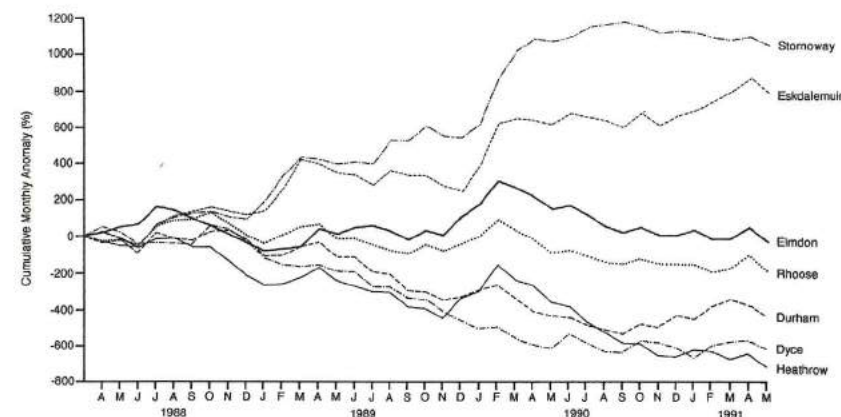
**Table 1.** Mean and frequency distribution of monthly rainfall percentages by district, April 1988 to December 1990.

	Mean Percentage	Percentage class				
		Under 40	40-100	100-160	160-200	200+
Scotland N.	123.5	1	13	12	4	3
Scotland W.	118.1	1	15	8	5	4
N. Ireland	103.0	0	18	10	4	1
Scotland E.	100.1	3	16	9	4	1
Eng. NW/N. Wales	99.4	2	17	9	4	1
Eng. SW/S. Wales	94.3	4	16	10	2	1
Midlands	89.5	2	19	8	3	1
Eng. NE/E.	88.1	3	17	11	1	1
East Anglia	86.5	5	19	5	4	0
Eng. SE/Cen. S.	83.8	6	17	5	4	1

Table 1 shows the mean monthly percentage anomaly for each of the official districts used by the Meteorological Office from April 1988 to December 1990. Values range from 124% over N. Scotland (a figure almost equalled by W. Scotland) to under 90% across the whole of the eastern half of England.

The frequency distribution of particular values may at first appear surprisingly similar in each region. The study period is clearly sufficiently long to enable all parts of the country to have recorded at least some very dry and very wet months. Closer inspection reveals that the incidence of these extreme months differs quite considerably. Whilst the districts in the north-western half of the country had an even distribution between the different classes, the probability of a month exceeding 120% of average rainfall was as low as 0.24 in South-east England, 0.21 in the Midlands and 0.12 in East Anglia. However, each of the four months in this category in East Anglia actually received more than 160% of average, highlighting the erratic distribution of recent monthly rainfall. The rainfall percentage likely to be exceeded in one month in three ranged from 100% in East Anglia to 150% in West Scotland.

An alternative means of presenting the rainfall anomalies is in the form of cumulative monthly anomalies in order to identify the timing of dry and wet spells. However, in order to preserve comparability between different parts of the country (the whole point of any such regional analysis), the anomaly has to be calculated in terms of the percentage deviation from the mean rather than the absolute deviation in millimetres, as used by Eden (1991), for example. The disadvantage of the absolute values is that the anomalies will be larger in areas of high average rainfall and also in the wetter times of the year at any one site. Cumulative percentage anomalies give an equal weighting to individual locations and months, disregarding their average rainfall. Although this allows comparison, it must also be remembered that it is not possible to precisely quantify a value at any given time in terms of rainfall amount. It also gives an event weighting to each month of the year.



**Figure 1:** Cumulative percentage rainfall anomalies, April 1988 to May 1991.



Figure 1 shows anomalies plotted for seven sites distributed from north-west to south-east. The divergence between positive anomalies at Stornoway and Eskdalemuir and negative anomalies elsewhere clearly reflects the dichotomy of rainfall fluctuations across the country. Whilst the increasing values at the two north-western stations ceased early in 1990 (with subsequent rainfall being close to average), the remaining stations continued to experience below average amounts; the only widespread interruption to this dry spell was the wet winter of 1989-90. This is clearly shown as an abrupt but short-lived increase in the curves with the notable exception of Dyce, arising from an enhanced rain-shadow situation produced by a strong and persistent westerly airflow over Scotland (Mayes, 1991). Conversely, by early 1991, both Durham and Eskdalemuir recorded a period of above average rainfall whilst the dry spell was remaining entrenched in south-east England. The large negative anomaly at Heathrow from March 1990 to May 1991 is representative of stations in East Anglia too.

Elmdon and Rhoose are intermediate both in terms of their small rainfall anomalies and their geographical position. The preponderance of positive values at Elmdon seems surprising but Fig. 1 shows that it is because much of the Midlands had above average rainfall through much of 1989. This gives a rare example of rainfall percentages decreasing north-westwards with the cumulative deficit at Ringway (not shown) reaching -303% in May 1991.

A more recent shift in rainfall anomalies in 1991 has been the emergence of very large deficits in the north of East Anglia and in Lincolnshire. Heavy rain in April, June and July halted the growth of the cumulative deficits over S. England but often failed to spread north-eastwards.

### SUNSHINE ANOMALIES

Not surprisingly, the distribution of sunshine anomalies (Table 2) is approximately the reverse of that of rainfall. Mean monthly percentages from April 1989 to December 1990 range from under 99% in N. Scotland (the only district to have averaged below average sunshine during this period) to 114% in

**Table 2.** Mean and frequency distribution of monthly sunshine percentages by district, April 1988 to December 1990.

	Mean Percentage	Number of months per class				
		Under 40	40-100	100-160	160-200	200+
Scotland N.	98.8	6	13	9	3	2
Scotland W.	101.0	8	9	10	3	3
N. Ireland	104.9	2	13	12	3	3
Eng. NW/N. Wales	105.3	3	11	12	4	3
Eng. SW/S. Wales	106.7	5	7	9	9	3
Scotland E.	108.7	1	11	10	9	2
Midlands	112.8	2	8	9	8	6
Eng. NE/E.	113.2	2	9	7	11	4
East Anglia	113.6	3	13	2	6	9
Eng. SE/Cen. S.	114.1	3	8	8	7	7

S.E. England, coinciding closely with the area of lowest rainfall percentages. As for rainfall, N.E./E. England is more favoured than S.W. England/S. Wales but so too in the case of sunshine is E. Scotland.

Whilst all classes of anomaly were recorded in each district, there are large variations in frequency. The probability of dull months (less than 80% of average sunshine) is markedly higher in N. and W. Scotland than elsewhere. The higher frequency in the south-west compared to E. Scotland suggests that exposure to moist westerlies has been more effective at reducing sunshine than increasing rainfall totals.

The frequency distribution of both sunshine and rainfall anomalies in East Anglia and S.E. England is bi-modal; the relative infrequency of rainfall percentages from 120 to 160 is matched by the lack of sunshine values from 110 to 120%. In other words, when positive anomalies of either rainfall or sunshine were recorded in this part of the country, they tended to be large.

### TEMPERATURE ANOMALIES

Table 3 shows the distribution of mean monthly temperature anomalies from April 1988 to December 1990. Positive anomalies outnumber negative in all districts, although the modal class in W. Scotland was negative (-1.0 to -0.1°C). The anomalies increase steadily from just +0.53°C in N. and W. Scotland to as much as +1.15°C in S.E. England, once again conforming to the patterns of anomaly gradients favouring the South-east of the United Kingdom. Within this overall pattern, E. Scotland appears to have benefitted from the persistent westerlies with only one month in five having below average temperatures.

**Table 3.** Mean and frequency distribution of monthly temperature anomalies (°C) by district, April 1988 to December 1990.

	Mean anomaly	Number of months per class				
		-2/-0.1	0/+0.9	+1/+1.9	+2/+2.9	+3/+4.9
Scotland N.	+0.53	7	19	5	1	1
Scotland W.	+0.53	15	8	5	4	1
N. Ireland	+0.63	10	11	7	4	1
Scotland E.	+0.76	7	15	4	5	2
Eng. NW/N. Wales	+0.80	10	9	7	6	1
Eng. SW/S. Wales	+0.91	8	10	5	9	1
Midlands	+0.99	9	8	7	6	3
Eng. NE/E.	+1.01	6	13	6	4	4
East Anglia	+1.02	8	9	7	7	2
Eng. SE/Cen. S.	+1.15	8	7	8	8	2

The seasonal incidence of the departures is quite striking, with every case of an anomaly reaching +3°C or more being recorded between December and March rather than in the warm summers of 1989 or 1990. The relative warmth of the eastern half of England from January to March 1990 is particularly notable. The smallest anomaly of any of the four districts here in any one of these months was a high as +2.7°C. The south-eastward increase in anomalies for the 1989 and 1990 winters is also shown by Hulme and Jones (1991)



together with the associated pressure anomaly patterns. The longest unbroken run of warmer than average months was the 13 months from May 1989 in N.E./E. England, S.E. England and S.W. England/S. Wales.

Whereas Scotland as a whole achieved the largest positive anomalies in the very mild winter of 1988-89, in general the majority of warm months (more than 2 °C above average) have been found away from western and northern coasts. Whilst this will accentuate any gradient favouring the south-east of Britain, this may simply reflect the more maritime thermal character of the north-west in which monthly temperature anomalies are more likely to be moderated by the influence of the sea. It might then be postulated that anomalies are bound to be larger in the south-east of the country simply because a period has been warm, rather than for any special reasons of synoptic character. This may, of course, have implications for the rate of warming of coastal districts in the short term, if a general climatic warming takes place in the future.

#### DISCUSSION AND CONCLUSION

This brief analysis has shown that the gradients in the anomalies of rainfall, temperature and sunshine since early 1988 have each favoured the south-east of the United Kingdom, with anomalies here being positive for temperature and sunshine and negative for rainfall. The geographical pattern of the gradients is very similar for each element. However, each part of the country has experienced a wide range of monthly anomalies, highlighting the erratic nature of month to month weather conditions. The basic conclusion from this is that data averaged over large areal units (such as the whole of England and Wales) should be quoted with caution: there is clearly a tendency to average out opposing anomalies to give an impression of apparent normality in national weather conditions.

Placing these results in their past context, gradients of increasing rainfall percentages towards the west were a feature of many years in the 1970s and 1980s. Woodley (1991) compared the areally averaged rainfall data of recent periods with the 1941-70 average. Whilst he concluded that the recent dry period since 1988 was not as extreme as 1975-76, his analysis shows evidence of England and Wales rainfall deficits increasing towards the east. Interestingly, this was found not just for 1988-90 but more generally from 1971 to 1990. The recent anomalies have therefore accentuated an existing anomaly which has persisted for sufficiently long to influence rainfall averages calculated for the 1961-90 reference period. This means of course, that 30 year averages are a variable base-line for the analysis of future rainfall anomalies.

The most obvious explanation for this gradient in weather conditions is the persistence of W airstreams over all, or part, of the country. Results of a regional airflow classification indicate that the frequency of W airflow types was above average over all parts of the country in each of the three years 1988 to 1990; the 1990 value for Scotland was the second highest in an annual series extending back to 1950. Whilst much was written about the decline in the frequency of westerlies in the 1950s and 1960s (e.g. Lamb, 1965; 1972), there

is little evidence, as yet, of a recent increase, though the increase in westerly activity since 1988 seems abrupt and dramatic, particularly over Scotland. As it is possible to see a cyclic pattern in westerliness (with the previous peak in the 1920s and 1930s), it could be argued that this recent increase is the start of another period of increased westerly activity which could last several decades.

A sustained increase in westerliness could have important implications for water resources. The possible rainfall deficits in the south-east would exacerbate the mismatch between supply and demand for water between a wetter north-west and the south-east, even if long term deficits were smaller than those found since 1988. Furthermore, if there continued to be a geographical association between the areas of largest rainfall deficit and largest positive anomaly of temperature and sunshine, this would further enhance soil moisture deficits by lengthening the growing season and increasing evaporation. Whilst these factors are now considered in scenarios of Britain's future climate (see, for example, Department of the Environment, 1991), the possible impact in certain regions could be far greater than that suggested by data referring to the country as a whole.

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### THE WOODWARD-MOORELAND TORNADO 26 MAY 1991

By DANA MACK

We arose into a morning bright and clear, except for a few wisps of stratus, denoting the existence of thick humidity at the surface, while on the northern horizon a few cumulus were indicative of an unstable atmosphere.

Adrian Mackey had just left yesterday, so I was feeling a bit flat and really was not expecting to do very much this day. How wrong I was! As soon as we arrived home from church, I discovered that Gary L., my friend who worked on



TV-9 in Oklahoma City as a meteorologist, had left a message on our recorder advising that there was a chance of severe storms in the north-western quarter of Oklahoma today.

1.00 p.m. The *Oklahoma Thunderstorm Outlook*, issued by the National Weather Service, advised that there was a *moderate risk* of severe thunderstorms north and west of a Cheyenne to Perry line, or the north-western quarter of the state. An outflow boundary left behind by morning storms over Kansas was sagging southward into the state, and was forecast to be intersecting a dryline in north western Oklahoma just north of Laverne, Oklahoma, by late afternoon. While the cap was strong over Mustang, it was a lot weaker further to the north and west, and with strong heating, and 70-degree dew points explosive development of storms was likely. Lifted indices in the area were around -8 to -10, which indicated extreme instability, and the presence of a short-wave disturbance in the upper-atmosphere would only add to this volatility.

Jo Anne, Greg, and I departed Mustang around 3.15 p.m. As I commented, rather prophetically, "Of course we have the 'Adrian Just Left the Other Day, So We'll See a Tornado Factor' working in our favour, so who knows?"

As we sped north and west towards Watonga, we began to notice that the boundary up north was showing signs of life. At 3.33 p.m., to our distant north, rendered indistinct by the haze, bubbling mounds of cumulus rose skyward, forming into large thunderstorm cells.

4.07 p.m. We turned north on U.S. 281 towards Watonga, by which time a line of thunderstorms lay to our north-west and a titanic over-shooting top the size of a cumulus build-up had punched up through the anvil cloud, probably a tell-tale signal that this storm was becoming severe. The sight of this made Greg and I wish that our car was able to do one-hundred miles-an-hour, but to our dismay, in the town of Geary, a sleepy town of one-storey shops and a few convenience stores, there was a thirty mile-an-hour speed limit posted.

The time seemed to ooze like thick molasses while we drove at the prescribed speed through town, as the storm to our north-west became a supercell, sucking all of the surrounding moisture into itself, and totally dominating convection in the area. It was with relief that we cleared the city limits, and were able to proceed at a much greater-than-posted speed. (Any Highway Patrol officers reading this are encouraged not to remember this statement).

5.21 p.m. The scenery was verdant and rolling, with small buttes and mesas abounding in the occasional badlands that added even more distant relief to the landscape. Bright rusty-red was visible from the faces of these bluffs, with tiny channels carved by rainwater of past storms. At Seiling, I contacted TV-9, and was told by the meteorologist there, that the monster storm to our north-west had a BWER (Bounded Weak Echo Region) and was over 56,000 feet. The

BWER is a radar signature of inflow, and indicated a developing circulation, while the height indicated how explosive was the development of this cell. After stopping at a convenience store to purchase some greasy fried chicken and potatoes, we resumed our north-west course; mammatus clouds were forming numerous pouches in an increasingly sullen sky, while yellow-hot electricity struck at the earth with increasing frequency and intensity. There was now a *Tornado Watch* out for parts of the Texas Panhandle and north-western Oklahoma, until 11.00 p.m., and with what was occurring before us, chills were sent running down our spines.

In the course of the next hour, while we were stationed half-way between Seiling and Woodward, on U.S. 270, a classically structured wall-cloud, in the form of a set of lens-like clouds stacked one on top of another, in a concave array, formed. The interstices between these layers were coloured in odd aquamarine cast, and beneath all of this, numerous funnels, exhibiting extremely tight rotation, kept forming. It was impossible to count them all, so numerous they were!

The lightning during this time was most unusual. It stroked earthward extremely rapidly, and with great brilliance, looking like something out of a *Frankenstein* movie, and not from the real world. Another interesting phenomenon was that the wind, gusting into the storm from the south-east, felt as though it were generated by a blast furnace, so that instead of giving a cooling effect, I actually felt hotter as it rushed into my face. Needless to say, with the lightning around, and the heat, we stayed in the car with the air-conditioning on!

Numerous *Tornado Warnings* were reissued for Woodward County, as this cell was crawling along at fifteen miles-an-hour, right over the city itself. A local radio station provided a superb commentary, and the announcer had an excellent view, as his window looked out to the west, right under the menacing black swirl of cloud. "Well, you know, it's not often you get to sit here in the control room of K101 radio, and see the, uh, rotating cloud . . ." said the announcer, in a tone of awe.

At 6.51 p.m. I exclaimed "There's a funnel right there . . . there's a funnel right there . . .!", as a funnel, one of those which are exactly in the form of the name, with very laminar edges, and colored a light gray against the dark-blue rain core beyond, extended towards the ground. As I examined the horizon, I could tell that a cloud of red dust rose from the tip of the funnel: it was a tornado churning up the rich, rusty soil of the fields below us. We were on a hill, which afforded us a fine view: fields of dun-colored wheat not yet harvested interspersed with plowed fields of rust, and separate from each other by lines of deep green trees, with our tornado beyond, sucking all this red dust into its vacuum. Maleficent bolts of wild electricity crooked through the tumultuous skies, impacting the terra firma in numerous locations.

The dust cloud was really becoming pronounced as large clouds, almost plumes, moved up and in towards the twister. "Oh look at it, its sucking



incredible . . .!" exclaimed Jo-Anne. We watched the tornado for a few minutes more, and then, at 6.57 p.m., we headed north-west to obtain a better view of the storm. Over one hill, into a dip, then over another hill past some chasers we roared, until we topped a rise and were surprised with something that changed our course one-hundred and eighty degrees.

"Just go . . . just . . . whoa, whoa, whoa . . . whoa . . . we got a second tornado. Just get the hell outta here. Second tornado, right there," I gestured, "On the ground, on the ground!!"

Our forward motion ceased abruptly, as Jo-Anne applied the brakes, and executed a hard turn. I continued my excited narrative into the tape recorder: "Dust on the ground . . . tornado on the ground . . . a second tornado! Go, go, go!!!"

A swirl of black dust rotated cyclonically just to the right of the highway, and yet another funnel, smooth-edged and light gray, slanted northwest-southeast beyond the swirl, as we raced south-east, away from this twister trap, past the chasers who were still gazing down into the valley, oblivious to the other two tornadoes lurking to their south-west.

I wonder what they must have thought when a white Toyota zoomed past with people leaning out and yelling at them. "Second tornado back there . . . Haul your tails!!!", screamed Jo-Anne.

A couple of ridges later, we felt safe enough to stop and begin video-taping again. A rope-like tornado was snaking its way to earth again, grayish-white in color like an albino reptile, and was rotating around the meso-cyclone's periphery. At this time, clouds of reddish dust were being drawn up towards the base of the wall-cloud, and on the southern end of the dust, we could see that it was curving counter-clockwise around in a circular fashion, assuming a scalloped appearance as it turned the corner.

This was, I believe, a weak large-scale circulation on the ground! If it could be classified as a tornado, and this is in doubt, then its size would have approached a mile in diameter! We followed the storm a few more hours, and dusk was settling in as we came to Orienta, the storm still rotating to our north, as a hot, stifling wind continued to advect north-westward into the cell. The local grocery store was dark and locked, and to our over-extended bladders, this was not welcome news. Fortunately behind a row of four white grain elevators, a grove of trees afforded some sort of privacy, and so our relief was at hand. We could now journey home, contemplating what we had seen Adrian, wish you could have been here!

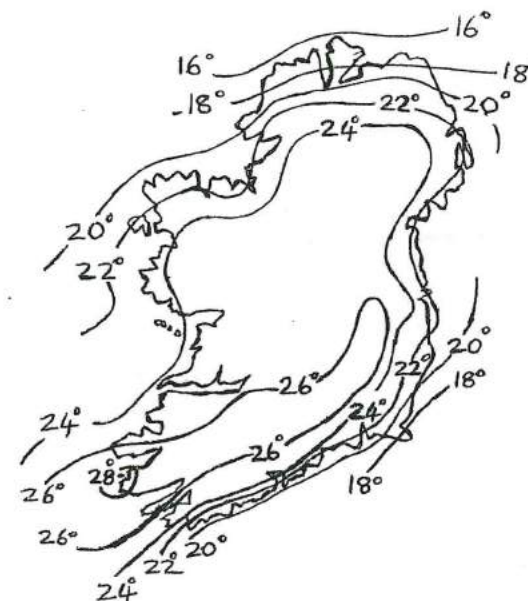
## LETTERS TO THE EDITOR

### 5 SEPTEMBER 1991 SETS NEW HEAT RECORDS FOR SOUTHERN IRELAND

September 5th 1991 was memorable for many observers at stations in southern Ireland when the highest September temperatures of the century were registered. Synoptically, the day saw Ireland in an easterly weather type with an anticyclone to the north-west of the British Isles. A cold front was sagging slowly south-south-westwards over the north of Scotland and the western North Sea and getting into eastern England. Ireland was almost cloud-free with thick haze of continental origin, but sea fog and patchy cloud affected County Donegal and the north of Northern Ireland.

By early afternoon sunshine was quite strong over Ireland, with a moderate easterly gradient south of a line from Dublin to Galway. Sea breezes affected the Wexford coast. At 10.00 B.S.T. I recorded 16°C, with a wet bulb of 14°C, the wind north force 1. By 12.00 the temperature was 20°C with wet bulb at 15°C and a force 3 easterly wind. The afternoon continued warm, and while I was engaged in outdoor work the elevated humidity and breeze kept it pleasant in the open despite the sun. I was quite surprised when I observed at 1500 B.S.T. that my screen maximum was 25.8°C, dry bulb 25.5 and wet bulb 19.8, with the wind east, force 3 and the sky still cloudless. This was high for my station which is at an elevation of 640 feet. Wondering if the temperature would go higher, I hastily shut the door of the screen, but upon checking at 1800 B.S.T. the maximum had remained at 25.8, and the temperature was now 24 and wet bulb 15 (wind east, force 1, haze and one okta cumulus. At 2000 temperature was still at 21°C and wet bulb 11°C (wind east force 1, 4/8 cirrus).

The evening weather forecast confirmed what I had already surmised: it had been the hottest day of 1991 in many parts of southern Ireland, but also a new station record of 28.4°C had been reached at Valentia in County Kerry where the previous September record was 26.7°C on 12th September 1959. For Shannon airport the record of 25.6°C on 12 September 1959 just failed to be equalled by a tenth of a degree. A few days later I was able to confirm through the help of Mr. Alan Morrisroe of Drumnacandra, Dublin, that 25 was exceeded over much of central and southern Ireland but that





26 was exceeded only in a narrow belt about 50 kilometres wide from south-west of the Wicklow Mountains through Counties Kilkenny, Tipperary, Limerick, north Cork and central Kerry. Local Fohn effects undoubtedly occurred west of the mountain ranges, adding to the overall heat content, but it was over the 3000 ft McGillycuddy Reeks in west County Kerry that the greatest effects came into play, pushing values to the extreme recorded in Valentia as the dry air descended westward over the mountains. However, two areas of Ireland were very much cooler this memorable day. North County Donegal was plagued by sea fog, and the south-east coast of Wexford suffered a strong sea breeze which limited temperatures to 17.5°C.

Mount Russell, Ardpatrick, Kilmallock,  
County Limerick, Ireland.

DAVID MESKILL

### "LUMINOUS TUBE" SIGHTINGS IN THE LITERATURE

This has been a summer of hoaxes but, all the same, congratulations to Mrs. Goold, Tom Winchcomb, and another witness for having observed, however briefly, their "remarkable phenomenon in the night-sky" as recorded in this journal's volume 16, number 162. This could be represented as making up for the shortage of positive results from the official CERES observation post atop Morgan's Hill some eight miles north of Alton Barnes, and equipped with radar sustained by banks of high-duty truck batteries. It had for almost two months a rota of anonymous observers who even logged (to my knowledge) nocturnal events such as distant military flares to the south-east and south and a flight-past in the southern distance at low level by A10 aircraft.

Although a "plasma vortex" seems to be the verdict on the sighting to the north-east of Alton Barnes, there could be an alternative of a lower-energy nature. One reason for suspecting that the former might not have been the case on this occasion was the observation in Mrs. Goold's account that the degree of brightness was not really suggestive of electricity, being of a "milky-white colour" in fact. Low-energy vortices such as waterspouts when occurring at night can resemble a "wandering pillar of light" according to an eye-witness mentioned in Theo Lobsack's 1959 book entitled *Earth's Envelope*. Its author surmised that the cause was the temporary suspension of marine plankton or Noctiluca, but a better explanation would be that charged water droplets were descending in a swirling column from the cloud above, helped by their own gravity and the reduction of pressure. The latter seems to be unproven but is logical provided that sufficient swirl exists to be concentrated above a low-drag surface terminal towards which it would sink.

This is but speculation, but it should be admitted in deference to the plasma hypothesis that a photograph was once taken, according to the Life Nature Library series of 1964, as indeed reproduced in its volume *The Earth* by Arthur Beiser, of an odd form of lightning termed "spiral of flame". This was seen to occur at night during a heavy thunderstorm over a city in Switzerland but showed no sign of widening out into a spiral when terminating on a wide street. On the other hand, a perhaps low-energy vortex as observed by Mrs. Goold et al terminated above ground level (perhaps for aerodynamic reasons) and definitely widened to give the impression of a spiral flame according to her drawing. This would be as expected, provided that the axial component of the vortex was not upward as in a tornado or dust-devil, but downward and stopping short of the friction-causing ground.

Tarlton, Gloucestershire, U.K.

GEORGE BATHURST

[Note by Editor: A plasma vortex can be defined as one in which the atmospheric vortex is electrified by the presence of a sufficient quantity of ions or electrons (i.e. electric charges) regardless of what the source of ionisation is (cf *The circles effect and its mysteries*, pp93, 104). Thus, ordinary land devils or whirlwinds – being weakly electrified by the spinning of dust particles which bear charges originating from frictional processes – fall within this category (*loc. cit.* 46-47, 104); their electric fields have often been measured. The same argument applies to waterspouts and tornado funnels in which the observed luminosities have been ascribed to the charging of cloud-water droplets (*loc. cit.* 39). In this sense the waterspout is just another weak plasma vortex, so there is no contradiction, for we see that all natural vortices spinning in dusty or humid air can be plasma vortices if the charge concentration is high enough].

### LIGHTNING VACATIONS

Do you want a holiday where you can watch and photograph atmospheric lightning close by, almost as you please? Then write to The Lightning Field, Two Wind N.W., Albuquerque, New Mexico 87120, U.S.A. for information and booking forms.

On the desert plains of south-west New Mexico a sculpture has been erected which is composed of 400 upright steel rods set in a rectangular grid over a mile-long area near the town of Quemado. The idea of landscape/skyscape artist Walter de la Maria is that when storms are about, as for instance can happen on sultry nights in August and September, the field of steel finds itself transformed into a lightning theatre as the rods or spires attract natural lightning bolts from the clouds.

The spectacle is called The Lightning Field and is administered by the Dia Art Foundation, an organisation which provides accommodation and meals for up to six persons in a homesteader's cabin outside Quemado. The foundation subsidises the overall costs and charges 65 dollars per night which is said to be about half the true cost to the organisation.

### SKY WATCH

Natural phenomena such as aurora borealis, meteor showers, noctilucent clouds, sun pillars and haloes and also unusual weather events are often missed by people who are interested in such occurrences. Many events escape being seen because people do not look at the sky at the right time or they live in towns and cities where the night sky is hidden by street lighting.

The main idea of "Sky Watch" is to set up an organisation that would consist of national and regional telephone call networks so that as many people as possible may be alerted to an unusual occurrence.

Anyone who is interested in being involved in such an organisation is requested to contact me either by phone or at the address below. I would be pleased to hear from anyone, young and old, from anywhere in the British Isles. Sky Watch may be of interest to meteorologists and astronomers, amateur and professional, in particular. Your ideas on organisations, observations and constitution, etc. will be very welcome. My telephone number is 0479 810662.

Malvern, Inverdrue, Aviemore,  
Inverness-shire, PH22 1QT.

IAN C. HUDSON

### LITERATURE REVIEWS AND LISTINGS

#### Book Reviews

**THE POTENTIAL EFFECTS OF CLIMATE CHANGE IN THE UNITED KINGDOM.** By the United Kingdom Climate Change Impacts Review Group. First Report. HMSO, London 1991, 124pp. £8.50.

This report by 16 experts contains numerous headings, sub-headings and brief paragraphs, arranged into 14 generally short chapters, most of which follow the same pattern (i.e. summary, introduction and background, estimated effects of climate change and sea level rise, uncertainties and unknowns, principle implications, and research policy needs). Together with the concise style of writing, this approach makes the book user-friendly. Its contents, moreover, are wide-ranging, so that they too should contribute towards attracting a large readership. Teachers will find several very useful tables and illustrations, the value of which sometimes goes beyond the study of climate change (eg. Fig. 9.1 Distribution of coal, oil and natural gas in the UK).

Books which attempt to see the future demand the utmost care from both



authors and readers. For their part, the authors of this book have tried hard to stress the tentative and approximate nature of their writings (eg. p.13 "It should be emphasized that the above estimates are scenarios, not predictions"; p.23 "... little research has so far been directed to investigating the impact of various scenarios of climatic change in soils"). Readers, therefore, should avoid mentally translating the authors' comments into firm predictions. In reality, the book is hedged around the uncertainties and limitations. Its value hinges on the merits of the 'Business-As-Usual' scenario as previously employed by the Intergovernmental Panel on Climate Change. This "assumes that current (greenhouse-gas) emission growth rates remain at their present levels over the period of projection with the exception of CFCs on which action is already being taken" and "that an equivalent doubling of the pre-industrial CO<sub>2</sub> level ... (will) ... occur in about 2030". On this basis the authors develop scenarios which aim to suggest how UK climate might be affected in the 21st century and what would be the likely consequences for the environment and the economy. The only major impact of climate change not considered is on human health, as this will be the subject of a future report. Although the terms 'environmental hazards' and 'geomorphology' do not appear in the chapter headings, they nevertheless represent subjects which are mentioned within the text.

Some people may feel that the book needs an up-to-date summary of how the 'greenhouse effect' works, if only to emphasize the uncertainties of our knowledge. Instead, by repeatedly and almost exclusively mentioning CO<sub>2</sub>, it gives a distorted picture of this complex problem: it also fails to discuss how CO<sub>2</sub> might interact with the overall cocktail of atmospheric pollutants. Nor does it make clear the difficulties of determining accurately the often-mentioned level of pre-industrial CO<sub>2</sub>. Greater stress might have been placed on the rapidity with which ideas about this and other 'greenhouse' problems are changing, though the point can be somewhat appreciated by looking at the bibliography, much of which contains papers written since 1985. As the book covers a wide range of subjects, interesting points are often dealt with cursorily, which makes it essential to provide clear guidance for further reading. This has not always been done. For example, brief remarks such as "... currently in the UK wind erosion is reasonably under control" and "Winter snow conditions in the Scottish mountains are critical for the future of downhill skiing" cannot be followed up through references in the bibliography. On the other hand, this is a book to be read for the thoughts and ideas it presents, rather than for its facts (though the latter are sometimes very interesting): it poses problems, suggests possibilities and begins to give us an insight into what the future might hold. In short, this is a very stimulating text, albeit one whose foundations may rest on sand.

L.T.

**EARTHWATCH: THE CLIMATE FROM SPACE.** By John E. Harries 1990, 216pp. Ellis Horwood, London, £25.00.

In the introduction to his book "Meso-scale Atmospheric Circulations", B. W. Atkinson observed that satellites were "the most recent and probably the

least useful" of tools for the meteorologist attempting to identify and analyse weather systems ranging from large scale features to smaller ones. This comment, which could be seen as under-rating the role of spacecraft in weather research, would also seem to suggest that John Harries' book is nothing more than a minor meteorological work.

Most would agree that satellites have extended our understanding of weather phenomena, and this book aims to draw together in a most readable way, the various strands of research.

John Houghton notes in his foreword to Harries' book – which is readable enough for the student yet detailed enough for the academic – that satellite images sum up the weather for most people through their appearance on television and in newspapers. Harries is now telling us *why* satellites are so important to the weather research fraternity.

As with many weather books which act as an introduction to a specific field interest, Harries wisely begins with basic principles in the first part of his work. He brings together various parts of the Climate System, as he terms it, such as the atmosphere, clouds, the radiation balance, the oceans, even the cryosphere (a subject often forgotten). The diagrams are easy to follow, especially when read in conjunction with the text. The mathematics can appear somewhat daunting at first, but is not a detraction from the readability of the publication.

The book is up-to-date, which is a great point in its favour. Ozone holes, greenhouse effects and the El Nino phenomena are all considered in some detail, and Harries emphasises the importance of space observations to our current understanding of these features.

Principles of space observation are articulated without the text becoming a satellite construction guide or a thesis on physics. Some of the information will be beyond the needs of most readers but is fascinating nonetheless.

In his section entitled "Space Observations – Some Examples", Harries shows just how important satellites have become to modern research and observation. Some stunning pictures, all in colour, only serve to emphasise this point.

Harries considers the future at the end of his major book by discussing the relevance of space station plans. NASA and the European Space Agency have plans for bases above the atmosphere, it seems, and this bodes well for meteorology.

Harries completes his book with a comment that sums up all that he has written before. "Ultimately the object of our attention, the Earth on which we live, is not only an essential system for our survival, it is also a very beautiful subject which any scientist would be grateful to have as a focus of his work".

ANTONY CLAY

**HOME-MADE LIGHTNING: Creative Experiments in Electricity.** R. A. Ford. TAB Books, Blue Ridge Summit, PA 17294-0850, U.S.A. 198pp. \$14.95 (185 x 235mm pbk).

The author is an enthusiastic experimenter, mainly concerned with static



electricity, and describes the construction and use of a wide range of electrical machines and instruments. He is also interested in various aspects of lightning, unusual theories, medical applications and historical records. This entertaining and instructive book, with many black and white illustrations, is worth a place on the shelves of meteorologists with a generous source of dollars.

ERIC CREW

## WORLD WEATHER DISASTERS: MAY 1991

- 1-5: Forest fire burned 30,000 hectares of woodland in the Oktyabreskoye region of the Soviet Far East, no casualties reported. *Lloyds List*.
- 1-31: Storms continued in many areas of Bangladesh following the April 29-30 cyclone, brief details below:-
- 7th: Storm described as a tornado cut a trail of destruction 805 metres wide by 8 km long through 20 villages near city of Ghazipur, 40 km north-east of Dhaka, destroying or damaging 8,000 houses, leaving 20,000 homeless, 45 dead and 122 injured; reported winds in storm reached 160 km/h. Meanwhile, in the north-eastern area of Sylhet, flash flooding along three rivers left two people dead.
- 8th: Storm described as tornado, destroyed eight villages near town of Ghorasal, 27 km north of Dhaka, seven deaths and 100 injuries reported, the storm also brought down trees and power pylons.
- 9th: Storm, described as tornado, struck Sirajgarj district, 153 km north-west of Dhaka, with winds of 150 km/h leaving at least 13 dead, 100 injured and scores of buildings demolished; the storm also touched off flash floods in the hill districts. In the evening, winds of 113 km/h and heavy rains hit Dhaka for 90 minutes, storm uprooted trees and demolished shacks. Storms hit other northern and eastern areas of country, flash floods in the Sylhet and Maulvi-Bazar districts; in all, 112 people reported dead in storms and floods, including the 13 deaths mentioned above.
- 13th: Reported that floods in the Sylhet and Maulvi-Bazar region have left 52 people dead; the floods, along the Surma river, inundated 656 sq. km and marooned about one million people; since the cyclone of April 29-30 at least 1270 mm of rain has fallen in Sylhet district.
- 17th: The Kushiara river burst its banks in seven places in the Sunamgarj area in the north-east of country, swamping three villages, leaving 10 dead.
- 19th: Floods continued in north-east districts, a storm with winds of up to 193 km/h, hit the Gournadi and Agoiljhara areas of Barisal district in south of the country; thousands of homes destroyed, trees uprooted, power supplies disrupted, crops destroyed; 73 deaths reported, with 1,000 others injured.
- 21st: Heavy rain fell on Dhaka, submerging wide areas of the city, 50mm of rain fell in six hours, heavy rains also fell in the Sylhet area.

23rd: Heavy rains easing off and floods begun to recede in areas.

27-28th: Heavy rains in Dhaka, 191mm of rain fell in a 24-hour period, many roads in city reported knee-deep in water.

*Lloyds List, Daily Telegraph, International Herald Tribune, Birmingham Evening Mail.*

- 2 (reported): Flash flood, following six hours of rain, swept through village in Tembagapura, Irian Jaya, Indonesia, leaving three dead, 14 missing, and 13 injured. *Jakarta Post*.
- 8 (reported): Snow, frost and rain storms, in Italy's coldest May since 1976, have damaged fruit and olive trees and endangered wine grapevines. Damage reported to grapevines, olive groves and fruit trees around Grosseto, Siena Arezzo and Firenze. *L.L.*
- 9-17: Monsoon rains, floods and landslides in northern India left at least 71 dead, including 12 soldiers in the Subansiri district of Arunachal Pradesh state, where another 17 dead were reported; 47 died in Assam state and seven died in Tripura state, worst of flooding reported from southern Assam. *L.L.*
- 10: Rockslide in the Matter Valley in Switzerland cut rail and road links to resort of Zermatt, no casualties reported, some boulders described as the 'size of houses'. *I.H.T.*
- 15-16: Heavy rains and flash floods in eastern Turkey left 30 dead and 16 others missing, floods hit provinces of Elazig, Maltia, Adiyaman and Bingol, cutting rail and road links and destroying houses and crops. *L.L.*
- 17: Thunderstorm in Washington D.C., U.S.A., lightning hit tree, breaking off a branch which fell onto group of people who were sheltering, leaving one dead and 10 others injured, hail size of golf balls fell in areas of city. *B.E.M.*
- 19-20: Thunderstorms, with rain and hail hit provinces of Sind, Punjab and North-West Frontier in Pakistan, causing extensive damage to property and crops, including orchards. A storm hit the Larkana district for two hours in the evening of the 20th, trees uprooted and buildings damaged. *L.L.*
- 24 (reported): An unseasonable frost has destroyed almost the entire wine crop of the Jura region of eastern France. *B.E.M.*
- 28 (reported): The worst summer ice in more than 20 years has halted fishing off much of the coasts of Quebec and Newfoundland, eastern Canada. *L.L.*
- 30-31: Strong winds, gusting up to 145 km/h, high seas and heavy rains hit the Maldiv Islands, in the Indian Ocean, no casualties reported. Some 3,000 homes and 51 jetties were damaged or destroyed, 21,000 people were made homeless, thousands of trees uprooted, damage put at at least \$30 million, storm described as worst ever seen in the islands. *L.L.*

ALBERT J. THOMAS



### WINDTRACKER 4000

Weather-Data have announced the launch of their latest product, a multi-purpose, low cost, "turnkey" weather station. The "Windtracker 4000" is designed to fulfil a number of monitoring requirements where a record of local weather information is critical. For example, airborne pollution monitoring, odour emission monitoring and control, noise monitoring and general meteorological studies. The "Windtracker 4000" is completely self-contained, portable, weatherproof and battery or mains operated. Information received from a selection of sensors is stored on a credit card sized removable memory known as a "Smart Card". The retrieval of data is a simple matter, remove the 'full' smart card and replace with an 'empty' one. The data stored on the card are then transferred to a personal computer using the card reader.

The instrument comes complete with a windspeed and direction sensor, two

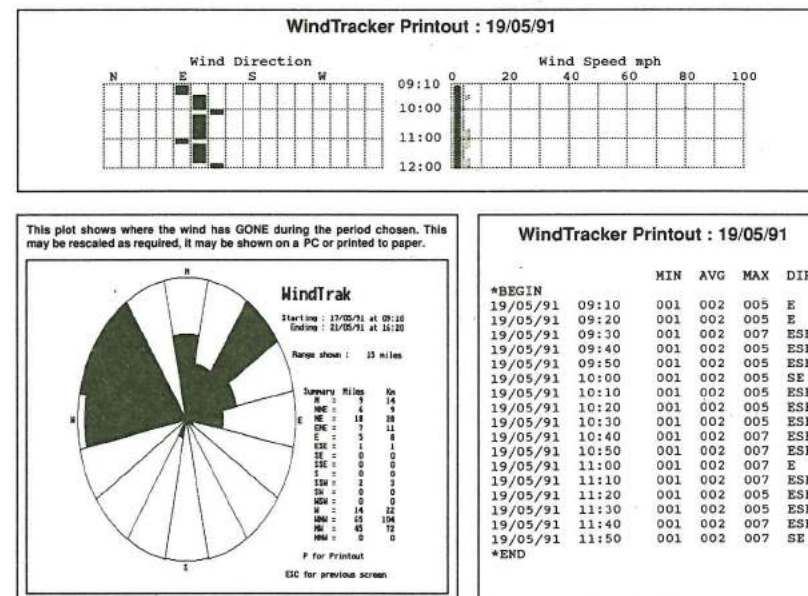


64k smart cards, and a card reader. Sensors for measuring air temperature, barometric pressure, relative humidity and rainfall are available as options and can be connected simply by the user.

There is also a powerful graphics package available which allows you to chart records, draw graphs or plot the wind vectors against time. This enables the operator to know *when* certain conditions occurred, saving many previously wasted man hours sifting through manual data. Another practical feature is its ability to control peripheral equipment. For example, pumps, motors, heating and ventilation systems and other machinery.

The "Windtracker 4000" is available from Weather Data, 51/53 Albert St., Rugby, Warwickshire CV21 2SG. Tel: 0788 537575. Fax 0788 537511.

### EXAMPLES OF PRINTOUT FROM THE "WINDTRACKER" SERIES



### NEW PRODUCT FROM THIES-CLIMA CUTS RAINGAUGE COSTS

In order to extend the life of existing raingauges and simplify the construction of new types, Thies-Clima have invented and produced an innovative tipping-bucket raingauge and data logging assembly which can be either incorporated into new instruments, or used to up-date raingauges previously thought to be totally unserviceable through age or mechanical failure.

Designed to operate with standard World Meteorological Organisation raingauge funnels, both from other manufacturers and including the Thies range, the unit renews and extends the life of raingauges previously consigned to be scrapped. Additionally the unit can provide data-logging facilities in raingauge equipment previously only fitted with an on-off switching device.

Constructed on a flat 4mm steel baseplate of 178mm diameter, the unit is simply fixed to the old raingauge base after removing all the existing fixing and mechanical parts.

The data logger incorporates a 16-character LCD display which shows date, time, precipitation of the day and the monthly total derived from a bucket with a precipitation resolution of 0.1mm capacity. A ring memory provides permanent data over a recording cycle span of 62 days. The unit is easily set-up and operated by means of two push-buttons on the data-logger case and is powered by four 1.5 volt high-capacity batteries which have a typical life of nine months. Other models shortly to be announced include magnetic-card



downloading and V24 modem/RS232 versions.

There are of course thousands of raingauges in the field, many of good design and manufacture; however, after two or three years service they often become very dirty, encrusted with calcium deposits and sometimes totally unserviceable – often consigned to be scrapped. This new product from Thies-Clima provides completely new operational components allowing the basic unit to be re-used indefinitely with new operational parts. Typically, a new raingauge with data-logging facilities meeting world-meteorological-office specifications costs in the region of £700.00 to £1,000.00. Providing that the cover, base and funnel of old raingauges are in serviceable condition, installing this new assembly from Thies-Clima at £430.00 could save meteorological users some £270.00 to £570.00 on each replacement.

It is not uncommon for some users to buy 20 new raingauges every year; taking the lower cost rate, if the Thies principle were to be adopted a £14,000 expenditure would be reduced to £5,400. Taking the worst financial comparisons, a saving of 45 to 50% is typical of those which can be expected.

For further information apply to Derek W. Mayes, Press and PR Services, Adelaide House, 5 Halstead Road, Gosfield, Halstead, Essex. CO9 1PQ. Tel: (0787) 474312. Peter Sale, Thies U.K. Ltd., Wentworth House, Bradford Street, Braintree, Essex, CM7 6AU. Tel: 0376 552975. Fax: 0376 552976. Mobile: 0860 799515.



## WORLD WEATHER REVIEW: May 1991

**United States.** *Temperature:* mostly warm (seventh warmest May since 1895); +4degC from S.E. Wisconsin to W. Pennsylvania. Cold from W. coast to W. Montana and N. W. Arizona; -2deg C from N. E. Oregon to C. Nevada. *Rainfall:* mostly wet (eighth wettest May since 1895); over 200% from E. Washington through c. Nevada to S. Wyoming; C. New Mexico; most of Louisiana to parts of Florida. Dry from S. and C. California to most of Colorado and Texas (except much of New Mexico); E. Oklahoma to most of North Carolina and much of Maine; most of Montana into N. Wyoming and N. W. Dakotas; S.E. Wisconsin, Hawaii. Under 50% from S. and C. California to W. Texas; E. Ohio to N. W. Pennsylvania; N.W. Hawaii; round Chesapeake Bay. Preliminary January-May tornado total 923 (normal 356; previous record 558 in 1982); May total 363 (normal 168).

**Canada and Arctic.** *Temperature:* warm in Alaska, Iceland; most of Canada; +4degC in E. Manitoba; +5degC in lower Mackenzie basin. Cold from Newfoundland to N. Hudson Bay, nearly all of Greenland and Franz Josef Land; extreme S. Alberta; -4degC in S. Baffin Island. *Rainfall:* mostly wet; over 200% locally in Alberta, S. Saskatchewan, S.E. Greenland, W. Iceland, S.W. Alaska and near Mackenzie estuary. Dry in most of Alaska; N. Saskatchewan to much of Ontario and at least parts of Quebec; C. British Columbia; Melville Peninsula to N.W. Greenland; S.E. Iceland. Under 50% in interior Alaska and Melville Peninsula.

**South and Central America.** *Temperature:* warm almost everywhere in South America 15-40°S. and from Mexico to Honduras; +3degC locally in N. Argentina, extreme S. Brazil and interior Mexico. Cold (-1degC) in N.W. Bolivia. *Rainfall:* wet in E. Bolivia; most of Paraguay (except N.W. and S.E.), N. and C. Argentina and Uruguay; extreme N.E. Mexico and locally in Honduras. Over 200% in N. and C. Argentina, N.E. Uruguay; locally in N.E. and S.W. Paraguay; very locally in N.E. Mexico and C. Honduras. Dry elsewhere in South America 15-40°S.; nearly all of Mexico to Honduras. Under 50% in N. Chile, W. Bolivia, N.W. Paraguay, extreme N.W. Argentina; most of Mexico to El Salvador; much of S. and C. Brazil; parts of Buenos Aires province.

**Europe.** *Temperature:* warm from Urals to White Sea, Leningrad and lower Volga basin; Portugal, W. Spain, Ireland, Scotland; +5degC in and near N. Urals. Cold elsewhere; -2degC from E. France to E. Poland, W. Ukraine, W. Bulgaria and Greece; Pyrenees, parts of E. Spain; -3degC from N. Greece and E. Italy to S.E. Germany and locally to Netherlands. *Rainfall:* wet from N. Urals through White Sea to Ukraine, N. and S.E. Poland, Austria, extreme S. Germany and most of Italy and Balkans (except Albania, S.W. Romania and parts of E. Yugoslavia and W. Bulgaria). Over 200% on Barents sea coast, S. Greece, W. coast of Italy; locally from Baltic Republics to Volga estuary and in Austria and S. Hungary. Dry elsewhere; under 50% from S. Urals to much of Volga basin; S. Norway, S.W. Germany, Portugal, extreme N.W. Italy; most of British Isles, France and Spain; parts of Low Countries. Provisional sunspot number 121.

**Africa.** *Temperature:* warm in and near South Africa; parts of interior Algeria; +2degC in S. Namibia; locally in S. Cape Province. Cold from Morocco to Tunisia; -2degC widely. *Rainfall:* mostly under 50% from Morocco to Tunisia and in and near South Africa, but over 200% in S. Tunisia, N. Transvaal and N.E. Natal.

**Asian U.S.S.R.** *Temperature:* mostly warm; +5degC in and near N. Urals. Cold from Yenisey Gulf to C. Kolyma basin; Turkmenistan to Tadzhikistan; -2degC from Lena basin to C. Kolyma basin. *Rainfall:* wet in N. Urals; Yenisey Gulf to Kolyma basin, L. Baikal and Tartary Strait; S.E. upper Ob basin; Turkmenistan to S.W. Kazakhstan and Tadzhikistan. Over 200% in last area and from E. Lena basin to C. Kolyma basin. Dry elsewhere; under 50% near Bering Strait; E. Kamchatka; S. Urals to upper Yenisey basin and E. Kazakhstan; near Gulf of Ob.

**Asia (excluding U.S.S.R.).** *Temperature:* warm in most of Saudi Arabia, India and Japan; S. and N. China, Thailand, Malaya, Philippines; parts of Mongolia; +2degC in extreme S. and parts of N.W. India and Mongolia; N. Japan. Cold in Turkey, Bangladesh, China from 30-40°N., S. Korea; most of Pakistan; parts of N. India; marginally in extreme S. Japan; -2degC in N. Pakistan; much of Turkey; parts of E.C. China. *Rainfall:* wet in N. Turkey, N. Pakistan, extreme N.E. India, extreme S. Japan, S. and locally in N. Thailand, Malaya; most of Bangladesh; much of E. China; over 200% at least locally except perhaps in Japan and N. Thailand. Dry in S. Turkey, Arabia, S. Pakistan, S. and N.E. China, Mongolia; almost all of India; most of Korea, Japan, N. Thailand and Philippines.



Under 50% at least locally in all these areas, especially Arabia, India, N.E. China, Mongolia and Philippines.

**Australia.** *Temperature:* warm everywhere, except in parts of extreme N. (-1degC in Cape York Peninsula) and marginally from Alice Springs to Adelaide; +2degC in interior Western Australia and inland from Brisbane. *Rainfall:* mostly under 50% except in E. New South Wales and S. E. Queensland (locally over 200%).

## WEATHER SUMMARY: September 1991

September was a warm month over much of the United Kingdom although mean temperatures over northern Scotland were very close to the average. Over England and Wales mean values were in excess of one and a half degrees Celsius above the normal over a wide area. All parts had a spell of very high temperatures during the opening week of the month. On 1st 29.7° was recorded at Heathrow and 25.5° at Achnasheen in the north-west Highlands. On 2nd 29.1° was reached at Honington (Suffolk) and 29° in parts of south Cumbria. The 3rd saw the temperature as high as 29.0° at Southampton and 26° was reached in some of the Highland glens of Scotland. Highest minima were 17.7° at Languard Point (Suffolk) on 1st, 17° on parts of the south coast on 2nd and 18° at Cromer (Norfolk) on 15th. Much cooler weather spread to all parts later in the month with daytime maxima down to 7.6°C at Tummel Bridge and to 10° to 12°C over parts of England on 27th. Many low lying stations reported their first air frosts of the autumn during the month. The temperatures fell to -2.4° at Rannoch School Dail (Tayside) on 30th while less extreme values included -2.3° at Aviemore (Highland) and Glenlivet (Grampian) and -0.5°C at Carlton-in-Coverdale (North Yorkshire) on 12th and -1.1° at Presteigne (Powys) on 20th. On the grass -5.0° was recorded at Laurieston (Dumfries and Galloway) on 24th and -7.6° at Cellarhead (Staffordshire) on 30th.

Parts of the Midlands, East Anglia and north-west Scotland reported above average rainfall totals but these were the exception and almost everywhere else it was dry. Percentages were widely between 40 and 70 percent of the average and less than 30 percent was reported locally in north-east England. Heaviest daily falls included 34.3mm at Nantmor (Gwynedd) on 15th, 60.4mm at Sloy, near Loch Lomond on 23rd and 37.4mm on the Island of Lundy on 26th. On 28th southern and central areas were particularly wet with 109.4mm at Poole (Dorset), 95.7mm at Velindre (Powys), 73.5mm at Tivington (Somerset) and 64.0mm at Haselbury Plucknett, near Crewkerne (Somerset).

All parts had a sunny month with many places reporting between 120 and 150 percent of the normal. However, southern coastal areas were not so sunny as elsewhere and west Cornwall had totals a little below the normal.

The first ten days of the month were dominated by high pressure to the north and north-west of the British Isles and after a little rain in places on 1st it was generally dry throughout the period apart from some patchy rain as cold fronts moved south across the U.K. on 5th and 10th. Initially it was exceptionally warm for September but less warm, fresher air pushed southwards to most parts by the morning of 6th. Temperatures continued to rise into the low twenties

until the second cold front spread much cooler southwards across the country on 10th and 11th.

The anticyclone slipped eastwards across the North Sea later on 12th allowing frontal systems and freshening south-westerly winds to spread across Britain from the west on 13th, accompanied by some rain, especially in the north-west, while the far south-east had another mostly sunny day. The 13th and 14th were much warmer days over England and Wales but by the morning of 15th the weather had again become temporarily cooler and fresher behind an Atlantic cold front. A deepening depression tracked north-eastwards towards northern Scotland on 16th and its associated frontal systems spread rain to all parts during the day, but on 17th rising pressure over south-eastern counties turned the weather dry and quite sunny for a few days. The 21st saw a major change of weather type as a deep depression moved rapidly north-east between Iceland and Scotland. All parts became very unsettled with spells of heavy rain, as active fronts crossed the U.K., and with strong to gale-force winds. Rain was slow to clear southern counties of Britain on 24th while northern areas were brighter with some showers. The 25th was a showery day and on 26th thunderstorms developed widely over England, some of them very heavy with hail. A deepening depression approached south-west Ireland on 27th and on 28th, as the very deep low became slow-moving near to the Brest Peninsula, many parts of England and Wales had a very wet and cool day. It took much of the 29th for the rain to finally clear from eastern counties and the 30th was a much brighter day as pressure rose across the country and the low filled and moved slowly away to the east.

*May we wish*  
*all our Readers*  
*A Merry Christmas*  
*and*  
*A Happy New Year*



## TEMPERATURE AND RAINFALL: SEPTEMBER 1991

	Mean		Max	Min	Grass	Rain	%	Wettest	RD	TL
	Max	Min								
BELGIUM: Uccle	20.8	11.5	28.4 (1)	7.5(13)	0.9(13)	55.7	80	15.8(24)	12	-
" Rochefort	20.2	7.4	29.6 (3)	1.2(14)		33.6	47	11.7(26)	12	-
" Liège	21.6	12.2	31.4 (1)	7.2(14)		44.0	68	8.5(27)	11	-
DENMARK: Fano	14.9	11.4	26.5 (2)	3.4(27)		59.1	72	10.4(29)	16	0
" Frederikssund	18.0	10.2	25.7 (3)	5.3(27)	1.1(27)	86.5	148	47.5(27)	12	0
GERMANY: Berlin	21.2	10.0	28.4 (4)	3.5(13)	1.7(13)	20.3	42	6.7(16)	10	0
" Hamburg	19.0	10.3	27.3 (3)	3.0(13)	-0.6(13)	62.3	92	19.9(26)	18	1
" Frankfurt	22.9	11.4	29.8 (1)	6.2(14)	3.9(14)	40.5	83	12.9(22)	11	2
" Munchen	21.5	9.9	28.0(10)	5.2(28)	1.4 (1)	58.9	82	18.6(22)	11	2
MALTA: Luqa	29.1	21.9	32.7(30)	18.6(21)	14.6(21)	8.9	22	5.0 (7)	6	8
NETHERLANDS: Ten Post	19.2	11.0	28.5 (3)	5.3(12)	1.2(13)	52.5	72	9.1(25)	13	0
SWEDEN: Valla	16.6	6.7	25.4 (1)	1.9(28)		45.1		15.3(30)	14	0
SWITZ'D: Basel	23.5	11.9	29.4 (5)	5.6 (8)		99.5	126	54.1(11)	10	5
EIRE: Straide	18.1	9.5	24.3 (5)	0.5(27)	-4.2(30)	67.1	65	11.3(15)	16	0
" Mt. Russell, Limerick	18.2	8.1	25.8 (5)	4.4(26)	0.3(26)	83.1		29.1(27)	16	0
SHETLAND: Whalsay	12.9	8.5	17.0 (4)	3.1(28)	-0.9(28)	138.2	127	22.2(16)	24	0
" Fair Isle	12.5	8.9	15.4 (3)	3.6(29)	-2.0(29)	66.6		13.4(22)	22	0
SCOTLAND: Braemar	15.7	5.8	26.7 ( )	-1.1 ( )	-2.8 ( )	58.3	71	12.7(23)	17	0
" Inverduie	16.3	5.3	27.0 (3)	-2.8 (3)	-7.9(12)	90.8	118	25.2(23)	18	0
" Rannoch	16.3	4.2	26.5 (3)	-2.4(30)	-4.0(11)	131.3		28.2(23)	12	0
WALES: Velindre	19.0	8.5	23.7(10)	1.8(20)	-1.5(20)	124.7	154	95.7(28)	11	1
" Carmarthen	18.4	10.3	24.3 (2)	5.0(19)	-1.4(30)	97.9	81	25.1(28)	16	0
" Gower	18.8	11.7	22.9 (3)	6.5(30)		89.0	78	21.6(28)	14	0
GUERNSEY: Airport	19.0	13.6	23.1 (9)	10.8 (v)		33.0		13.6(27)	14	0
JERSEY: Carrefour/Ciq	20.2	13.1	25.9(21)	8.3(26)		54.1		21.2(27)	14	0
ENGLAND:										
Denbury, Devon	20.1	11.3	25.0 (3)	4.3(20)	-0.3(20)	105.9	139	47.0(28)	12	0
Minchhead, Som	19.9	12.1	24.7(21)	7.1(20)	2.6(20)	80.1	5	57.8(28)	10	1
Gurney Slade, Som	19.6	8.6	24.5 (8)	1.2(20)	0.8(20)	86.3	75	44.5(28)	12	1
Yatton, Avon	20.8	10.3	25.2 (8)	4.6 (8)	2.3(30)	40.8	49	20.8(28)	10	0
Reading Univ, Berks	20.6	10.1	27.5 (1)	3.7(20)	-3.1(20)	47.3	91	27.5(28)	9	1
Sandhurst, Berks	20.8	8.9	27.2 (1)	2.2(20)	-0.1(20)	56.4	106	26.6(28)	12	1
Romsey, Hants	21.2	9.2	26.4 (3)	1.1(20)	-0.4(20)	47.6	92	30.7(28)	9	0
Brighton, Sussex	20.0	11.6	26.7 (1)	6.9(30)	6.4(30)	44.9	73	10.2(21)	13	1
Hastings, Sussex	20.1	14.2	27.0 (4)	8.5(30)	6.2(30)	39.5	57			0
Dover, Kent	19.8	10.4	25.4 (2)	4.8(28)		45.2	66	8.4(28)	13	3
East Malling, Kent	20.5	10.2	26.6 (1)	3.8(28)	-0.5(19)	37.0	61	8.8(21)	10	1
Epsom Downs, Surrey	20.8	9.4	29.0 (1)	1.8(20)	-0.2(20)	48.5	82	21.6(28)	8	1
Guildford, Surrey	20.7	11.1	27.0 (1)	5.6(20)	2.8(20)	37.8	59	21.1(28)	9	1
Sidcup, London	20.9	10.5	27.8 (1)	4.2(20)		46.4	75	10.5(29)	11	2
Hayes, London	21.1	10.6	28.9 (1)	5.4(20)	2.7(20)	56.9	121	25.5(29)	11	1
Hampstead, London	20.0	11.1	27.8 (1)	6.1(30)	0.3(19)	48.3	84	12.2(26)	9	0
Royston, Herts	20.5	10.9	29.0 (1)	6.0(28)	1.4(20)	57.0	115	19.9(26)	10	1
Loughton, Essex	20.3	10.2	27.5 (1)	4.1(20)	-1.0(20)	72.4	167	25.4(26)	10	2
Buxton, Norfolk	20.0	9.2	28.2 (1)	2.8(21)	1.3(12)	59.7	117	32.7(28)	9	0
Ely, Cambs	20.8	8.2	29.2 (1)	2.9(20)		36.2		18.5(28)	11	1
Luton, Beds	20.2	9.8	28.9 (1)	1.9(20)	0.7(20)	70.9	126	36.8(26)	13	1
Buckingham, Bucks	20.8	8.9	29.5 (1)	1.2(20)	-2.6(20)	54.2	97	13.5(28)	12	1
Oxford University	20.1	10.5	26.2 (1)	4.2(21)	1.6(21)	42.8	71	19.1(28)	10	-
Wolverhampton, W.Mid										
Louth, Lincs	19.4	9.4	25.6(14)	3.3(12)		75.0		40.1(28)	9	0
Keyworth, Notts	19.9	10.2	27.8 (1)	3.9(30)	-0.9(30)	58.6	110	41.7(28)	7	0
Lowdham, Notts	20.2	9.7	28.4 (1)	4.7(20)	3.0(20)	57.4		32.5(28)	9	0
Derby, Derbys	19.9	10.6	27.2 (1)	4.5(30)	3.9(30)	46.7	88	25.6(28)	9	0
Middleton, Derbys	17.0	9.1	23.6 (1)	3.0(30)		50.6		17.8(28)	11	0
Keele Univ, Staffs	18.7	9.4	25.0 (2)	2.4(30)	-2.5(30)	51.3	68	12.1(26)	12	0
Lathom, Mersey	19.0	9.9	26.0 (2)	1.9(30)		56.5		17.0(14)	11	0
High Bradfield, S.York	17.4	8.6	23.0 (1)	5.1(30)						
Carlton-in-Cleveland	18.2	9.1	24.5 (7)	1.1(12)	-2.1(12)	26.4		6.7(21)	9	0
Durham Univ, Durham	18.1	7.5	24.1 (7)	-0.5(12)	-3.3(12)	24.3	48	5.3(28)	12	-
Sunderland, Tyne & Wear	17.4	10.4	22.5(16)	4.2(12)		17.4	34	5.4(15)	10	0
U.S.: Bergenfield, N.J.	24.9	12.9	35.0(16)	3.3(30)	2.8(30)	118.4		60.2(25)	6	1
JAMAICA: Kingston	33.5	25.6	35.0 (5)	24.3(25)		77.6	73	54.0(24)	7	4
" Montego Bay	31.9	24.7	33.8 (6)	22.8(18)		92.0	72	27.5(18)	7	9
AUSTRALIA: Leopold, Vic										

Cumbria Rainfall: Carlisle 49.3mm (55%); Appleby Bongate 32.6mm (41%); The Nook, Thirlmere 132.4mm (54%); Coniston 123.7mm; Hawkshead 106.2 mm.

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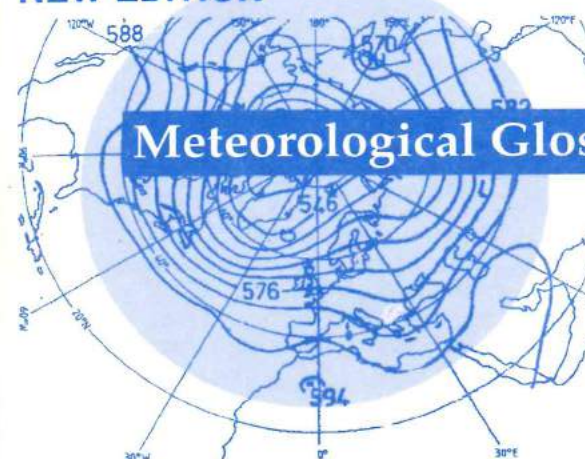
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Tipping-bucket rainguage from Thies-Clima.

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